Abstract

Understanding Curriculum Integration In Medical Education

by

John Vergel

MA in Education, Universidad de Los Andes, 2012

BS in Medicine, Universidad Industrial de Santander, 2003

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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in Education

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Abstract

Curriculum integration (CI) has been embraced as a notable strategy for reforming and creating medical education programs around the world. However, medical schools seem to struggle when integrating their curricula. This is possibly a consequence of the confusing definitions of CI that are anchored on diverse learning theories. Thus, clarifying the framework of CI may provide stakeholders insights into how to succeed in the endeavor of analyzing, designing, implementing and evaluating an integrated curriculum. This thesis aimed to understand medical CI from a contextual perspective by answering what the meanings of CI are in the practice of two types of integrated curricula. To answer it, we analyzed the stakeholders' subjective experiences of their problem-based learning curriculum and built four theoretical constructs of CI. Then, we transferred the constructs to understand the meanings of the practice of an integrated-systems curriculum. By doing this, we refined and extended our theoretical constructs. We also evaluated the effectiveness of both types of CI by assessing students' knowledge integration while applying clinical reasoning skills. The overall analysis was framed in the qualitative research paradigm. Our results allowed us to extend the theoretical basis of CI in medical education towards a perspective of complex adaptive system. We also found that the type of CI in which medical students are enrolled may influence the style they have to integrate knowledge when solving a clinical problem. Implications for analyzing, evaluating, and understanding CI through these approaches are discussed.

Keywords: Curriculum integration – Medical education – Clinical reasoning
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Dedication

I dedicate this dissertation to my mother, Amanda Guerrero, who has been my constant source of motivation and support.

I also dedicate my dissertation work to my best friend, Patricia Gaviria for helping me to overcome difficult times, and teaching me what emotional intelligence in action is about.
Acknowledgments

I wish to thank my supervisor and my visiting research advisor for guiding me in this endeavor. A special feeling of gratitude to Juny Montoya for patiently listening to my catharsis and giving me your precious time throughout my process. I believe that accepting to guide a student that behaved as a necio the first day you met him is a reliable evidence that you are a wise person. For that act, I admire you. And that thing you saw in me that made you consider supervising me, whatever it is, I am grateful for having it.

Thank you, Diana Stentoft for receiving me at the Centre for Health Science Education and Problem-based Learning at Aalborg University, helping me to reflect on my research concerns, and guiding me in my writing process.

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I also want to thank the staff and faculty members, teachers, and students of Universidad de Los Andes and Aalborg University medical schools for helping me to conduct my research.

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General Introduction

Why do I write a doctoral dissertation? This question became my mantra for the last three years because many times I got lost in the multiple tasks entailed in the doctoral program. The answer helped me recovering my path towards my research purposes and allowed me reflecting on my learning process. This is why I start the dissertation with this fundamental question. To answer it, I have to go backwards to revisit my experience as a medical student and tell you my personal story. Unfortunately, as a very young boy I had the "magnificent" opportunity to study medicine in one of the most traditional and well recognized medical schools in my country. However, when studying medicine I had to undergo the worst six years of my life. Medical training became a cruel environment of suffocating egos, humiliation, discrimination, perfidious rivalry among peers, arbitrary assessments, and thousands of hours memorizing things I barely understood.

Nowadays, when I ask myself why I tolerated that environment, I recognize that I did it because I had a dream to become a medical doctor, and I believed many sacrifices had to be done to achieve it. Moreover, as a young student I did not have the self-confidence nor the knowledge to demand a change. I could not complain, for example, when my neurosurgery teacher frequently told me "bruto, animal, use las neuronas!" because I was frightened of the dreadful system that gave teachers an incredible power and silenced students. I did not want to fail; therefore I remained mute.

\[1\text{Stupid, animal, use your neurons.}\]
After graduation, I got involved in reflecting about my experience, and I noticed many young boys and girls including my little sister have the same dream of becoming a medical doctor. Then, I thought, instead of complaining about the past; I might embrace the purpose to do something for providing them a better learning environment than that of I had. Therefore, I decided to study education and began my master studies. Nevertheless, the transition from medical towards educational sciences was a tremendous challenge. At that time, I decided to make an incursion in the research field of the information and communication technologies because that was the most suitable issue for my limited knowledge. But when I decided to start my doctoral studies, I took my initial purpose again. However, this decision made face another tremendous challenge: leaving my research comfort zone and entering a research field I was terrified of, curriculum. The efforts I made in my master course of curriculum to comprehend its complex and complicated concepts were titanic, and this situation was a cause of doubt when it came to decide my new research field.

Telling you the story about why and how I finished investigating medical curriculum integration was one of the most difficult parts of writing my dissertation. Most of the time, I was focused on writing the three papers and thinking what I might do to be published. But when I began thinking how I could make visible for you not only my products, but also my learning process to become a researcher, things became confusing. The confusion was overcome when I read Galindo (2011), another doctoral student that explains the tension between process and product in doctoral training as following:
“Without inside stories our external narratives are only boring repetitions of disciplinary power schemes. Without those internal stories, our work is lifeless and runs the risk of falling apart. Nevertheless, the emergence of the inside story would deform, immobilize and even destroy the external narrative. There is always risk involved in bringing together process and product in doing sociological research. But what would life be like if everything were flat, if there were no mountains as there are in my Bolivia?"

He provided me some clues on how to address the tensions between product and process by writing a dissertation biography, which he defines as a research diary that narrates the process for becoming a researcher. Galindo (2011) came with this idea by a suggestion of his advisor:

"Then, think of your dissertation as if you were a craftsman, a painter. Think of your dissertation as a work of art, a form of expression, and a reflection of you. Engage your mind in assembling the data. Your research is not to satisfy the demands of a grant, or the demand of a particular profession. Your dissertation is a personal painting of a craftsman, a home, and an opportunity for people to come alive on the paper."

I followed his advice and moved onto reviewing the research diary I wrote in my e-Portfolio (See Vergel, 2012). Curiously, I must to admit I complained when I was forced to write it in my doctoral research course because the "order" emerged from a partial study we were discussing that concluded writing a research diary was an unpleasant and unsuccessful experience for some master students. However, I believe

2 I had to travel to Bolivia to apply for my Danish visa; thus, I understood what he was talking about.
now that my e-Portfolio is my beautiful treasure that helped me to keep track of how my intellectual evolution was and why I made the decisions I made. Thus, the next paragraphs are an attempt to explain you why I investigated curriculum integration in medical education, and what I learned from the research process using the most relevant ideas of my research diary. Next, I will introduce you in my research products by summarizing their principal aims and results, and explaining how the three papers are inter-related.

As I explained above, my guiding principle to conduct my doctoral research was to investigate something that might change the negative learning environment medical students might face, as I did. Seeking this purpose made me abandon my master research field and consider another concern more aligned to the issues I lived as a medical student. A precious opportunity came to me after that decision. The faculty dean of the Universidad de Los Andes medical school invited me to take part of the program evaluation they were conducting to reach accreditation. Although I could not finish the project, I had the opportunity to conduct a case study for exploring authentic, interesting issues regarding this medical program.

August 31st, 2012

*I think one of the main purposes for the faculty members of the program is to achieve accreditation, but I think my role is to involve them into the need to reflect on other formative aspects. Although I do not understand yet the differences between learning assessment and program evaluation, I overall conceive assessment is for learning. (...) learning from the evaluation process, from the program in itself, its evolution and impact on society. (...) However, a change in the evaluation culture of medical education might bring negative effects.*
Traditionally, medical teachers have been used to specific ways of teaching and assessing students. Thus, a change in these habits may generate obstacles to the program evaluation process. Considering these aspects and how to solve them is a key element to design the evaluation.

When deciding on the appropriate method to evaluate the program, I learned (confirmed) that democratic and participatory program evaluations in medical education are not devoid of obstacles (Arguello, 2009). It is usually difficult for students to participate in the evaluation of their program and feel ownership of the process (Morrison, J. (2003). Although I reflected on the importance to involve students in the evaluation, I decided to use a CIPP model to conduct the evaluation, and I assumed the role of an external evaluator.

September 18th 2012

I think the CIPP model (Stufflebeam & Shinkfield, 1987) is appropriate to develop this evaluation project, and the reasons are listed below: (...) because what is expected is precisely collecting information that would be useful for troubleshooting the program and making decisions for improvement. Also to understand why and how these problems occur (...) because it is geared to the needs of the manager, the decision maker. To this context it is an advantage because faculty members take decisions and I can be in close contact with them. However, I acknowledge there is a limitation regarding the impact of the evaluation results, because it excludes teachers and students. It is possible that when making adjustments to the program, they might reject the decisions because they did not participate in them. I think once reviewed and studied other authors or theories; I may find other strategies to solve this limitation.

When conducting my exploratory study, I turned to the responsive evaluation model (Stake, 2004) because I reflected I needed to understand the tensions of the
program in depth. I did it on the grounds that it would help me to find out a research concern for my doctoral study that could allow me to reach my guiding research principle. I believed that by understanding a crucial tension in medical education, I could contribute to a significant change in learning environments. Thus, one of the findings caught my attention. The finding regarded to a tension about the intention to integrate biomedical and clinical themes.

December 11th 2012

Some students perceived as a major failure of the program the tension between what is expected of their learning in biomedical courses and what is expected in clinical courses, particularly with learning antibiotic and antihypertensive therapy. The difficulty arose from the existing misalignment between their learning in the pharmacology course (pharmacokinetic, pharmacodynamic, pharmaco-vigilance, and pharmaco-investigation), and their learning activities in clinical and integrated-systems courses. In the last courses, teachers expected students to be able to identify what type of medication should be provided to a particular patient, or which the dose is. For students, pharmacology teachers’ expectations differed than those of clinical teachers. The first ones believed that antibiotics would be learned in clinical courses, and the second ones assumed that it should already be known to get into clinical courses.

To get a better understanding of that tension, I decided to review the medical education literature regarding curriculum integration (CI). Nevertheless, I struggled comprehending the CI concepts because I found multiple and confusing definitions of it. This unexpected finding made me think that my concern about CI, which emerged from an authentic problem, would be an excellent research theme for my doctoral investigation. I believed that if key concepts such as CI were as considerably confusing
as I noticed, probabilities to involve medical students to participate in the evaluation of the medical education programs would be minimal. Thus, I thought that the chance to give medical students voice for claiming a change in their learning environments might be a reality if I clarify the CI tension.

Struggling moments continued in my research process. Although I had identified an interesting theme to be investigated, I was unsure on how to penetrate into my research concern. I mean, there were lots of papers related to CI in medical education. Thus, I had to think about a different and alternative pathway to study it. The answer came to me in a course of research methodology. We discussed how obvious could the results of some studies be because they did not provide a different perspective. In that meeting, Marcela Ossa\(^3\) recommended us to think about "the angle of our investigation". That suggestion made me questioning what the concept of research angle is about, and how to achieve it.

March 23\(^{rd}\) 2013

(...) the angle of research, which is the extent to which the researcher penetrates his research questions. The selection of methods he will use to answer them and the complexity with which he will discuss his findings depend on the research angle. It is like the angle in which a swimmer dives from the diving platform into the water. In my case, water is what I want to investigate, and the portion of water being dived by the swimmer is the reality that I am building by investigating it.

\(^3\) Teacher at the Center for Research and Development in Education (CIFE), Universidad de Los Andes.
Nonetheless, struggling got worse. Specifically, my expectations about the doctoral program were not completely satisfied. In addition, I could not find my research angle, and I felt I lost my guiding principles. Therefore, I was anxious and depressed. Fortunately, I read Virginia Richardson (2006) at that time, and that reading gave me some clues on how to overcome the darkness moment. The clues were to contact other researchers with my similar concerns and ask them how they achieved it. My supervisor helped me to contact one of her former supervised student who had conducted a program evaluation at the same medical school I was interested in. Arturo Arguello agreed to meet me, and I interviewed him about his research experience. After that meeting, everything changed. I realized that I lacked critical autonomy, and I thought that I needed to develop that skill to advance in my process.

March 6th 2013

*Then, when our meeting ended, I started walking through the shopping mall where I was. I was wondering about what had happened and asking myself what could exist beyond my doctoral research? Why was I doing that beyond becomes a technical researcher? What was my purpose to investigate in education? Suddenly, I felt released, and I find no other word to describe that feeling, I only understood it when I read Mejia (2007). He mentions that in his opinion, developing critical autonomy means “hacerse cargo de su propia vida, a no ser*
Developing critical autonomy empowered me to continue my research process, gave me confidence in myself to take my decisions based on critical reflections (and I made lots of autonomous decisions), and allowed me to leave anxieties regarding what the others could think about my products. After this moment, I found my research angle. I noticed most of the papers in connection to CI in medical education had a static and theoretical perspective. They also highlighted that CI was an ongoing and struggling issue for medical schools. Thus, I reflected that this phenomenon could be studied by a contextual angle. That is, studying how medical schools integrate their curricula and considering the problems they may face in that process may provide some insights into understanding CI in depth. I speculated that the meanings of CI might emerge by analyzing the subjective experiences of stakeholders enrolled in integrated curricula. This is why I decided to study not only the type of CI in Universidad de Los Andes, but also to compare it to other type of integration for broadening my understandings about my research concern. Then, I had the opportunity to make a visiting research at Aalborg University medical school to study its problem-based learning curriculum.

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4 "to take charge of your own life, not to be determined historically and, ultimately and, therefore, to be truly free."
During 2014 and 2015 I conducted my research and wrote my products, the papers, in collaboration with my supervisors. The three papers will show you my gained understandings about CI in medical education in relation to its processes and results. In the first paper, “Extending the theoretical framework for curriculum integration in medical education from a contextual perspective”, I aimed to offer new insights to the confusing theoretical framework of CI in medical education by constructing four theoretical constructs through studying the practice of a problem-based learning (PBL) integrated curriculum. I did this using grounded theory. From this bottom-up perspective, I suggest the notion of CI should be broadened from static theoretical to include dynamic and contextual because it involves conflicts, tensions and diverse learning perspectives interacting within the integrated curriculum. This contribution was focused on the CI processes and attempted to offer an analytical framework that medical students and teachers may use to understand more about CI in their particular settings. In the second paper, “Transferring theoretical constructs of medical curriculum integration emerged in a PBL curriculum into an integrated-system curriculum”, the research objective consisted in transferring the four theoretical constructs emerged from the first study into a different setting. I appraised if they were sufficiently abstract to understand the practice of CI in a dissimilar type of integrated curriculum. Specifically, I interpreted the participants’ subjective experiences of the practice of their integrated-systems curriculum through a top-down process. First, I used the four theoretical constructs as lenses to understand the conflicts, tensions and learning perspectives influencing the
practice of CI in the new setting. Thus, more themes were coded from the new
gathered information using the elaborating coding process. And second, the new themes
were regrouped into four refined constructs by including the differences and similarities I
found in both types of CI. Therefore, they represent more abstract categories that show CI
may be understood as a complex adaptive system because they entail features such as
self-organization, tensions, integration, interactions, adaptation, complexity,
reconfiguration, and dynamics. The contribution of this second paper was also focused on
the CI processes, and it also attempted to offer an analytical framework that stakeholders
may use to understand more about CI in their particular settings. However, it differs from
the first paper because the offered analytical framework of CI was extended and refined
by including the meanings of the practice of CI in a different context. Furthermore, it
shows and explains how the old constructs were transferred to understand the other type
of CI.

Nevertheless, I was unsatisfied understanding CI exclusively as a process as
aimed in the two first papers. Studying the effectiveness of CI was a missing aspect of
my research. For this reason and despite I had little time to finish my dissertation, I
decided to conduct a final study instead of writing a third paper about my reflections on
the literature review of CI. The third paper titled "Evaluating curriculum integration by
analyzing students’ clinical reasoning enrolled in both PBL and Integrated-systems
medical curricula", aimed to understand how students from different integrated curricula
organize their knowledge when solving a clinical problem. It was an effort to understand
the results of CI with regards to the students' knowledge integration and how
the type of CI influenced the way they did it. I conducted this study by using think aloud
protocols in performance assessments of the students’ clinical reasoning. Thus, by
making the participants’ thinking visible while they were solving a clinical problem, I
analyzed how they integrated knowledge from different sources. Then, I compared this
process to the type of CI in which the participants were enrolled. The findings indicated
that participants from both medical schools display different styles of clinical reasoning
and the type of integrated curriculum seems to influence how students integrate their
knowledge when solving a clinical problem. These differences on clinical reasoning may
be the key to evaluate the effectiveness of CI and may provide important clues on how to
improve it.

Additionally, I could not finish this introduction without explaining that the
papers were written according to the requirements of the medical education journals.
They include the structure of IMRD (Introduction, Methods, Results, and Discussion).
Although I acknowledge this is the most recognized organization to write scientific
papers, it also challenged me to maintain a logical thread among them. This type of
organization tended to fragment my research process, and telling you my personal story
through the biography helped me to connect them again. As you could see, the three
papers are part of a whole that begins with my concerns on how to improve the learning
environments of medical students. The whole represents an extended framework to
analyze and understand CI taking into account the particularities of the context in which
it is implemented. The first paper provides the first theoretical constructs that emerged from studying the practice of one type of integrated curriculum. The second paper illustrates how to transfer those old constructs into a different type of CI in order to understand it. It also shows how the old theoretical constructs of CI were refined by elaborating them into more abstract and new theoretical constructs. At last, the third paper provides some insights into how to evaluate the effectiveness of the type of CI through assessing students' clinical reasoning. It also contributes to understand the results of CI in students' learning by promoting the integration of their knowledge.

In summary, the goal of this thesis was to understand CI from the setting in which it was experienced. This thesis also addresses the confusing theories of CI by providing an extended framework to analyze, evaluate, and understand CI. This contribution was done by taking into account the contextual issues faced by two medical schools when designing and implementing their integrated curricula. I believe I achieved two principal learning outcomes after conducting this research. The first outcome relates to changing the comprehension of CI from a statical and theoretical perspective to dynamic and contextual. I changed my initial understandings of CI when I recognized that the four theoretical constructs that emerged from studying two types of integrated curriculum had characteristics of the complex adaptive system. These characteristics include self-organization, complexity, emerging tensions, and integration of multiple dimensions and levels. This change of perspective allowed me to understand why medical schools struggle when they implement CI. I hypothesize that they struggle because they remain
stopped whereas the curriculum is evolving by itself. Therefore, the tensions that arise from this evolution and the new configuration that the curriculum is acquiring are not well understood. I speculate that incorporating the theoretical constructs into the process for understanding the particular CI implemented by these medical schools, they may success in the endeavor of integrating a medical curriculum.

My second learning outcome relates to the effectiveness of CI and how to evaluate it. As I will explain below, many quantitative studies on this issue claim that there are no significative differences on the students' test results of diagnostic competences when comparing traditional (fragmented) curricular to integrated curricula. In contrast, other research found that PBL curricula and integrated-system curricula are better than traditional curricula to promote these competences. However, it also claims that integrated-system curricula are better than PBL curricula on diagnostic competences in the preclinical training. My results showed me that students in preclinical training from both PBL and integrated-system curricula provide diagnoses and treatments for a clinical case. Nevertheless, they use different styles to integrate knowledge when applying their cognitive skills of clinical reasoning. Students from the PBL curriculum tend to encapsulate biomedical knowledge whereas students from the integrated-system curricula tend to make conscious this type of knowledge. I hypothesize that standardized tests on diagnostic competences do not render visible students' clinical reasoning in action; thus, they do not see differences among students from diverse types of curricula. Also, although one study found that students from an integrated-system curriculum tested better
than those of a PBL curriculum in diagnostic competences, I speculate that these findings may be explained by the knowledge encapsulation of PBL students. However, I believe that PBL curricula are superior to promote knowledge integration because their students tend to reason in a clinical case by identifying a key symptom and relating it to relevant information. In contrast, students from the integrated-system curriculum tend to analyze the information in separate sections; thus, they provide multiple diagnoses that are not related to the patient disease.

Finally, I believe that the practical implications of the extended CI framework offered in my thesis is to help medical students enrolled in integrated curricula to understand what, why, and how they are doing to learn with a good comprehension. Thus, they may have the understandings to participate in the design, implementation and evaluation of their integrated curriculum. I speculate this may be a plausible route to change the non-pedagogic experiences in medical education.

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http://wwwprof.uniandes.edu.co/~jmejia/PDF/autonomias.pdf


http://johnvergeldoctordo.blogspot.com/

**Chapter 1: Extending the theoretical framework for curriculum integration in medical education from a contextual perspective**

John Vergel

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5 Universidad de los Andes, Centro de Investigación y Formación en Educación (CIFE), Bogotá, Colombia.
Abstract

Although curriculum integration (CI) is considered a priority in reforming medical education programs around the world, many medical schools struggle integrating their curricula. This is possibly a consequence of CI being an unclear concept, which has been understood in diverse ways depending on the learning theories by which it is framed. In the current study, we aimed to offer new insights to the theoretical framework of CI in medical education by constructing new concepts from a contextual perspective. First, we collected the official curriculum, interviewed several curriculum designers, teachers and students, and observed some learning activities. Then, based on grounded theory we analyzed and triangulated this information. Four abstract concepts emerged after analysis: (1) Complexity of CI embedded in the institutional learning perspectives. (2) CI as a tool to harmonize conflicting learning perspectives in the practice of the curriculum. (3) CI both creates tensions and self-organizes its structure. And (4) CI renders itself visible in collaborative learning spaces. Our concepts provide an analytical

6Aalborg University, Centre for Health Science Education and Problem Based Learning, Aalborg, Denmark.

7Universidad de los Andes, Centro de Investigación y Formación en Educación (CIFE), Bogotá, Colombia.
framework to understand CI as a dynamic process. We believe that the conceptual and methodological issues of CI may be resolved from this dynamic and contextual perspective instead of using exclusively general theories of learning. Consequently, approaching CI from the proposed concepts may give some insights to medical educators for making curriculum integration more effective.

**Keywords.** Curriculum design - Curriculum integration - Integrative education - Grounded theory - Medical education

**Background**

In the last three decades, curriculum integration (CI) has been widely recommended as an innovation in medical education, but not clearly and completely defined (General Medical Council, 1993; Schmidt, 1998; Lancaster et al., 2002; Malik & Malik, 2004; Jippe & Majoor, 2011; Goldman & Schroth, 2012; Whitehead et al., 2013; Brauer & Ferguson, 2015). The increasing amount of new information in the medical field, from the past century, has been overloading traditional curricula; hence the need for strategies to manage this explosion of information (Bolender et al., 2013). According to Schmidt et al., (1996), one of these strategies has been using CI because, instead of studying lots of separate topics, it allows students to understand the function and malfunction of the human body by seeing the whole picture and its connections. These researchers found that students from problem-based and integrated-systems curricula tested better than those of traditional curricula in diagnostic competences. Thus, CI and the resulting understandings made by students may be the key to evaluate, diagnose and
manage health problems more successfully (Woods et al., 2005). Nevertheless, the meaning of CI is unclear based on the diverse definitions it has had during this time. Some authors in medical education have described and recommended specific ways to integrate medical curricula based on learning theories that provide the principles to arrange them. (Harden et al., 2000; Kemahly et al., 2004; McNeil et al., 2006). But one can discover many and varied types of integrated medical curricula according to diverse types of learning theories (Table 1). Even a single medical program could have more than one integrative approach at the same time. As a result of this theoretical diversity, the definitions of CI have been multiple, varied, and particularly confusing. For instance, a medical school may struggle with CI when it implements an integrated curriculum using a learning theory that is different from the one present in its own context. Schmidt (1998) describes how stakeholders in medical programs resist and have little participation in curricular reforms that include integration. Although resistance is a logical reaction to changes, it also may represent the stakeholders’ misunderstandings about CI because they believe they could lose their identities (Schmidt, 1998).
Table 1

*Some types of integrated curricula in medical education according to specific learning theories*

<table>
<thead>
<tr>
<th>Types of integrated curricula</th>
<th>Learning conceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Based Learning (PBL)</td>
<td>Students integrate the knowledge they are building while they identify learning objectives and gather information to solve problems (O'Neill et al., 2000).</td>
</tr>
<tr>
<td>Integrated Systems curricula</td>
<td>Show a systemic comprehension of learning (Schmidt et al, 1996).</td>
</tr>
<tr>
<td>Spiral Curriculum</td>
<td>Underlies a conception of repetition to learn effectively (Harden, 2005).</td>
</tr>
<tr>
<td>Core Curriculum–Special Studies Modules</td>
<td>Include the notion of connecting teachers’ concerns with students’ interests (Hardem, 1994; Harden &amp; Davis, 1995).</td>
</tr>
<tr>
<td>Basic–clinical–humanities sciences integration</td>
<td>Possesses the idea of interdisciplinary learning (Schmidt, 1998).</td>
</tr>
</tbody>
</table>

*From the beginning: CI in middle education*

Another possible explanation for misinterpreting CI in medical education programs may derive from the historical tensions among integrative approaches to design curricula (Genkre, 1998; Hopkins et al., 2015). Nonetheless, theorists in middle education have provided some insights into this issue. Although CI also has had multiple definitions in this field, these definitions can be classified in two main trends (Genkre, 1998; Shriner et al., 2010). First, the subject-based perspective connects the curriculum organizational elements preserving the disciplinary boundaries (Jacobs, 1989a; Vars, 1993). The
purpose of this integration is for students to learn how the knowledge of
different disciplines allows them to solve or examine issues, problems, themes, topics or
subjects (Jacobs, 1989b; Fogarty, 1991; Vars, 1991). The second trend is the
experienced-based perspective; here the integration is focused on students learning
experiences (Beane, 1993). These experiences are based on real life problems/issues and
organized without the direct influence of disciplinary boundaries (Beane, 2010).
However, because both of the integrative trends have dissimilar interpretations of the role
of the disciplinary boundaries on CI, tensions emerge from the contrasting viewpoints
and may create a perception of two opposed poles. Thus, positioning from any of the
poles to understand CI may imply a limited picture of it because each one by itself
constraints visualizing and taking into account the opposite side.

Struggling with integration: the instrumental use of CI in medical education

The limited perspective about CI in medical education is revealed by the emphasis
that has been placed on the structural elements of integration rather than the stakeholders’
conceptions about it (Hopkins et al., 2015; Haramati, 2015; Hooper et al., 2014). To put it
differently, we reasoned that medical schools have struggled with CI during the past three
decades because they have paid extremely attention on how to link the organizational
elements of curricula instead of how and why their specific conceptions of learning allow
or prevent them interconnecting their curricula. For instance, more conservative
conceptions of learning are aligned with the subject-based integration due to the
importance given to disciplinary boundaries (Jacobs, 1989a). In contrast, experience-
based integration may bring challenges to conservative conceptions of learning because it entails a shift of focus away from disciplines towards students’ concerns (Beane, 2010).

*Understanding CI in depth: the need of a contextual angle*

Because of the instrumental use of integration to organize medical curricula, it is necessary to extend the CI theoretical framework. Nevertheless, this extended framework should be developed from a contextual angle. Specifically, the concept of integration, as same as the concept of curriculum, depends on the educational context. In other words, on what stakeholders of a medical program understand by integration and curriculum in a particular setting (Posner, 2004, p. 43-45). But this perspective could vary due to cultural, social, historical, economical and political dimensions of the context (Gimeno, 1991, p. 24-25). Accordingly, the stakeholders’ multi-dimensional conceptions affect the way in which curricula are defined, organized and integrated (Posner, 2004, p. 45-55). The contextual angle, therefore, may provide the lacking patterns of abstract concepts, necessary to comprehend CI in an overall fashion, as a result of seeing how a curriculum is integrated in a particular medical program. Consequently, the abstract concepts may help medical schools to get into CI and improve their integrated curricula by understanding in depth the meaning of integration. This meaning may be grasped by taking into consideration the contextual particularities of the medical school instead of looking exclusively at foreign learning theories. Therefore, through the abstract concepts,
medical schools may abandon what Hopkins et al. (2015) have called the “curricular carousel”, in simple terms, the recurring implementation of curricular reforms without substantial changes (Bloom, 1988; Whitehead et al., 2013).

The purpose of this study

This study aimed to construct abstract concepts of CI, which emerged from an interpretive analysis according to Grounded Theory (Auerbach & Silverstein, 2003). The analysis was focused on the meaning that the context (medical program) gave to CI in the official curriculum and in the learning experiences. The research was conducted during six months on how Aalborg Medical School, with a constructivist learning perspective, designed and implemented a PBL curriculum, and what the stakeholders comprehended by integration. Some abstract concepts emerged in this investigation, however, they should be re-elaborated according to other contextual settings that have different ways of looking at CI. This is why the current study is part of a larger research project that transfers these concepts into a different medical program to identify diverse patterns on how curricula are integrated as a result of different contextual perspectives (For more methodological information see Silverstein et al., 2002). Therefore, the current research questions were the following: (1) how does the investigated medical program integrate the curriculum? (2) What does this learning context understand by CI? (3) What is the meaning of CI from a contextual perspective?
Methodology

The research paradigm

As we were concerned to explore the concept of CI from a contextual angle, the current study is based on grounded theory defined as “a form of qualitative research developed (...) for the purpose of constructing theory grounded in data” (Corbin & Strauss, 2015, p. 6). Specifically, we considered extending the theoretical perspectives of CI by taking into account the context. It meant seeing how the stakeholders in a particular medical program designed and implemented an integrated curriculum. By studying these subjective experiences, we interpreted what were the stakeholders’ meanings about the CI, and how it makes sense for them. Moreover, the qualitative research paradigm was suitable to extend the theoretical perspectives of the concept because participants define social actions, like implementing the curriculum (Cohen, et al., 2007, p. 19). Using qualitative tools such as documental analysis, observations, and interviews, we accessed the participants’ experiences and their interpretations of them (Onwuegbuzie & Combs, 2010, p. 409). Then, we analyzed the descriptions of the experiences and interpretations to yield abstract concepts of CI (Schwandt, 2003, p. 296). We started collecting the descriptions of the experiences that compounded the qualitative information. After that, we interpreted the contextual meanings of CI in the qualitative information in a systematic way, according to our theoretical approaches described on the background section. To do this, we developed a methodical structure of themes "grounded" in
particular segments of the texts considering the research concerns. In the next step, we organized groups of themes into theoretical constructs or abstract concepts according to their logical relations. Finally, we presented and discussed the theoretical constructs into a theoretical narrative to help others understand CI more clearly (Silverstein et al., 2002).

Setting

According to the official curriculum, the medical education program at AAU was compound by a Bachelor degree in three years and a Clinical Master degree in additional three years. Its learning activities were based on the seven-jump model (see Stentoft et al., 2014), and their learning goals were based on a particular set of knowledge, skills and competences\(^8\) that were organized according to a problem-based and project-based curriculum design. The PBL curriculum was implemented by various activities such as Case-oriented PBL, projects, plenary lectures, resource sessions with exercises, clinical skills practice, and clinical placement (see Figure 1). The Cases and projects were the

\(^8\) For the official curriculum, knowledge is defined as understanding topics. Skills are defined as the capacity to perform certain medical activities including listen to the heart sounds. Competence is defined as a higher level. For example, when a student not only understand a topic or can do a specific task, but also he knows when and what for to do it.
major learning activities whereas the other sessions were intended to support learning. In a Cases activity, ten to fourteen students discussed the clinical information of a patient guided by a facilitator. The patient's history was unstructured, incomplete, and included social issues. Then, students went through three phases (1) At Cases start, they identified the keywords of the history and their connections. These connections were usually depicted by arrows on a blackboard and were used to establish the learning outcomes. A learning outcome was a theme or an issue derived from the keywords relationships and identified by students. For instance, “The histology of bones or how do bones heal?” (2) Students worked on the learning outcomes individually or collaboratively during a week, supported by the rest of learning activities. (3) At Cases close, students met again with the facilitator to present and discuss their understandings of the learning outcomes. On the other hand, projects were also collaborative activities guided by a facilitator and directed to develop skills in experimental research. The topics or content units of the project were selected by the students in coordination with the facilitator; for example, Attention Deficit Disorder in the Public Health unit. However, unlike Cases, students had more time to work on the project, and they had to present a research report. Additionally, Bachelor program teachers at AAU were researchers well trained in PBL methods and had backgrounds in biomedical engineering.
Figure 1. Curriculum organizational elements and connections at AAU.

**Design**

The research design is shown in Figure 2. Multiple-method approach was adopted to obtain a complete description of the CI implemented in the medical school (Flick, 2007, p. 43). The steps in the research methodology were selected according to the researchers’ inquiry style (Stake, 2010, p. 89), and conducted during August 2014 to January 2015. We choose Aalborg University (AAU) to study the medical curriculum because it has a particular approach to integrating the curriculum based on a PBL model in which we were interested. Additionally, the program was relatively new and the curriculum had no reforms from traditional programs; hence, the CI approach would be
authentic. Nonetheless, we began the research considering our possible biases about the program that might invalidate our inferences from the results. One of these biases could be assuming that the curriculum was sufficiently integrated. For this reason, we decided to analyze the documents of the official program before observing learning activities. Moreover, the first researcher (JV), who was unfamiliar at the University, collected the data directly. Then, I discussed these data with the other researchers that had more or less preconceived ideas about the program.

As shown in Figure 2, the design included four stages according to our research questions. Firstly, in the document analysis, we studied the official curriculum to identify the structure of the program, the type of curriculum, and the connections among its organizational elements. Secondly, we interviewed some curriculum designers to understand the rationale behind the interconnecting structure and the learning conceptions. These interviews were semi-structured and had open trigger questions such as what is the meaning of competences? What is a case and what is a project? Why do the students learn cyclizing? Thirdly, we observed the learning activities of some students to know how the curriculum was implemented. The non-participant and non-blinded observations were primarily focused on Cases learning activities, and we planned the observational units before conducting them. These units included what do they learn? How are they learning it? What and how are they integrating it? Field notes were taken, but the principal challenge faced in observations was the language. Although students spoke English fluently, they preferred conducting discussions in Danish whereas the
teachers guided them in English. Because JV did not speak Danish, post hoc interviews were performed with some students in English to understand in depth the content of their discussions. Finally, we interviewed some teachers and students to understand their interpretations of their learning activities. These interviews were also semi-structured with open questions. For example, what is your role as a case facilitator? What and how do you do in cases? A prior informed consent was signed by the participants, and all interviews were taped and transcribed for further analysis.

Figure 2. The research design
Participants

Regarding the research participants, we selected them until the information was saturated. This means, we stopped collecting data when no new information was found to build the constructs up. (See Cohen, et al., 2007, p. 116). Participants included three curriculum designers, two teachers, and five students from two small groups in third and fifth semester. We observed nine learning activities in the muscle-skeletal and gastro-intestinal units. Because we required easy access to participants that allow us to directly observe their learning activities, they were selected as a ‘convenience sample’ using the technique of ‘snowball sampling’ (Cohen et al., 2007, p. 113-116). Year 2 and 3 medical students were engaged for three main reasons. First, little attention has been given to study preclinical education (Rotgans, 2012). Second, we believe CI is particularly important in preclinical years because students have few encounters with patients in natural settings; thus, integration would facilitate understanding health problems in classroom learning activities. Third, we also wanted to compare differences in how students advance across the spiral learning.

Data analysis

We applied the methods of grounded theory described by Auerbach and Silverstein (2003, p. 31-41) to analyze the collected information. We did this because it helped us to conduct an inductive analysis from text-based concepts towards high-level theoretical and abstract constructs. Starting from transferring the text to the Atlas.ti
software (version 6.2), reading repeatedly the raw information, and selecting relevant segments of text, we interpreted these segments into themes. For instance, one of the participants said that because teachers explained a lot of unnecessary stuffs in lectures, like history, he had troubles to learn from these activities. Instead, he preferred watching videos about the learning outcomes as he was very visual and needed to see drawings to remember things. We coded this idea as the theme *tension between student's expectations and the official documents of the study program*. For the official curriculum lectures supported learning, but for this student some lectures did not do it as effectively as he expected.

After coding all the texts into themes, we arranged the themes into groups according to their logical connections with the research concerns (See Table 2). We then interpreted these connections into theoretical constructs, which were abstract concepts that defined the relationships among the themes in a particular group. Continuing with the previous example, we realized that participants had specific learning expectations, and some of them were very different from the official learning perspective. Thus, when the learning expectations of the participants and the integrated learning activities of the program interacted, they sometimes created tensions as avoiding lectures to watching videos. We conceptualized these tensions as the theoretical construct *CI BOTH CREATES TENSIONS AND SELF-ORGANIZES ITS STRUCTURE*. In the results section, we will explain this concept in depth, but for now we want to clarify that this procedure of analysis was cyclizing and the theoretical constructs were constantly re-elaborated.
after multiple sessions of discussion and reflection among the researchers and
between researchers and some participants such as the curriculum designers.

Additionally, we only depicted in Table 2 some of the themes that provided the most
relevant information to form the theoretical constructs because each group had from 6 to
24 themes and from 33 to 84 quotations.

Table 2

_Themes and theoretical constructs built in the analysis_

<table>
<thead>
<tr>
<th>Theoretical constructs</th>
<th>Themes</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) COMPLEXITY OF CI EMBEDDED IN THE INSTITUTIONAL LEARNING PERSPECTIVES</td>
<td>There are many types of organizational elements in the curriculum that are connected in varied complex ways. Spiral integration.</td>
<td>Curriculum designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Official curriculum</td>
</tr>
<tr>
<td>(2) CI AS A TOOL TO HARMONIZE CONFLICTING LEARNING PERSPECTIVES IN THE PRACTICE OF THE CURRICULUM</td>
<td>Experience-topics integration in cases. Disciplinary knowledge has an important influence in the official curriculum learning outcomes.</td>
<td>Teacher and curriculum designer Official curriculum</td>
</tr>
<tr>
<td>(3) CI BOTH CREATES TENSIONS AND SELF-ORGANIZES ITS STRUCTURE</td>
<td>Tension between student’s expectations and the official documents of the study program. Students adjust their learning activities when they struggle with the sessions.</td>
<td>Teacher and observation Student</td>
</tr>
</tbody>
</table>
Credibility of the interpretations

At this point, it is important to remember that our criticism of the theories of the CI in medical education is precisely the lack of a contextual angle to define and analyze it. Although we employed subjectivity, interpretation, and a contextual perspective to analyze the data, we also used other strategies to justify that our constructs arose from the data instead of from our preferences. According to Rubin and Rubin (1995), there are some criteria to use subjectivity in the research analysis in a justifiable manner. We applied these criteria such as (1) Transparency (we showed to other groups of researchers, at the same and in different learning environments, how we interpreted the data). (2) Communicability (we discussed with some participants, researchers at AAU and at Universidad de los Andes, if our constructs made sense to them). And (3) Coherence (we also had periodical discussions considering if our constructs told a coherent story) (Auerbach & Silverstein, 2003, p. 84). In addition, when we were building the theoretical constructs up (Table 2), we used triangulation to examine if our

<table>
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<tr>
<th>(4) CI RENDERS ITSELF VISIBLE IN COLLABORATIVE LEARNING SPACES</th>
<th>Case close are spaces in which students can discuss and explain their learning outcomes.</th>
<th>Student and teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drawing on the blackboard is an activity that supports learning.</td>
<td>Observation</td>
</tr>
</tbody>
</table>
interpretations were found in multiple sources (Stake, 2010, p. 123). This type of evidences indicated us, in like manner, that the interpretations were justifiable.

Results

In this section, we explain the theoretical constructs shown in Table 2 in detail. The constructs were abstract concepts about CI that emerged from interpreting the meanings of CI in the studied program. They were also a theoretical contribution to minimize the confusing issues about the definitions of CI in medical education but from a contextual perspective. In addition, the first two theoretical constructs were related to the institutional learning perspectives used to design and implement the curriculum. The last two constructs were connected with the implications of the CI meanings in practice.

Complexity of CI embedded in the institutional learning perspectives

One of the meanings of CI was that it is a complex, multi-level and multi-dimensional structure of curriculum organization that depends on the learning perspective of the institution. The major elements of the curriculum organization at AAU were cases and projects, but the curriculum also had other elements intended to improve learning including lectures, theoretical exercises, clinical skills, and practices. As depicted in Figure 1, the organizational elements had intricate connections to each other; thus, integration was characterized by complex, multi-level and multi-dimensional interactions within the curriculum. It was complex because there were numerous components
interacting to each other. For instance, lectures and theoretical exercises were linked to cases to support students’ learning outcomes. It was also multi-level due to organizational elements were implemented cyclizing (spiral integration). The loops of themes showed the increasing level of difficulty in the learning activities. Moreover, it was multi-dimensional because it included diverse dimensions such as basic-clinical sciences integration, organ systems integration, humanities -clinical sciences integration, or knowledge-skills-competences integration, among others.

The connections among the organizational elements of the curriculum depended on the learning perspective of the educative context. Many medical programs might use similar elements, but the way these elements were integrated was framed on the learning understandings of the stakeholders. In this case, learning was understood as a construction of knowledge; hence CI was organized according on how students built their understandings up as following described.

“(…) The primary form of learning is problem-based learning (PBL). This is practiced in several forms throughout the program. The majority is practiced through Case-oriented PBL so that the constituent learning elements are well defined. A smaller portion is practiced through project-oriented PBL where the focus is on academic competences. (…) These learning outcomes typically include elements of classical medical disciplines such as anatomy, physiology and biochemistry, and there are often softer or secondary learning outcomes regarding, for example, public health, ethics, communication or utilization of resources. (…) At case closure, the students actively present what they have learned and compare and discuss this. Theoretical knowledge is put into perspective in relation to clinical skills practice and experiences from the clinic. Finally, students reflect on their own learning.” Official curriculum.
As described previously, CI in this program had two trends that created tensions when interacting: experience-based integration and disciplinary-subject integration. However, the tensions between the CI trends were overcome by integrating them. Some of the tensions were related to the learning perspective of the university and the broad topics medical discipline had. On one hand, AAU had a constructivist perspective based on projects-oriented learning.

“(…) The curriculum is not defined in a traditional way when the curriculum fixes in books and pages of books. It’s defined as learning outcomes. (…) We are very into the construction of knowledge.” Curriculum designer CD3J.

On the other hand, medical education has been traditionally influenced by disciplines and broad topics. However, learning broad topics by projects was not effective because projects were built upon specific issues instead of general themes. Therefore, to overcome this tension between projects-oriented learning and broad-topics learning, they established organizational elements for each approach (i.e., cases, lectures and projects). Then, they connected them using CI as a strategy to support students learning including both learning perspectives.

“(…) In cases students define what they need to gain this knowledge, and they can use the lectures as part to put it into the Case, and they can use their experience in clinics also, and they can use their books, or they can use their experiences on theoretical exercises. So, all this knowledge together, they can discuss it in cases. (…) So, all students since the first year, they get the same Cases. Then they have to read about heart attack, cardiovascular physiology, and anatomy. (…)” Curriculum designer CDT1.
CI both creates tensions and self-organizes its structure

Curriculum integration produced some tensions between the stakeholders' learning expectations and the learning perspective of the official study program. Even though CI was used to overcome the tensions between broad-topics and narrowed-issues learning perspectives, it also produced other tensions between learning expectations and perspectives. The way organizational elements of the curriculum were connected, and the rationales behind this, generated some conflicts with what students and teachers believed was useful for learning.

“(…) Sometimes I choose not to go to the lectures because they only have 45 minutes, so they have to focus on some things and not to talk about other things. So it is not every time that I get what I need in the lectures.” Student S5L.

In this example, the curricular elements lectures and Cases were connected to support students’ learning. Lectures were supposed to happen after Cases and provide an overview about some broad topics students need to answer the learning issues emerged from the Cases. However, some students saw them as unnecessary activities or they had different expectations about how learning activities should be organized.

“… I think is really nice to have just one lecture or two lectures before we have the case start. So, we have a bit more knowledge, and then the brainstorm is better because when we have this case, we see like that was what he said something about this osteoporosis or something. So, I think it is a better brainstorm when we know a bit more.” Student S1A.
As a consequence of these tensions, students explored some alternative learning activities that were integrated to the major curricular components. They constructed their own curriculum integration.

"I’m very visual and I have to see the stuffs like drawings. If you would like to explain how a bone is looking and they have a power point presentation. Which is really good. But sometimes, they don’t explain things in a simple way. It’s just they say a lot of unnecessary stuff like history. (…) Instead, I like to watch some videos on the Internet, and read in my books, and then I write my stuffs down in my notebook. When I’m done, and when I wrote down what I learned, I go to the lecture, and I can see. Okay, I have to learn this. Okay, I got it." Student S2T.

CI renders itself visible in collaborative learning spaces

CI makes sense when students had a space in which they could explain by themselves their learning understandings. This suggested CI had a nexus to social learning in this particular context. For instance, Cases were the curricular elements that allowed students not only to identify their learning issues, but also to see the connections among them. These connections were depicted in their brainstorm drawings at Case start. Nevertheless, students finished discovering the integrated meanings at Case close. In this activity, they discussed their learning issues and explained by and to themselves the meanings of what they had learned each week. The discussions were guided by the issues crossing multiple disciplines.

"(…) The facilitator draws the neural tube to discuss something related to embryology. (Summarizing what students had concluded during the session). He summarizes what structures developed from the parts of the neural tube? Where is the conscious activity? If we are unconscious, are we dead? Where is the heart control? Does
the heart need the brain to beat? Can we breathe when we sleep?" Field notes in observations.

The influence of CI in students’ knowledge was visualized when they had these spaces of social learning. As the issues were established after making connections among the keywords of the cases, students understood the relationships of the knowledge learned during the social activities. Drawings were the main way by which CI was depicted in the students’ discussions. Through draws, students explained and discussed the connections among disciplines, subjects or issues.

"It’s just that the patient is Anders. He is 9 years old, and he is a male, and the key thing that has happened to him is that he is losing his muscle power. And then, we wrote bad heart compensation (in the draw), and then that’s because we think that, okay, he loses muscle power, okay the heart is a muscle, and that is a connection between losing muscle power and the heart compensation. Okay, he has bad heart compensation; therefore, he has edema in his legs. Okay, losing muscle powers, his respiratory muscles are weakening which also makes sense, right? And we just arranged these things together. So they make sense. So, you can look at this picture and say ohhh that is why, and you get a small story of it. Okay, instead of all the words were placed randomly, you would look at them and ohh what order is in this." Post hoc interview after a case observation-student S2T.

**Discussion**

In this paper we aimed to extend the theoretical basis of CI going beyond the learning theories that have framed the term, but created confusing, varied, and limited definitions of it. The unclear development of the CI theories in medical education highlights the need for understanding the meaning of CI in more detail. This is why we used a contextual perspective to obtain a broader insight into the CI concept by
interpreting the stakeholders’ practice of a PBL curriculum. The study was guided by three questions: (1) how does the program integrate the curriculum? (2) What does the learning context understand by CI? (3) What is the meaning of CI from a contextual perspective? Thus, the overall findings illustrated this medical program contained four theoretical elements that configured CI as a dynamic complex process that is not separated from the context.

The first construct “Complexity of CI embedded in the institutional learning perspectives”, represents the complex structure of CI when analyzing the official program and the curriculum designers’ experiences. The connections among curriculum components occurred in varied levels and dimensions such as basic-clinical sciences integration, spiral integration, or knowledge-skills-competences integration. We speculate that considering integration as a simple link between two elements, for example two courses, makes impossible to understand the multilevel and multidimensional configuration of CI derived from the institutional learning perspectives. As suggested by Muller et al. (2008), CI should be understood as a complex process with multiple connections. Nevertheless, many researchers and meetings in medical education have reduced the CI concept to basic-clinical sciences integration, leaving aside many other relevant curricular components and interrelations (General Medical Council, 1993; Dahle et al., 2002; Muller et al., 2008; Boudreau & Cassell, 2010; Bolender et al., 2013; Dennis et al., 2014; Brooks et al., 2014; Goldszmidt et al., 2012). We believe that the reduced approach to CI in relation to the basic-clinical sciences dualism may have a negative
impact on how integrated curricula are evaluated and improved. As the emphasis on CI is applied at biomedical-clinical sciences integration, the curriculum evaluation and reform would not take into account some of the connections from different learning perspectives at diverse dimensions and levels.

On the other hand, the second and third constructs “CI as a tool to harmonize conflicting learning perspectives in the practice of the curriculum” and “CI both creates tensions and self-organizes its structure” represent the dynamic nature of CI in practice. In the second construct, we realized how this medical school overcomes the tensions of the integration approaches with regards to disciplinary boundaries (Dowden, 2007; Gehrke, 1998). Specifically, in Cases activities they combined experience and subject-based integration using collaborative discussions (learning experiences) of clinical issues to explore broad subjects of biomedical sciences (disciplinary integration). Therefore, the CI meaning was not only the organization of curriculum components, but also the combination of diverse learning perspectives within the program. That is, different ways to understand learning medicine coexist in the practice of the curriculum.

Nonetheless, CI does not remain static after been designed and implemented as represented in the third construct. We noticed in learning activities and students/teachers’ conceptions that CI in practice also produced disorganization because stakeholders had their particular learning expectations. These expectations interacted with the integrated learning perspectives and disturbed the pre-established CI arrangement; thus, creating new and emerging patterns of CI. For example, we identified some students that did not
attend some learning activities (with specific learning aims) because they
expected to learn in a different mode. Therefore, they created new learning activities such
as watching Internet videos and writing conceptual maps that were then integrated to
other activities. The tensions-solutions-tensions pattern we identified in the
implementation of CI suggests it possess features of self-organization that shape its
dynamic nature. We found empirical evidences of what Menin (2010) has suggested as
the self-organizing integration. He states self-organization is a characteristic of CI and
defines it as a dynamic open-ended process by which new patterns are created during the
feedbacks produced in curriculum implementation. Self-organization implies that CI
reconfigures its structure or pattern because new tensions are created by the interrelations
of the curriculum components. We speculate that taking into account self-organization as
a characteristic of CI when designing, implementing and evaluating integrated curricula
might positively contribute to reform medical programs. As the tensions derived from
integration would be considered and brought to light through the integrated curriculum
evaluation, specific efforts to resolve them and improve the medical curriculum could be
conducted.

By the same token, the fourth construct “CI renders itself visible in collaborative
learning spaces” represents the link between the integrated curriculum and the students’
knowledge integration (Bolender et al., 2013). In the Cases discussions, we recognized
students made explicit the knowledge integration when they explained and discussed
their understandings of the connections made from different sources of knowledge. We
found there were some educational aims behind the CI structure, but the achieved aims were particularly evident in social learning sessions. Although our initial criticism of the instrumental use of CI did not provide alternative recommendations to estimate its results on student's learning, the fourth construct holds some clues on how to evaluate the effectiveness of CI. As suggested by some authors, understanding CI beyond its logistical function is to characterize it as an educational aim (Woods, 2007; Norman, 2000). This aim should entail “to achieve a conceptual, cognitive connection between different types of knowledge” (Kulasegaram et al., 2013). As knowledge integration is displayed in collaborative learning activities, evaluating efforts focused on these spaces may provide appropriate feedback to improve CI.

In summary, the four theoretical constructs provide a broader understanding of CI in medical education because they also take into account the challenges that medical schools may face when integrating their curricula. As these challenges emerge from the learning particularities of the medical school, the theoretical constructs may serve as strategies for analyzing the methodological issues of CI in its contextual practice. However, we believe that improving effectively integrated curricula requires a profound shift of perspective from an instrumental, static, and reductionist understanding of CI to conceive it as an educational, dynamic, and complex process that is aiming for students’ knowledge integration. With this change, we offer an analytical framework that stakeholders of the medical education programs can use to discover more about CI in their particular settings. The analysis involves diagnosing what are the learning bases of
CI? What are the different learning perspectives of the institution and the learning expectations of the stakeholders? How are these perspectives and expectations interacting to each other? Which are the tensions derived from integration? How are the CI patterns changing with these tensions? Which dimensions and levels are been considered or forgotten when integrating the curriculum?

Nonetheless, several limitations of this study must be taken into consideration when estimating the transferability of the theoretical constructs. Although Auerbach and Silverstein (2003) affirmed theoretical constructs are at a more abstract level that can be extended beyond a particular setting, we acknowledge further research should be done to explore if our four theoretical constructs are applicable to different medical education cultures when understanding CI. Yet we recognize that the constructs does not answer all the challenges medical schools face when making CI and need to be refined according to these new challenges.

References


Chapter 2: Transferring theoretical constructs of medical curriculum integration emerged in a PBL curriculum into an integrated-system curriculum

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Juny Montoya
Diana Stentoft

Abstract

Curriculum integration (CI) is widely embraced as a strategy to facilitate students’ integration of knowledge of multiple disciplines and fields. However, the framework of CI in the medical education literature is confusing because of its varied and conflicting definitions. In this research we aimed to provide different lenses with which to view and understand it. The lenses emerged from a former study and they are compounded by four theoretical constructs that allowed us to look at CI as dynamic and contextual. We transferred these constructs into a new setting to appraise if they are sufficiently abstract

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to understand the practice of CI in a different medical school. The results show that the constructs possess the perspective of the complex adaptive systems. Implications about our theoretical contribution for understanding CI from this perspective are discussed.

**Keywords.** Curriculum integration - Transferability – Elaborative coding - Complex adaptive system

**Introduction**

The interest in the concept of curriculum integration (CI) has increased dramatically in medical education literature in the last two decades (Brauer & Ferguson, 2015). One of the reasons for the raised attention on CI may correspond to the demand of trained doctors who can integrate the knowledge of multiple sciences to improve their clinical practice (Maeshiro et al., 2010). Despite the importance of knowledge integration in medical training, CI is perceived as a confusing concept by medical stakeholders (Hopkins et al., 2015). For instance, several medical schools have struggled using CI as an educational principle to promote learning (Kulasegaram et al., 2013).

One possible factor that contributes to the confusing approach to CI may be the diversity of pedagogical models that underlies the curricula of the medical schools. The diversity of models implies that there are multiple ways to understand learning and to define curriculum (Posner, 2004, p. 43). In other words, varied and conflicting definitions of curriculum have been influencing what stakeholders understand by CI. This is possibly
why the CI concept has experienced an unclear evolution in medical education (Bolender et al., 2013). Because we are aware of the conceptual problem originated from the unclear evolution of CI, we propose it is necessary to clarify the CI framework in the medical education field. We believe it should be done by a contextual perspective. The contextual perspective may provide the lacking theoretical elements necessary to understand CI because it takes into account how the conceptual issues emerge from the practice of the curriculum.

For this reason we conducted a previous qualitative study in order to abstract theoretical constructs of CI from analyzing the descriptions of the learning activities, the stakeholders’ learning conceptions, and the official medical curriculum at Aalborg University (AAU), Denmark. With the former research, we aimed to extend the theoretical framework of CI by taking into account the meaning that the context (medical program) gave to the integrated curriculum. We discovered four theoretical constructs that helped us to broadly understand the conceptual issues of CI: (1) Complexity of CI embedded in the institutional learning perspectives. (2) CI as a tool to harmonize conflicting learning perspectives in the practice of the curriculum. (3) CI both creates tensions and self-organizes its structure. And (4) CI renders itself visible in collaborative learning spaces. These concepts are explained in detail in Table 1.

Nonetheless, we acknowledge the concepts pertain primarily to the studied setting, and there is a limitation to make generalizations about our extended theory. As we pursue the theoretical constructs may be used by other stakeholders to solve the CI
challenges in their medical schools, we considered apprising if the constructs are abstract enough to be applied to a different cultural group. Auerbach and Silverstein (2003, p. 86) state themes are culturally specific, but theoretical constructs are at a more abstract level that can be extended beyond a particular sample. They defined as “transferable” the theoretical constructs that can be used to understand other contexts, but also can recognize the cultural diversity.

As an alternative to generalizability in the quantitative research paradigm, transferability would assist us to refine our theoretical constructs from a qualitative perspective (Greenhalgh & Taylor, 1997). Thus, the constructs could be used to understand diverse stakeholders’ subjective experiences in the practice of CI. This is why, the current study aimed to transfer our CI theoretical constructs by using them as a framework to analyze the contextual meanings of CI in a different setting at the Universidad de los Andes Medical School (Uniandes), Colombia. The meanings were coded into new themes that were then regrouped into new, extended, and refined theoretical constructs. Our final goal was to exemplify a more abstract theory with which understand the practice of CI in others medical schools. The initial questions we researched were: (1) how does this medical program integrate the curriculum? (2) What does this learning context understand by CI? (3) What is the meaning of CI in this setting? And, (4) what are the differences and similarities of the CI meanings with the previous studied context? As we will explain in the discussion section, our extended theory is related to the complex adaptive system. We will discuss the implications about
how they are related and what is our contribution to use them as a framework to understand CI in medical education.

Table 1

Former theoretical constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Complexity of CI embedded in the institutional learning perspectives</strong></td>
<td>CI is a complex structure that have many components interacting to each other, involves multiples dimensions (e.g., basic-clinical sciences integration, organ systems integration, humanities -clinical sciences integration), and varied levels (e.g., spiral integration).</td>
</tr>
<tr>
<td><strong>CI as a tool to harmonize conflicting learning perspectives in the practice of the curriculum</strong></td>
<td>There are varied learning perspectives in a medical program (e.g., subject or experience-based perspectives). Sometimes these perspectives are conflicting, but CI can be used as a tool to overcome the tensions emerged from different perspectives by connecting diverse learning activities.</td>
</tr>
<tr>
<td><strong>CI both creates tensions and self-organizes its structure</strong></td>
<td>CI creates tensions between the stakeholders' learning expectations and the learning perspective of the official study program (e.g., students study individually instead of attending lectures).</td>
</tr>
<tr>
<td><strong>CI renders itself visible in collaborative learning spaces.</strong></td>
<td>CI makes sense when students have a space in which they can explain by themselves their learning understandings. In these spaces students show the interconnectedness of their learning.</td>
</tr>
</tbody>
</table>
Method

Qualitative approach

This particular study forms part of a larger research effort that examines the contextual meanings of CI from different medical schools. We aimed to obtain a broader understanding of the experience of medical stakeholders in integrating their curricula by using a qualitative approach. As stated by Auerbach and Silverstein (2003, p. 173), the theoretical constructs that emerged from a former source of information should be refined and extended by studying new sources of information in a process denominated as theoretical sampling. Specifically, in the former study we explored a problem-based learning (PBL) curriculum, but in this opportunity we wanted to choose a different type of CI to transfer our constructs and look at transferability. Therefore, we selected an integrated-systems curriculum at Uniandes Medical School. Besides refining our former theoretical constructs, with this different setting we aimed to collect more information that underpins them.

Setting

The Uniandes curriculum integrates biomedical and clinical courses around major organ-system courses in a middle cycle (from fifth to seventh semester). These integrated-systems courses are composed of three principal learning activities: lectures by biomedical and clinical teachers, clinical case presentations, and small group discussions
guided by a clinical facilitator. Students sometimes engage in laboratory work and patient demonstrations.

**Design**

We collected information from February to June 2014. Firstly, we obtained the official curriculum to explore the design and the institutional learning perspectives. Secondly, we interviewed one curriculum designer, two teachers, and four third-year students to understand their conceptions about CI. Finally, we observed eight learning activities of the neurology-system course in sixth semester to see how the curriculum was implemented (see Figure 1).

*Figure 1. The research design*
**Participants**

Participants and learning activities were selected as a convenience sample using the technique of ‘snowball sampling’ (Cohen et al., 2007, p. 113-116). We stopped interviews and observations when confirmed saturation of the information (O’Reilly & Parker, 2013). At the beginning of the interviews, informed consents were obtained. The interviews were semi-structured and included trigger questions [e.g., what is your role as a teacher or a student? What do you do in learning activities?]. The interviews also were taped and transcribed for further analysis. Year 3 medical students were engaged because we studied the same level in the former research. Another reason was that little attention has been given to investigate preclinical education (Rotgans, 2012). The observations, on the other hand, were semi-structured [e.g., How were the learning activities and interactions], non-participating, uncovered, natural setting, and documented in field notes (Cohen et al., 2007, p. 397-412).

**Analysis**

We transferred transcriptions, field notes, and documents to the qualitative analysis software Atlas.ti (Version 6.2). Then, we analyzed the information using the elaborative coding process proposed by Auerbach and Silverstein (2003, p. 104). They postulated a top-down coding process that takes into account the constructs derived from previous studies. This is a different approach of what we had done in our first study. Specifically, we had analyzed the information in a bottom-up direction to identify themes
with no previous categories. The themes were then arranged into theoretical constructs. However, in the current study we selected the relevant information from Uniandes by taking into consideration the theoretical constructs emerged from the AAU research. That is; we chose the information that was compatible to our previous theoretical constructs. Next, the relevant ideas of the selected information were coded into new themes in regards to the old constructs and possible new constructs. The themes were then grouped into new coherent categories that reflected the old constructs. To put it differently, the old constructs were re-elaborated and refined by organizing the new themes emerged from the Uniandes descriptions into new theoretical constructs compatible with the old constructs.

The next representative example illustrates the step-by-step process described above. (1) We expounded our understandings of CI based on our old constructs and the research concerns of this study. For instance, we stated that CI was complex, multidimensional, multilevel, and it was embedded in the multiple institutional perspectives of learning. Moreover, we were concerned about how Uniandes integrated its curriculum. (2) We read the new collected information using our understandings and concerns described in step 1 and selected the relevant ideas compatible with them. For example:

“These students see a gross part of the human anatomy and physiology in fourth semester. They review it again, for example physiology, especially in fifth, sixth and seventh semester. But they do it on a single system of the body at once.” Teacher P9.
(3) We coded the selected information into new themes that reflected the old constructs. For instance, we coded as *spiral integration to remember forgotten subjects* the text presented above. This new theme reflected the old construct because it represented different levels of integration throughout the medical program, and it was anchored in the institutional learning perspective that students learn by repeating activities. We also show other themes related to the same old construct in Table 2. (4) The new themes were organized into four coherent, new, and refined theoretical constructs. This organization also reflected the old constructs. For instance, the new themes shown in Table 2 were organized in a more abstract theoretical construct titled *CI complexity*. This new construct is related to the old construct because it represents the *intricate structure of CI sustained by the official learning perspectives*. (5) We explained how the new constructs were elaborated by considering the differences and similarities in the practice of CI between the former and current studied settings (See discussion section).

Table 2

*New themes from Uniandes information related to the old construct “Complexity of CI embedded in the institutional learning perspectives”*

<table>
<thead>
<tr>
<th>Themes</th>
</tr>
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<tbody>
<tr>
<td>Autonomous learning curriculum perspective</td>
</tr>
<tr>
<td>Biomedical-clinical integration across case studies</td>
</tr>
<tr>
<td>Biomedical and clinical integration across courses</td>
</tr>
<tr>
<td>Biomedical and epidemiology integration</td>
</tr>
<tr>
<td>Biomedical lectures</td>
</tr>
<tr>
<td>Case presentation after lectures</td>
</tr>
</tbody>
</table>
Case study in the end of the learning week
Case study is different from PBL
Case study learning different from PBL
Cases are based on real life problems
Cases are structured and well defined
Cases have a written book pattern
Cases present limited information
Cases presentation in big students group
Clinical lecture
Collaborative learning
Core principles-based curriculum design
Curriculum integration is designed under a deductive learning perspective
Discipline-based integration in the first two years
Disciplines-based integration in the final two years
Experience-based learning
First years have a memorizing learning perspective
Hidden integration with ethics
Integration among biomedical sciences
Integration goes beyond systems
Integration is based on a deductive learning perspective
Integration aimed to study again but in context
Integration led to a global thinking
Integration makes easy to remember and understand subjects
Integration gives students the global picture
Integration with research
Integration helps students to reflect about their learning
Interdisciplinary and multidisciplinary curriculum perspective
Issues allow integration
Learning issues are addressed at the end of the learning process
Learning issues are established by professors
Lectures address interdisciplinary subjects
Lectures at the beginning of the week
Multidimensional integration
Normal-abnormal integration
Readings before lectures are expected
Simple-complex integration
Small group learning
Spiral integration to remember forgotten subjects
Students also identify other learning issues
Subject based curriculum
Systems-based integration in the second two years
Traditional learning perspective
Validity

Triangulation was used to examine how accurate the interpretations were because it makes possible to identify if the evidences that supported an interpretation were found in multiple fonts; hence they were not a product of the researcher’s credulity (Stake, 2010, p. 123). Furthermore, the theoretical constructs were consulted with faculty members and educational researchers’ focus groups to know their opinions on whether constructs make sense to them (Auerbach & Silverstein, 2003, p. 84).

Results

In the current study we refined the four theoretical constructs that emerged from a former research about the meaning of CI but taking into consideration the contextual perspective at AAU medical school. As explained above, we developed the old constructs through a rigorous qualitative analysis of a PBL curriculum. The old constructs included: *Complexity of CI embedded in the institutional learning perspectives; CI as a tool to harmonize conflicting learning perspectives in the practice of the curriculum; CI both creates tensions and self-organizes its structure; and CI renders itself visible in collaborative learning spaces.* In this study, we transferred the old theoretical constructs into the analysis of an integrated-system curriculum at Uniandes medical school. To
gather the Uniandes information about its type of CI, we were guided by four research questions: (1) how does this medical program integrate the curriculum? (2) What does this learning context understand by CI? (3) What is the meaning of CI in this setting? And, (4) what are the differences and similarities of the CI meanings with the previous studied context? We used the old constructs as a framework to select the relevant information from Uniandes. Then, we coded the selected information into new themes that were further organized into the new theoretical constructs. We used this analysis process to understand the subjective experiences of Uniandes stakeholders when designing and implementing their integrated curriculum. Thus, the analysis generated four new, refined theoretical constructs\(^{12}\): *CI complexity; CI for harmonizing different learning perspectives; the dynamics of CI; and CI evaluation in collaborative learning activities.* In this section, we will answer the first three research questions by explaining the new constructs, but the fourth research question will be addressed in the discussion section because we planned to approach it by comparing findings from both contexts.

**CI complexity: the intricate structure sustained by the official learning perspectives**

Uniandes medical curriculum had multiple components that were interwoven in a complex pattern. The components were embedded in diverse dimensions such as learning

\(^{12}\) The new theoretical constructs were refined because they became more abstract concepts in the elaborating coding process.
experiences (lectures, clinical case presentations, small group discussion), learning objectives (disciplinary knowledge, competences, skills), and organic systems in the middle cycle (neurology, cardiovascular, among others). Moreover, the CI pattern was composed by varied levels of difficulty (spiral integration). For example, students started the program studying the basics of the organic system, but further they faced elaborated clinical issues in cases presentations. For these reasons, the CI structure showed a multilevel and multidimensional form of arrangement that represents its complexity.

However, because Uniandes medical program had a different official learning perspectives than AAU medical program, the structural patterns of CI were also dissimilar. The pattern showed the CI complexity depends on the institutional learning perspectives. Although recognizing the official institutional perspectives of learning in Uniandes was not an easy effort because they were not clearly defined in the official curriculum, we identified in the observations and interviews that they were placed in a spectrum. That is, they ranged from a traditional learning perspective (knowledge transmission) towards an active and collaborative learning perspective.

Thus, the broad approach to learning guided a singular way to integrate the curriculum. For instance, in the integrated systems cycle students started the week with lectures reinforcing the biomedical subjects they studied separately in previous semesters. As one teacher said “[…] they (students) will see all the basics they need to interpret clinical themes.” (Teacher P5). Because of this, subjects were linked with clinical cases
presentations to obtain a deeper understanding of clinical issues. These issues were organized by organic systems such as neurological, nephrological or endocrinological systems, among others. After lectures, teachers identified and presented to students the learning outcomes in clinical cases presentations. In these presentations, teachers also introduced them into a structured and well-defined clinical case. Sometimes, teachers invited clinicians from different disciplines to have a conversation with students about different themes, but in connection to the principal issue studied in the case. For example, ethics and neurology were discussed in a case about coma. Then, students prepared the learning outcomes in the autonomous workweek to discuss them further in a final activity. This activity was a case study within a small group of students guided by a clinical facilitator. Here, students explained their clinical understandings using biomedical knowledge.

*CI for harmonizing different learning perspectives: beyond the static and dualist organization*

The CI type of Uniandes medical school provided a scaffold for stakeholders to resolve the tensions derived from the interrelation of multiples learning perspectives embedded in the program. At the beginning of the program, students learned broad topics in disciplinary courses in biomedical sciences. These courses included learning activities based on a transmissionist learning perspective such as lectures or laboratory sessions, but these activities were considered problematic. As one student explained:
“Before (first semesters), we struggled memorizing too much because it was a memorizing process. For example, in anatomy we learned this and this, but we did not see the point [...] in third semester was so difficult to understand why a nucleus (in the spinal cord) was there, and you just learned it because the spinal cord had a butterfly shape and the nucleus was in the middle of it. Now (in his actual semester), you get to this point and you logically understand why it is there, because it has to be connected with the ear and the cochlea and it is related to the person’s stability [...] It is the ability to remember things better, it is easier to understand it, to make sense of. Before, it was harder to understand and retain things [...] With this process, it is easier to figure things out, to understand why it (a structure) is there, and what function it has with respect to all neighboring structures that are there, and you can join things easier, you can associate them much easier.” Student P6.

This student referred to other learning activities (clinical presentations and small group discussions) that were further connected to the curriculum in the integrated system cycle. The activities helped her to better understand the biomedical topics memorized in the first cycle. In contrast with biomedical courses, the integrated systems courses entailed active and collaborative learning perspectives. Thus, not only learning activities were integrated, but also varied learning perspectives were interwoven in the practice of the curriculum. This integration approach facilitated them to overcome the tensions produced by a linear, fragmented, traditional, and static curriculum that provided students memorizing broad topics but with little comprehension.

Furthermore, the biomedical-clinical sciences dualism is considered a core aspect of CI, as stated by a student "What we do is to review the anatomy, physiology, histology and pathology in a way that it correlates with clinical pathologies. So we can implement them into practice." (Student P10). However, the stakeholders also spoke about the
integration of social sciences and critical thinking skills in the integrated systems cycle. As explained by a teacher:

"It also goes into the social part of that person (the patient), the psychiatric aspect, how will he assume the disease? What other things (diagnoses) are escaping from me? I put it from the perspective of Neurology. If, for example, I have a patient with heart failure, could it affect him neurologically? (...) May it affect him from the psychiatric viewpoint? (...) How is facing his family that heart failure?" (Teacher P5).

We also observed the integration of soft competences\textsuperscript{13} and social issues in clinical case presentations and small group discussion. In these activities, learning issues (clinical and biomedical) are used to trigger discussions about social and ethics implications of diseases.

\textit{The dynamics of CI: disorganization in integration}

Although the CI approach offered students a better understanding of biomedical subjects and clinical/social issues, stakeholders also reported some tensions emerged between their learning expectations and the integrated learning activities. These tensions included diverse understandings of integrated systems among teachers ("each teacher did them as he or she was learning. We did not have meetings." Teacher P9), and

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\textsuperscript{13} Soft competences are learning objectives that emerge from the case study, but they are not planned in the official curriculum. For example, learning how to manage depression in a patient with a muscle disease when the official objectives are learning the muscle system.
disconnection between biomedical and clinical teacher ("barriers from clinicians to give biomedical teachers the value they deserve [...] that is the most important challenge." Teacher P11). Students also had different appraisals of learning activities. For instance, lectures were appreciated by some students but perceived as repetitive and unproductive by others ("The boring part is that teachers tend to describe what is already written in books". Student P6).

We speculate that the integration of varied learning activities (and learning perspectives) in a complex curricular pattern produces tensions with stakeholders’ learning expectations. These tensions represents the dynamic nature of CI in which connecting curricular components also creates disorganization of the curricular structure when interacting with stakeholders’ expectations. However, the tensions were solved by stakeholders through incorporating new strategies to connect curricular components. For example, one teacher mentioned that because she was disconnected to the teaching activities of the other teachers, she used students' feedbacks to plan her lectures:

"I asked them, did you study descending pathways with this level of detail with this teacher? They say yes or no. And I said you must to attend a class of diencephalon tomorrow (...) I try to maintain an order, and I have communication with them regarding the integration of information. But I think that we should do much more like meetings among teachers" Teacher P11.
Students guided their learning upon the outcomes established by teachers in lectures and clinical cases presentations. Nevertheless, in the small group discussions (at the end of each curricular loop), students made explicit their comprehensions of the learning outcomes. During the social discussions, they clarified by themselves and to each other their understandings about the issues given by the clinical expert facilitator. Thus, the collaborative learning activities were suitable spaces to visualize students’ knowledge integration. We observed the type of knowledge students expressed in their discussions was deductive because they used biomedical topics to understand clinical issues. That is, they went from general biomedical themes towards particular patients’ clinical issues. This student explained the deductive thinking process in connection with the CI approached in detail:

"My impression is that when we began to attend integrated systems, we started to see things in a logic way. It is like reasoning and deducing things easier. Logically, if this happens, then this (patient) will have these symptoms and signs. [...] If you give the pathophysiological explanation, then it is easier to look at treatment, symptoms and signs than if you learn them separately. Before it was memorizing and memorizing, but we did not understand why we were memorizing. I just knew that this structure should be there because it was that way. Now, we know this structure is there because it has an association with this structure, and they have an integrated function." (Student P6)
Discussion

In medical education literature, CI has been usually understood as static and theoretical. We proposed this view requires a change that could be developed from a contextual perspective. For this reason, we conducted a former study in a PBL curriculum to comprehend the meanings of CI in practice. Four theoretical constructs of CI emerged from this study that allowed us looking at it from a dynamic approach. In the current research, we aimed to understand the meanings of the practice of CI in an integrated systems curriculum using the old four theoretical constructs to investigate the contextual descriptions of CI. Based on an interpretive perspective, we analyzed the official curriculum, several of the stakeholders’ learning conceptions, and some learning activities. Once analyzed the gathered information, four new constructs were elaborated and refined. By explaining these new constructs in the result section, we answered our first three research questions, but in this section we will address the fourth question (4) what are the differences and similarities of the CI meanings with the previous studied context? Then, we will explain what is our theoretical and methodological contribution to understand the confusing CI framework, and what are the limitations of our study.

Regarding the fourth research question, our most striking finding is that the old four theoretical constructs helped us to understand CI in the new setting. Nevertheless, some differences and similarities in the CI meanings of both medical education programs guided us to refine the old constructs. Specifically, we began the study knowing that CI should be understood as a complex process because curriculum components were
integrated into multiple dimensions and levels. The varied dimensions and levels were organized according to the official institutional learning perspectives. For instance, AAU learning perspectives included the construction of knowledge and the acquisition of specific skills and competences regarding the medical practice. These learning outcomes were expected to be learned from cases and projects, but supported by other sessions such as lectures, clinical encounters, and resource exercises. We also found characteristics of complexity in Uniandes CI including the arrangement of the curriculum elements into multiple dimensions and levels (CI complexity). That is, by seeking at multidimensional and multilevel patterns of integration, we discovered the complex structure of Uniandes medical curriculum. However, the structural organization of CI was completely different than that of AAU. For example; integration was used in the middle cycle of the program for repeating biomedical themes in lectures to understand clinical issues in cases presentations and small group discussions. The dissimilar learning perspectives of the medical schools would explain this different CI organization. It suggests that despite both curricula used similar elements in their structure, the configuration of CI was differently shaped by the contextual meanings of learning that converge within the setting.

We also knew that the institutional learning perspectives are varied and sometimes conflicting: Thus, CI can be used to harmonize the tensions derived from the interaction of the perspectives in practice. In the Uniandes curriculum, the harmonizing strategy consisted in implementing spiral lectures to memorize disciplinary topics that
were then comprehended by discussing clinical issues (*CI for harmonizing different learning perspectives*). Nevertheless, the curricular structure did not remain static as we had learned in the AAU study. The interaction between the institutional learning perspectives and the stakeholders' learning expectations also created tensions that reconfigured the CI pattern. For instance, barriers between clinical and biomedical teachers to connect their teaching activities, or the students' perception that lectures were negatively repetitive were tensions we identified in the Uniandes context. These findings support the idea that CI is a dynamic process because new tensions are produced from the designed interconnections (*the dynamics of CI*). The tensions self-organized the CI pattern and created new and different links within the curricular structure as we noticed when a teacher told us she interviewed students for receiving feedback about their prior learning activities. With this information the teacher planned new learning activities that could be connected to what students had learned.

Regarding our last theoretical construct, we identified in the AAU study that collaborative learning spaces allowed students to discuss their learning understanding with their peers at the end of each case process. That is, the knowledge integration rendered itself visible in the social discussions. Therefore, collaborative learning activities could be appropriate spaces to evaluate the effectiveness of CI to promote knowledge integration. We identified the same opportunity in Uniandes CI. Collaborative learning activities embedded in the small group discussions made possible to visualize the students' knowledge integration while they explained their learning understandings to
their peers (*CI evaluation in collaborative learning activities*). This finding provides significant insights into how CI results might be evaluated because assessing efforts may be concentrated in students’ social discussions.

In summary, we could transfer the theoretical constructs into a different setting, and they helped us understanding a different type of CI taking into account the contextual issues of the program. Nonetheless, we acknowledge that our extended theory is not disconnected from our initial understandings of CI derived from a literature review. Instead, they are interwoven in a macro-process of theory making compounded by two main phases. In the first phase, themes emerged from the gathered information using our old constructs as a theoretical framework. But in the second phase, while themes were grouped to build the theoretical constructs, we took into consideration the CI theory we had reviewed before the analysis. In other words, the new themes that emerged from the information were connected considering our previous understandings of CI to extend its framework into our four new theoretical constructs. When we were analyzing the information and the themes, we noticed that they had the features of a complex adaptive system (CAS) including self-organization, tensions, integration, interactions, adaptation, complexity, reconfiguration, and dynamics (Holland, 2002; 2006; Dooley & Van de Ven, 1999).

We believe it is pertinent explaining our analysis process in detail because we want to clarify that the theoretical constructs are not a new theory. Instead, they constitute an extended framework for understanding CI in medical education that emerged from
studying the contextual issues of the integrated curriculum practices. However, we also acknowledge that approaching to CI in the medical education field from the CAS theory is not novel. Other authors have attempted to explain learning and CI by framing it within the CAS theory (Fenwick & Dahlgren, 2015; Sturmberg & Martin, 2009; Ogrinc et al., 2003; Menin, 2007; Bleakley, 2006; Fraser & Greenhalgh, 2001). We provide below an example of these explanations by presenting a passage of the work of Menin (2010, p. 25):

"Integration, as applied in curricula, has been primarily about the proximity and sequence of content,(...) and the learning venues and processes by which it is thought to be achieved.(...) Self-organized learning is a ‘bottom-up’ process that takes place through local recursive interactions among learners and between learners and learning resources in a rich context.(...) Top-down curriculum planning and bottom-up learning are complementary and, ideally, should both come into play at the same time to achieve dynamic and sustainable integration in the planning, implementation, learning and evaluation of health professions education. (...) Understanding, the new patterns and ideas that form through self-organization, emerges whole and fully integrated. It is not constructed from the sum of the parts."

Although this view is an important change to comprehend CI, we believe it had focused on a theoretical perspective and little attention has been given to real contextual issues. For instance, the examples given by Menin (2010) to explain the CAS concepts are hypothetical. The unreal examples, in addition to the complicated concepts of CAS, might challenge the efforts made by medical educationalist to transfer them into their own setting to solve their particular CI issues. By contrast, we speculate that our constructs and their explanations may facilitate the comprehension of CI as a CAS because they illustrate how they emerged from real contextual issues. They also show the
process to transfer the theoretical constructs into another setting for understanding its specific issues in a different type of CI. Therefore, medical stakeholders may found in our extended CI framework a more straightforward way to understand and improve their integrated curricula.

Finally, it should be noted that this research has been primarily concerned with the process of CI. Unfortunately, we were unable to determine from this information the effectiveness of CI regarding the learning results. Notwithstanding its limitations, this study may offer some insights into the evaluation of the CI result. We identified that collaborative learning spaces were suitable activities to assess students' knowledge integration because it became visible in students' discussions. Nevertheless, we were not able to conduct a rigorous assessment of students' knowledge because the addressed clinical cases in both medical schools were completely dissimilar and discussed in different languages. We suggest future research on students' knowledge integration according to the type of CI in which they are enrolled should be performed. This research focus could bring up more theoretical and practical implications of CI in medical training.

References


Chapter 3: Evaluating curriculum integration by analyzing students’ clinical reasoning enrolled in both PBL and Integrated-systems medical curricula

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Diana Stentoft\textsuperscript{16}

Abstract

Medical curricula have been increasingly including curriculum integration as a strategy to promote cognitive skills or competences that require knowledge integration such as clinical reasoning. However, little attention has been paid to assess students’ clinical reasoning in order to evaluate the effectiveness of the curriculum integration design. We aimed to understand how students from two different integrated curricula organize their knowledge when solving a clinical problem by conducting performance-based assessments. Fourteen students from both curricula volunteered to work on a clinical case on acute myocardial infarction. We used think aloud protocols to make

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visible how they organized their knowledge while reasoning to diagnose and
treat the patient (clinical reasoning). The transcribed verbatim was analyzed in a step-by-
step procedure based on an interpretive qualitative approach. We coded the text units
with actions that described their clinical reasoning, that is, what the participant was doing
and how he was doing it. Then, we analyzed the patterns of knowledge integration used
by students from both curricula to solve the case. Our most significant result is that both
groups evidenced distinct styles of clinical reasoning while integrating their knowledge,
and the type of curriculum integration in which they were enrolled seemed to play a role
in those differences. Thus, assessing students' clinical reasoning appeared to provide
relevant information about how to improve curriculum integration in a medical school.

Keywords. Curriculum integration – Clinical reasoning – Think aloud – Performance
assessment – Knowledge integration

**Backgrounds**

Many meetings in medical education have recommended curriculum integration
(CI) as a strategy to manage the explosion of knowledge in medical discipline and to
provide students an environment to promote skills or competences that need knowledge
integration; for example, clinical reasoning (General Medical Council, 2009; Brynhildsen
et al, 2002; Bolender et al., 2013). In response, a growing number of medical schools
around the world have been reforming their traditional curricula towards curriculum
integration (CI) (Brauer & Ferguson, 2014). In traditional curricula, medical knowledge
is usually divided into biomedical and clinical knowledge (Quintero, 2014). Biomedical
knowledge is frequently arranged into fragmented, linear courses of basic sciences such as biochemistry, anatomy, physiology, or pathology (de Bruin et al., 2005). By the same token, clinical knowledge is organized into separated clinical courses that are provided after the biomedical cycle (i.e., internal medicine, pediatrics, cardiology, obstetrics and gynecology, general surgery, or mental health) (Watmough et al., 2009).

On the other hand, the logistics of CI has been less clear and diverse than traditional curricula. For instance, some medical schools opted for integrating biomedical and clinical knowledge with humanities and social sciences knowledge into integrated-systems courses (e.g., cardiovascular, neurological, muscleskeletal systems) (Schmidt et al., 1996). Other schools preferred a problem-based learning (PBL) integration in which disciplinary knowledge is integrated through the students’ investigation and social discussions of unstructured clinical problems (O’Neill et al., 2000). Another example is spiral integration in which disciplinary knowledge is treated repeatedly along the curriculum by increasing the levels of abstraction and understanding of the topics (Bruner, 2009; Harden & Stamper, 1999).

Although robust information about the instrumental organization of CI exists in medical education literature, little attention has been paid in appraising the students’ knowledge integration according to the type of CI in which they are enrolled. Because the purpose of CI is for learners to promote knowledge networks from diverse information sources, assessing this integrating quality of their knowledge may provide useful information about the effectiveness of the implemented CI strategy (Kulasegaram et al.,
Some authors suggest the students’ integrated knowledge could be assessed in activities that require applying clinical reasoning (CR) because the cognitive integration of biomedical, clinical and others types of knowledge is the basis for developing it (Norman, 2005; Verkoeijen et al., 2004).

Specifically, few studies have assessed CR using standardized tests to determine score differences among students from varied types of medical curricula (Williams et al., 2011; Hecker & Violato, 2008). Their results have shown little disparities among students from traditional, PBL, and integrated-system curricula. Thus, their authors state that intentions to reform medical curricula to promote diagnostic reasoning skills should be carefully analyzed to match efforts to results. Nonetheless, before considering that diverse types of medical curricula produce similar results on students’ CR, we should scrutinize in depth the CR concept and, therefore, question if those standardized assessment were suitable to assess it.

Different understandings of CR

CR has been recognized as fundamental to medical training and practice, yet it has remained one of the most challenging aspects of medical education (Williams et al., 2011). To date, there is no common understanding of what the term CR means (Krupat et al., 2011). When searching the literature, CR has been interpreted and assessed differently depending on the epistemological and methodological approaches used by researchers (Loftus, 2012). As the approaches have been varied, the results were
consequently dissimilar (Durning et al., 2013). Therefore, the way CR is defined and assessed has important repercussions on evaluating the effectiveness of diverse, integrated curricula.

However, research trends on CR in the past four decades have moved from characterizing it as a general trait or a memory-based process to different underlying mental representations (Norman, 2005). The mental representations exemplify varied strategies employed to organize and use diverse types of knowledge necessary to solve patients’ health problems (Schimdt et al., 1990). The varied strategies are developed by increasing clinical experience and include: (1) causal knowledge, (2) clinical knowledge, and (3) exemplars derived from experience (Norman, 2005).

The first mental representation is also named basic mechanisms of disease and defined as the use of biomedical knowledge to solve clinical issues, especially when the issue is confusing (Schmidt et al., 1990). The second mental representation is also known as illness script (Barrows & Feltovich, 1987), schemas (Mandin et al., 1997) or probability associating (Eva, 2005). It relates to the use of typical cases or probability matrices to represent diseases and, therefore, to diagnose and treat them when identifying similar patterns (Wingelaar et al., 2012). The last mental representation relates clinical practice to experiential knowledge (Eva, 2005). Specifically, pattern recognition or exemplar models are representations of past clinical experiences that are retrieved automatically when facing similar clinical encounters (Norman, 2005; Norman & Brooks, 1997). As shown in the three strategies, CR is content-dependent and based on causal
connections (Schmidt & Boshuizen, 1993a). Therefore, studying the application and mental organization of the specific knowledge used in clinical problem solving may elucidate how successful medical curricula are to promote students’ knowledge integration.

Another approach to assess CI effectiveness

We believe that standardized tests used to assess students’ CR have two important limitations to provide useful information about the effectiveness of CI. Firstly, they usually measure memory recall whereas many cognitive actions of CR are ignored (List, 2015; Kirton & Kravitz, 2011). For example, the process of knowledge integration that shows us the extent of CR development is not evidenced directly. Secondly, they have little consideration regarding the differences in which students from varied types of curricula learn (Salinitri et al., 2012). For instance, in curricula in which learning is understood as a transmission of knowledge, multiple-choice tests may be more useful to assess the transmitted knowledge but it would be no equal to other types of learning understandings such as knowledge construction.

Because of the limitations of standardized tests to evaluate CI effectiveness, we suggest performance-based assessment would fit better to value the results of varied types of integrated curricula. This is why we included think aloud protocols to understand how students from two different integrated curricula integrate different types of knowledge when solving a clinical problem. Think aloud protocols are defined by Young (2005) as “listening to the students articulate their thoughts while they engage in practical
activity”. Collecting think aloud information has been successfully used to study CR in medical education research (Patel & Groen, 1986; Boshuizen & Schmidt, 1992; Goldszmidt et al., 2013; Chamberland et al., 2013; Kiesewetter et al., 2013). Their results have shown that novices, intermediates and expert clinicians had different styles of CR, that is, the extent of development of their knowledge integration to solve clinical problems was not the same (Boshuizen & Schmidt, 1992). Medical experts seem to apply more global, automated, unconscious mental processes that integrate more clinical than biomedical knowledge whereas novices and intermediates appear to have more analytic, sequenced, slow mental processes that integrate predominantly biomedical knowledge (Patel & Groen, 1986; Custers, 2013). Thus, assessing students’ CR should also take into account differences in their styles to integrate knowledge because it shows the connection between CR and CI.

Based on the purpose of this study, the research question is as follows: What is the relation between the type of CI in which students are enrolled and the style of their CR when performing a think aloud protocol? However, it is important to highlight that this study was part of a larger project investigating the relation between CI and students’ knowledge integration. On the first phase of the project, we studied the CI meanings in the practice of the two different integrated curricula. Although both CI strategies were dissimilar, we noticed students' knowledge integration is visible in collaborative learning spaces. That is; they displayed their mental representations from multiple sources in discussions among peers. But, because students from both curricula were engaged in
different learning activities and clinical problems, on the second phase of the research we decided to assess their knowledge integration through the same clinical case.

**Methods**

*The compared curricula settings*

The Aalborg University medical school (AAU), Denmark, established a PBL curriculum organized around both cases- and projects-PBL (Stentoft et al., 2014). However, problem-based cases represented the principal component in the Bachelor’s curriculum. Each week small groups of students met to discuss a case guided by a facilitator expert on biomedical research. The cases methodology was based on the seven-jump model (David, et al., 1999). The model included a case start session where one to three unstructured clinical problems, framed on a specific organ system, were provided to the students. Through discussing what they knew and did not know, students brainstormed to identify the keywords of the case and arranged them into a network interconnected by arrows. In the next jump, students extracted the knowledge gaps from the network and, therefore, reached at their learning outcomes. Then, students had time to gather information related to the learning outcomes through varied activities such as autonomous work, lectures, resource sessions, and clinical practice. In the final jump, students and facilitator met again in a case close session, and discussed their new knowledge constructed during that time. The patients’ cases were repeated in a spiral
organization during the program, but increasing the complexity of their health problems. After cases, students engaged in projects, which were extended activities (3-12 weeks) where they worked on their own learning issues to product a report. The work was framed by a theme such as the health system, and supervised by a teacher.

On the other hand, the Universidad de los Andes medical school (Uniandes), Colombia, had a program divided in three cycles. In the first two years, students engaged in basic science courses that included lectures, laboratory work, and some clinical encounters. In the next two-years cycle (preclinical training), the curriculum integrated biomedical and clinical sciences around courses of integrated-organ systems. Each course was organized by sessions compounded with lectures, clinical case presentations, and small group discussions. The lectures aimed to remember the subjects studied in the prior cycle related to the organ system of the integrated course. In clinical case presentations, clinical expert teachers introduced students to a structured clinical problem and provided them specific issue questions regarding the studied system. The case structure usually included patient’s chief complaints, present and past history, personal and family history, review of systems, physical examination, imagenology and paraclinical test results. The provided issue questions were then addressed in the students’ small group discussions guided by a clinician. The logistics of the discussions were varied, from student-centered and case-oriented to teacher-centered and discipline-oriented. In the final two-years cycle, students engaged primarily in clinical practice.
Participants

Fourteen medical students participated in the study. We recruited the students from December 2014 to March 2015. The selection criteria included: (a) They were enrolled in fifth semester (preclinical training), (b) and they had attended a cardiovascular module prior to the actual. We selected first the participants at AAU as a ‘convenience sample’ (Johnson & Christensen, 2014, p. 263), that is, we choose a small group of students guided by a facilitator whose learning activities were observed by us before conducting the protocols. Seven of eleven students of this group agreed to participate in the study. On the other hand, participants at Uniandes were further selected using the technique of ‘snowball sampling’ (Cohen et al., 2007, p. 113-116). A curriculum designer contacted by us recommended the first student. Once this student agreed to participate in the research, he recommended another students and so on. Seven Uniandes students volunteered and consented to take part in the study.

Design and materials

Think aloud protocols were used to understand the students’ integration of knowledge when applying CR. The students were presented with a clinical case of an elder man with an acute myocardial infarction from a necropsy record (Table 1). We choose a heart disease because its importance in public health around the world and due to both groups of students had learned it in previous modules. Before the think aloud protocols were conducted individually, students were given an oral example of what was
expected. Next, the protocol was divided in two phases. First, once the paper-based case was provided to the participant, he was asked to think aloud while being presented with the text and to provide diagnoses, treatments, and reasons behind them. He was given all the time required to complete the task. However, because some authors claim that the biomedical knowledge is encapsulated and integrated into clinical knowledge by clinicians when gaining experience of similar cases (Schmidt & Boshuijen, 1993a, 1993b), pictures of the anatomopathological findings from the necropsy record were given to the participant to obtain more explanations about his diagnoses and treatments. That is, in the second phase we used visual information to release the possible encapsulated knowledge of the participant. The pictures included gross findings of the brain, lungs, coronary arteries, heart, liver, kidneys, and histological findings of myocardium, respectively. These protocols were tape-recorded and the duration of the sessions are shown in the result section. Additionally, protocols at AAU were conducted in English, but they were applied in Spanish at Uniandes even though they are translated here into English. At the end, verbatim was transcribed for further analysis.

Table 1

Clinical case used in the think aloud protocols.

<table>
<thead>
<tr>
<th>Clinical case used in the think aloud protocols.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 72-year-old Colombian man consulted to the emergency department of a primary care hospital at 11:00 am. He complained about anxiety, diaphoresis, intense retrosternal chest pain, like pressure sensation, unremitting for the last 30 minutes and dyspnea for 4 hours duration. He also has palpitations, weakness and restlessness. He recalled an episode of indigestion the day before and was found by his daughter this morning, laying down in bed pale and sweating. He was a farmer by occupation, but he stopped working five years ago. He had no history of diabetes mellitus,</td>
</tr>
</tbody>
</table>
hypothyroidism, but he had hypertension. Physical examination: blood pressure: 160/110; irregular pulse: 105 / minute; temperature: 37 °C; respiratory rate: 22/minute. Thin carotid pulsation. He weighed 64 kg and was 163 cm tall. His body mass index was 24 kg/m2. He had corneal archus. His systems exam revealed tachycardia, S3 gallop on cardiac auscultation and bibasilar crackles in the lungs. Funduscopic examination: narrowing of arterioles. The rest of the physical examination did not show further abnormalities. Echocardiogram showed a hypokinetic anterior wall of the heart, with a left ventricular ejection fraction of 30%; aortic valves were normal with no evidence of valvular stenosis.

Laboratory tests His labs revealed normal blood counts and renal functions. His fasting lipid profile showed high total cholesterol, LDL cholesterol and triglycerides. Imaging tests Chest X-ray: no abnormalities

Analysis

The analysis of the transcribed verbatim mainly aimed to identify if the students showed evidences of knowledge integration while reasoning to solve a clinical case, which type of knowledge they used to diagnose and treat the patient, how was the process applied, and how was the style of CR. These aims were reached in a step-by-step procedure based on an interpretive qualitative approach (Boshuizen & Schmidt, 1992; Merriam, 2002, p. 6), although we also used quantitative indicators calculated in Microsoft Excel 2011 for Mac (see Tables 3 and 5) (Chi, 1997). First, the verbatim was transferred to the Atlas.ti software (version 6.2) and segmented according the ideas that were causally related to one another or isolated statements that had not explanations. In the next step, the segments were coded with actions that described what the participant was doing and how he was doing it. For example, consider the following answer:
“the artery in the heart when it is clotting it does not give enough blood to the heart and maybe that is why the 30% of the left ventricle is hypokinetic, the anterior wall of the heart. What about the lung? I just wondering if the blood mmmm how to say it... if the heart is not good it comes bad for the lung as well.” AAU participant TA4AEr.

This text was segmented into two units and each unit was coded as showed below:

“the artery in the heart when it is clotting it does not give enough blood to the heart and maybe that is why the 30% of the left ventricle is hypokinetic, the anterior wall of the heart”.

*Code: Offering anatomopathological explanations by interpreting paraclinical results.*

“What about the lung? I just wondering if the blood mmmm how to say it... if the heart is not good it comes bad for the lung as well”.

*Code: Identifying related organs affected by identifying physiopathological alterations.*

Then, codes of each participant were arranged in the order they were created to analyze the process of CR. As an example, the CR process of the student described above is presented in Table 2. The codes 5, 10, 13, and 15 show the integration between clinical and biomedical knowledge. In the final step, the protocols were analyzed with respect to the style of the students’ CR. To do this, the explanations of the underlying biomedical or clinical knowledge manifested on the first protocol phase were counted. Then, we calculated the percentage of biomedical and clinical explanations from the total number of segmented units and the proportion clinical/biomedical explanations. Finally, we extracted the diagnoses and treatment provided by the students, and the CR general processes derived after the anatomopathological visual inputs.
Table 2

CR process of the participant TA4AEr during the protocol.

1. Identifying a syndrome by interpreting the symptoms
2. Interpreting a symptom by identifying the antecedents
3. Identifying key symptoms
4. Identifying antecedents
5. Identifying the organ mainly affected by detecting abnormal antecedents
6. Identifying normal physical examination findings
7. Identifying abnormal physical examination findings
8. Relating physical examination finding to abnormal physical examination findings
9. Identifying physical examination findings not well known
10. Relating the identified anatomopathological alteration to abnormal physical examination findings
11. Identifying paraclinical results not well known
12. Offering multicausal relations
13. Offering anatomopathological explanations by interpreting physical examination findings and paraclinical results
14. Providing a diagnosis by relating paraclinical results to physical examination findings
15. Offering anatomopathological explanations by interpreting paraclinical results
16. Identifying related organs affected by identifying physiopathological alterations

After visual inputs

17. Confirming anatomopathological explanations
18. Deducing physiopathological consequences
19. Relating symptoms to the organ affected and to identified pathophysiological alterations

Results

What is the relation between the type of CI in which students are enrolled and the style of their CR when performing a think aloud protocol? To answer this question we analyzed the protocols verbatim looking for the following findings: (1) the type of
knowledge used by students. (2) Evidences of integration of different types of knowledge. (3) The amount of statements per minute of protocol. (3) The amount of biomedical and clinical explanations of the causal connections. (4) The percentage of biomedical and clinical explanations of the total amount of statements. (5) The proportion of biomedical and clinical explanations. (6) The overall styles and the processes of CR in each integrated curriculum. (7) The provided diagnoses and treatments. And (8) the type of elaboration of the explanations made by students after seeing the visual inputs. We present the results of the AAU students first and then those of the Uniandes students. In the discussion section, we interpret the general findings conjointly.

*Reasoning by connecting a key symptom with relevant information*

Overall, participants from AAU exhibited evidences of integration between biomedical and clinical knowledge in their causal connections. However, other types of knowledge were not used in the task, for example, ethic, psychosocial, or technological knowledge. An example of knowledge integration is showed in the statement presented below.

“So that essentially is his heart is not functioning you can see that then in his lungs he has some crackles which is a congestion he got it is possible due to an embolism or his heart malfunction” AAU participant TA1AE.

This student established a causal connection between an embolism and a heart malfunction (biomedical knowledge) and the patient’s sign crackles (clinical knowledge).
To do this, she reasoned that the lungs were congested because the heart was not working well (biomedical explanation).

Moreover, not all the statements were causal connections. Sometimes, participants exposed single claims such as “his survival parameters, they are high blood pressure, high pulse” (AAU participant TA2AT). Nonetheless, most of the provided causal explanations were biomedical and no clinical explanations were delivered. Additionally, their general CR processes were characterized by identifying the organ mainly affected through interpreting a key symptom (chest pain), and relating it to other clinical and paraclinical findings (e.g., diaphoresis, dyspnea, thin pulse, high cholesterol) in a non-specific order. In other words, they had a global view of the patient’s problem by interpreting the most relevant information. Although all of them arrived at accurate diagnoses, some participants did not propose treatment. Nonetheless, after receiving the visual inputs of the anatomopathological findings, most of them used the new information to refine their biomedical explanations. For example, the statements presented below were extracted from a student’s verbatim. The first statement was provided before he saw the visual inputs whereas the second refined explanation was offered after the inputs:

1. “I think if he has high tension, it could be that the heart is getting bigger or the thickening of the muscles … the cardiac muscle isn’t working as it should … and that also is producing on the heart … the effect on the bomb, that is not working as well … and it could have a hypoperfusion” AAU participant TA5AS.

2. “It could happen other things like a heart failure. I don't know … high blood pressure is pretty high, at least the past history, and I remember the high blood pressure
can give heart failure ... mmm, that could give thickening of the heart walls. So that also could be the arteriosclerosis. So it is difficult. But yes, I think what he has now is a heart attack due to the other facts that can also ... I just think ... eh, just blocking the ventricle and that's what make me think that is not a heart failure, and that is an atheroma, so there is a lot of things” AAU participant TA5AS.

Another finding was that some of the participants deduced phenomena they did not know previously from their biomedical explanations, like why the patient have crackles? For example: “*Maybe the crackles in the lung is because if the blood isn’t pumped in the body so it runs back to the lungs*” AAU participant TA7AC. The rest of their results are shown in Tables 3 and 4.

Table 3

*First part of the think aloud results of the AAU participants.*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Statements</th>
<th>Biomedical explanations in phase 1</th>
<th>Percentage of biomedical explanations</th>
<th>Duration of the protocols (minutes)</th>
<th>Statements per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA1AE</td>
<td>24</td>
<td>11</td>
<td>45,8</td>
<td>13,59</td>
<td>1,8</td>
</tr>
<tr>
<td>TA2AT</td>
<td>16</td>
<td>4</td>
<td>25,0</td>
<td>21,39</td>
<td>0,7</td>
</tr>
<tr>
<td>TA3AU</td>
<td>14</td>
<td>3</td>
<td>21,4</td>
<td>11</td>
<td>1,3</td>
</tr>
<tr>
<td>TA4AEr</td>
<td>27</td>
<td>6</td>
<td>22,2</td>
<td>10,37</td>
<td>2,6</td>
</tr>
<tr>
<td>TA5AS</td>
<td>23</td>
<td>10</td>
<td>43,5</td>
<td>14,09</td>
<td>1,6</td>
</tr>
<tr>
<td>TA6AAn</td>
<td>16</td>
<td>2</td>
<td>12,5</td>
<td>14,5</td>
<td>1,1</td>
</tr>
<tr>
<td>TA7AC</td>
<td>13</td>
<td>5</td>
<td>38,5</td>
<td>12,5</td>
<td>1,0</td>
</tr>
</tbody>
</table>
Table 4

*Second part of the think aloud results of the AAU participants.*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Diagnoses</th>
<th>Treatments</th>
<th>Elaboration of explanations after seen images</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA1AE</td>
<td>Atherosclerosis. Myocardial infarction. Embolism.</td>
<td>Take an ECG. Take an echocardiogram. Hypertension is needed to control by medication.</td>
<td>Offering multicausal relations. Confirming patient's management. Providing additional treatment</td>
</tr>
<tr>
<td>TA3AU</td>
<td>Heart attack.</td>
<td>No</td>
<td>Confirming patient's diagnosis by identifying other anatomopathological findings. Refining diagnosis. Offering multiple connections among etiology, diagnosis and symptoms.</td>
</tr>
<tr>
<td>TA4AEr</td>
<td>Heart attack.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TA5AS</td>
<td>Heart attack. Infection of the heart. Something in the stomach.</td>
<td>ECG Need a new heart. Removing the clot or put an stent or bypass</td>
<td>Providing additional anatomopathological explanations. Considering differential diagnosis. Confirming diagnosis. Refining biomedical explanations by relating them to paraclinical results. Offering multiple connections among etiology, diagnosis and physical examination findings.</td>
</tr>
</tbody>
</table>
Reasoning by analyzing the clinical history systematically

Participants from Uniandes also showed integration between biomedical and clinical knowledge in their verbatim and, similar than AAU participants, they did not apply other types of knowledge. By contrast, they provided clinical explanations to their established causal connections, although the amount of biomedical explanations was superior (See Table 5). The following example represents the knowledge integration providing a clinical explanation:

“He (the patient) says he remembers an episode of indigestion yesterday, but the episodes of indigestion are often confused with pain. Because it can be a peptic ulcer, both may appear similar. But clearly the resolution of the pain is different if it is a peptic ulcer or a heart attack. He may have had indigestion yesterday or eating a lot, but I would correlate it with a coronary process (obstruction) that he was suffering the previous day” Uniandes participant TAUJC2.

As described above, the student made a causal connection between the patient’s symptom indigestion (clinical knowledge) and the coronary obstruction (biomedical

<table>
<thead>
<tr>
<th>TA6AAAn</th>
<th>Heart attack. Atherosclerosis.</th>
<th>Confirm the diagnosis</th>
<th>Relating abnormal paraclinical results to anatomopathological findings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA7AC</td>
<td>Blood clot. Atherosclerosis.</td>
<td>Something that can make this clot thinner. Bypass</td>
<td>Refining biomedical explanations. Providing management deducing it from the biomedical explanations. Offering additional treatment</td>
</tr>
</tbody>
</table>
knowledge). However, he used the differences in the characteristics of the pain between two diseases to support his reasoning (clinical explanation).

With one exception, the Uniandes group had a different style on the CR processes than AAU participants. Overall, they followed the clinical history order to reason about the findings of each section including complaints, past history, physical examination, and paraclinical test results. That is, they had a view of the patient’s problem as a sequence of information derived of each clinical history section. This may be the reason why they arrived at more diagnoses than AAU participants, although some of the diagnoses were not accurate. However, they proposed a principal, accurate diagnosis in the end of the protocol first phase and deduced possible signs or symptoms suffered by the patient from the biomedical explanations. For instance, “The alveolar space will be filled with fluid that will be blood ooze. It would not be uncommon that the patient could had hemoptysis like staining a napkin” Uniandes participant TAUJC2.

By the same token, they provided more options of treatment particularly focused on their final diagnostic choice. Another interesting finding was that the students who had the highest percentage of biomedical explanations did not offered clinical explanations to their causal connections (See Table 5). In contrast, the first Uniandes participant showed the highest proportion of clinical/biomedical explanations, and the fourth participant evidenced a CR style similar to AAU participants. That is, this student Identified and interpreted key symptoms and signs relating them with abnormal paraclinical results.
These links were performed in a non-specific order but supported on relevant information. The rest of Uniandes participants’ results are shown in Tables 5 and 6.

Table 5.

First part of the think aloud results of the Uniandes participants.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Statements</th>
<th>Biomedical explanations in phase 1</th>
<th>Percentage of Biomedical explanations in phase 1</th>
<th>Clinical explanations in phase 1</th>
<th>Percentage of Clinical explanations in phase 1</th>
<th>Duration of the protocols (minutes)</th>
<th>Proportion Clinical/Biomedical explanations</th>
<th>Statements per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAULH1</td>
<td>39</td>
<td>5</td>
<td>12,8</td>
<td>10</td>
<td>25,6</td>
<td>13,59</td>
<td>2,9</td>
<td></td>
</tr>
<tr>
<td>TAUJC2</td>
<td>52</td>
<td>17</td>
<td>32,7</td>
<td>7</td>
<td>13,5</td>
<td>21,39</td>
<td>2,4</td>
<td></td>
</tr>
<tr>
<td>TAUS3</td>
<td>33</td>
<td>16</td>
<td>48,5</td>
<td>0</td>
<td>0,0</td>
<td>11</td>
<td>3,0</td>
<td></td>
</tr>
<tr>
<td>TAUMA4</td>
<td>25</td>
<td>8</td>
<td>32,0</td>
<td>2</td>
<td>8,0</td>
<td>10,37</td>
<td>2,4</td>
<td></td>
</tr>
<tr>
<td>TAU15</td>
<td>45</td>
<td>18</td>
<td>40,0</td>
<td>0</td>
<td>0,0</td>
<td>14,09</td>
<td>3,2</td>
<td></td>
</tr>
<tr>
<td>TAUSAN6</td>
<td>40</td>
<td>13</td>
<td>32,5</td>
<td>3</td>
<td>7,5</td>
<td>14,5</td>
<td>2,8</td>
<td></td>
</tr>
<tr>
<td>TAUJU7</td>
<td>43</td>
<td>10</td>
<td>23,3</td>
<td>3</td>
<td>7,0</td>
<td>12,5</td>
<td>3,4</td>
<td></td>
</tr>
</tbody>
</table>

Table 6

Second part of the think aloud results of the Uniandes participants.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Diagnoses</th>
<th>Treatments</th>
<th>Elaboration of explanation after seen images</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAUJU7</td>
<td>Lung pathology.</td>
<td>Take an ECG</td>
<td>Confirming diagnosis</td>
</tr>
</tbody>
</table>
Discussion

In the current study, we assessed students’ CR to evaluate the effectiveness of the CI in which they were enrolled during the preclinical training. To achieve this, we used think-aloud protocols to access the participants’ reasoning; therefore, to understand how they integrated knowledge when solving a clinical problem. We believe that the extent in which students integrate knowledge show us how effective is CI. Additionally, we compared results from two groups of students: AAU PBL curriculum and Uniandes integrated-systems curriculum. Our most significant result is that both groups evidenced distinct CR styles, and the type of CI of their medical education program seemed to play a role in those differences. We arrived at this conclusion when we realized that the participants' strategies to integrate knowledge during the protocols were highly similar than those of applied in their respective integrated curriculum.

Specifically, AAU participants tended to identify a key symptom and to connect it with other relevant findings arriving at few accurate diagnoses. They explained the links using biomedical information, and sometimes they deduced causal connections from these explanations. Similarly, the type of CI of their PBL curriculum showed comparable strategies of integration from varied disciplines. From identifying keywords of a clinical
problem, students established connections through arrows and arrived at specific learning outcomes that guided them in the construction of knowledge. On the other hand, Unianes participants navigated systematically through the text according to the components of the clinical history. In each component, they interpreted the information using lots of biomedical and, sometimes, clinical explanations; thus, arriving at multiple diagnoses. Although several of the provided diagnoses were not accurate, their explanations also helped them to deduce causal connections in some cases. This strategy is also used in their integrated-systems curriculum. As we observed in their lectures and clinical case presentations, knowledge from diverse disciplines were introduced to students through a set of steps based on the clinical history structure.

These results suggest that the performance assessment of the students’ CR may provide useful information about the effectiveness of the CI designs. Specifically, although it would be expected that preclinical students have a CR level of novices, our findings show that CI seems to be involved in developing students’ CR towards a more mature level. For example, AAU participants showed some CR characteristics that are also displayed by clinical experts such as identifying key findings and connecting them to provide accurate diagnoses (Boshuizen & Schmidt, 1992). However, CR performance assessment may also indicate how to improve the CI design. For instance, AAU participants offered no clinical explanations as experts do to support causal connections, and their suggested treatments were extremely general or unspecific. We speculate this may be possibly related to the fact that their case-PBL facilitators are research experts but
not clinicians, or more clinical encounters appear to be needed to acquire experiential knowledge (Eva, 2005). By contrast, Uniandes facilitators were clinical experts, biomedical lectures were followed by discussions with clinicians, and students seemed to have enough clinical practice. These facts may have influenced the presence of clinical explanations in Uniandes participants' protocols because their learning activities were also focused on clinical explanations and specific treatments. Nonetheless, the fragmented analysis and the multiple inaccurate diagnoses provided by this group show some deficiencies in the Uniandes CI strategy. As the CI was designed and implemented according to the clinical history structure, students seemed to assimilate this pattern in their reasoning. Thus, they may have offered diverse diagnoses disconnected from other relevant information in different parts of the clinical history.

Moreover, although the CR styles of both groups were dissimilar, the macro processes used by participants to provide diagnoses and treatments (with some exceptions) and their results did not follow divergent paths. This finding supports the hypothesis that cognitive processes of CR are similar even though students may have developed different CR styles (Kiesewetter et al., 2013). As found by Kiesewetter et al. (2013), medical students use three main cognitive actions in the CR process: denomination (gather information), analysis (produce diagnoses), and implementation (validate a plan). But they also found students performed other cognitive action in less proportion including exploration (understand the problem), plan (create plans), evaluation (confirm or discharge hypotheses), representation (create a mental pattern of the
problem), and integration (decide on one diagnosis and treatment). Although we also identified those cognitive actions in the protocols, we believe assessing CR should go beyond understanding macro processes or testing results. Assessment should also study the CR style, that is, the extent of development of the student’s knowledge integration to solve clinical problems because it shows the connection between CR and CI. Specifically, despite the fact that Uniandes participants offered multiple diagnoses, they also choose one or two diagnoses after analyzing all the textual information at the end of the protocol first phase. Their final diagnoses were the same than those of AAU participants. This finding suggests that if we had measured the students' CR as their capability to arrive at final diagnoses or to follow particular processes but without taking into account the analytical style, we would not have discovered important differences. As same as found by other investigations, students from different integrated curricula seem to have similar results in providing diagnoses of clinical problems (Williams et al., 2011; Hecker & Violato, 2008). However, the developmental level by which those students integrate knowledge may not be the same.

Besides that, a critical aspect of CR that should be taken into account in the CI evaluation is the knowledge encapsulation that was described by Schmidt and Boshuizen(1993a) as follows:

“An alternative possibility is that during the internships, students acquire new clinical and experiential knowledge directly linking patient signs and symptoms to diagnostic hypothesis, and apply this kind of knowledge in their clinical reasoning. Such a process would result in a shift from biomedical to clinical knowledge application, and, if nothing else happens, it also would lead to inertia of the biomedical/theoretical knowledge base. Hence, the encapsulation of biomedical knowledge under higher order
propositions observed in this study must emanate from an additional process invoking the integration of biomedical and clinical knowledge, of theoretical and experiential knowledge.”

As evidenced in the protocol second phase, students from the PBL curriculum tended to encapsulate their knowledge possibly inside their constructed connections. Thus, their encapsulated knowledge may not be evidenced in assessments that do not have an appropriate stimulus to make it conscious. In our case, the stimulus was the anatomopathological pictures of the necropsy record. Seeing the pictures seemed to facilitate students remembering encapsulated knowledge and, therefore, refining their explanations.

Another major finding was that two of the Uniandes participants exhibited a different style of CR than that of their peers. One presented a higher proportion of clinical explanations, and the other had a CR style similar to that of manifested by the AAU participants. Although we do not know the exact reasons behind these patterns, we speculate they may have had more patients' encounters that allowed them develop their CR skills in depth. As pointed out by de Bruin et al. (2005), routine clinical encounters play an important role for developing CR skills by incorporating clinical concepts into causal connections and making biomedical knowledge less relevant. This is why future research should be directed to understand how the students’ CR evolves in clinical training according to the type of CI involved in this phase.

Finally, we would like to point out that we have not evaluated students’ CR using real clinical encounters because of ethical considerations. Nevertheless, it should be
highlighted that think aloud protocols do not provide information about the students’ skills to gather information from the patient. As this skill is a fundamental part of CR, our results are limited to analysis and decision-making. We believe research in clinical training may overcome this limitation and clarify how different CI designs are related to the gathering information skills.

References


