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**SUMMARY**

**SAMENVATTING**

## Summary

### Introduction and problem definition

This thesis revolves around the integration of clinical and basic sciences in medical education, and the role concept maps can play in the articulation of this integration. Its point of departure was the assumption that teaching programs rely on knowledge that can be made explicit. Students might learn explicitly or implicitly. However, a curriculum can only be designed by the knowledge that can be identified. This means that to help students build a sound knowledge base that comprises intertwined clinical and basic science knowledge, this integrated knowledge should be explicated.

The importance of vertical integration, that is integrating clinical and basic sciences, is widely emphasized, with the focus on the curriculum level. In this thesis we explore integration of clinical and basic sciences on the level of clinical problems. It is this level that pertains to the day-to-day practice of teaching in medical education. On the level of clinical problems, a clinician should be able to explain and predict clinical phenomena, which manifest themselves during history taking, physical examination, lab research, and clinical conclusions such as possible diagnoses, via knowledge about basic sciences such as anatomy, physiology, and biochemistry.

We have chosen concept maps as a vehicle to help teachers with this task. In a concept map a subject is depicted in a schematic way. The map contains the concepts needed in order to understand the subject, with these concepts linked in order to express the relations. There are always hierarchic relations in a concept map; an umbrella concept is explained by the concepts subsumed by the umbrella concept. The activity of concept mapping has already proved an adequate approach to evoke knowledge. It is considered a promising approach particularly for the elicitation of tacit knowledge, that is, knowledge used unconsciously.

Protagonists in the four studies presented here were teachers, because integration starts with them. They determine what and how students are taught. Not only does an integrated curriculum require teachers to explicate the clinical and basic science concepts and their relations, an integrated curriculum in which basic scientists and clinicians do not cooperate when developing an educational program is also difficult to imagine. Educational research on the articulation of clinical and basic sciences on the level of clinical problems is still in an explorative phase. Consequently, insights into the way teachers cope with this integration are needed before we turn to look at students.

Cognitive psychological research on the knowledge base of experienced clinicians, and of experts in general, has increased our understanding of how clinical and basic sciences are integrated within the mental organization of clinicians. These insights can provide a basis for educational innovations. This also applies to concept mapping instructions intended to help medical teachers to articulate integration. In the literature, concept mapping is recommended as a technique to articulate integration of clinical and basic sciences. However, the concept maps published so far have not exhibited integration of clinical and basic sciences to any great extent. Often, the emphasis is either on clinical sciences or basic sciences. Hence, it seems to make sense to endeavour to improve the articulation of basic sciences by means of instructions that harmonize with the knowledge base of experienced clinicians. These instructions might help clinical and basic science teachers to articulate integration. When medical teachers construct concept maps intended to visualize integration, their challenges lie in the comprehensiveness of the maps, in particular pertaining to the different phases of clinical reasoning, in the articulation of basic science knowledge which often belongs to clinicians' tacit knowledge, and the articulation of the different kinds of relations between clinical and basic science concepts. We designed specific concept mapping instructions, which are intended to meet these challenges.

Whether medical teachers are able to articulate integration in concept maps if they are supported by instructions actually focusing on integration is an empirical question. However, it is still unclear what precisely constitutes integration of clinical and basic sciences on the level of clinical problems. In order to measure effectiveness of instructions to articulate integration in concept maps, we needed a framework that can describe this integration on the level of clinical problems.

At the heart of integration lies communication and cooperation. Integration offers a multidisciplinary view and to attain this integration varied medical disciplines should be engaged and should give their input. In addition to adopting the cognitive psychological perspective on integration, in our research project we also set out to examine what was the impact on the articulation of integration of communication and cooperation when multidisciplinary groups of medical teachers jointly endeavour to construct a concept map.

The first three studies in this thesis can be characterized as Design-Based Research. Starting with theory-based concept mapping instructions, we conducted experiments to improve these and relate them to context variables, in order to understand why medical teachers articulated integration to the extent and in the way visualized in the concept maps and finally to improve them. What is pivotal in Design-Based Research is the linking of the concept maps (as the product of the learning

process to articulate integration) and the process of concept mapping (in which communication and cooperation are essential). This enabled us to examine what factors affect the construction of integrated concept maps by multidisciplinary groups.

## Aims of the studies

The theme of the use of concept maps for the articulation of vertical integration was investigated from four different angles, each covered in a separate study. The first angle is based on the view that it is possible to describe integration and to improve the articulation of integration. This angle is covered in the first study in which we explored the articulation of integration of clinical and basic sciences in concept maps by expert groups of clinicians and basic scientists, and the way to measure this articulated integration. The groups were guided by instructions focusing on the articulation of integration. In the second study, this perspective was broadened to include differences between groups of clinicians and basic scientists of different expertise levels. The third angle was intended to shed light on the process of concept mapping, in order to understand what it is that process characteristics contribute to the articulation of integration. In addition to our investigations of the construction of concept maps and its learning effects, the fourth study focused on the usefulness of the concept maps themselves in medical educational programs as perceived by medical teachers. By comparing the views of teachers that constructed the concept maps with the views of teachers who were not engaged in the construction process, we questioned the relevance of active communication and cooperation for the articulation of integration. Chapter 6 adds to the insights gained in the previous chapters by comparing the results and conclusions of Chapters 2 and 3, so that the framework of features is further refined and the lessons learned from Chapters 2, 3 and 4 are combined in order to sharpen concept mapping instructions for the articulation of integration.

## Results

**Chapter 2** sets out with the first perspective on the role of concept maps for the articulation of integration of clinical and basic sciences, and focuses on the questions *Can integration of clinical and basic sciences be articulated in concept maps, and to what extent, if instructions intended to support the articulation of integration are used? What features describe integration in concept maps?* We derived concept mapping instructions from current insights into the knowledge base of experienced

clinicians concerning the integration of clinical and basic sciences. Our instructions were intended to turn constructors' focus to the contribution of their own discipline, to help them organize the concepts along two hierarchical devices to purposefully link clinical and basic science concepts, and to check comprehensiveness and relations between clinical and basic sciences concepts by means of two patient cases. Seven groups of three experts, both clinicians and basic scientists, each constructed a concept map about a clinical problem along these instructions.

Because there were no instruments to measure integration, either in concept maps or presented in other ways, a framework of features by which the concept maps could be described both qualitatively and quantitatively, was required. We developed such a framework, evaluated it and proposed refinements. Integration in concept maps can be measured by clinical umbrella concepts that encapsulate basic science concepts, by basic science umbrella concepts that subsume clinical concepts, and by links between clinical and basic science concepts, for which it is meaningful to distinguish the phases in clinical reasoning linked to a basic science concept. Moreover, if less than a sixth of the concepts were of basic science origin, there were hardly any features of integration visible. Umbrella concepts that indicated general clinical categories such as 'history' and 'lab research' hindered the articulation of integration, whereas umbrella concepts that were specific for the clinical problem at hand seemed to facilitate the articulation. Clusters of clinical and basic science concepts coincided with basic science umbrella concepts subsuming clinical concepts, and were therefore not informative about the articulated integration.

We concluded that the experts in our study were able to construct concept maps that articulated integration of clinical and basic sciences, as measured by the framework. They mostly articulated integration by links between basic science concepts and diagnoses, and there was a preference for clinical concepts that encapsulated basic science concepts. However, regarding the actual level of integration the concept maps showed a wide variation. We proposed some adaptations of the instructions, to improve the articulation of integration in concept maps.

The second study is reported in **Chapter 3**, and focused on expertise differences that could become apparent in concept maps. The research question was: *What consistent variations are found in concept maps constructed by groups of experts, and by groups of constructors at resident level?* Whereas in previous research on concept mapping differences in concept maps that visualized one theme were investigated, we searched for consistent differences regardless of theme - in our study, clinical problems-. Moreover, we mainly examined differences concerning the articulation of integration of clinical and basic sciences. Concept maps constructed by seven

multidisciplinary groups of experts were compared with concept maps constructed by seven groups of residents and basic scientists in training, with the same disciplinary composition as the expert groups. This enabled us to look for evidence for three hypotheses regarding the articulation of integration, derived from cognitive psychological research on expertise knowledge organization.

The first hypothesis referred to the theory of knowledge encapsulation, and stated that residents would use more basic science concepts in their concept maps, because these concepts are not encapsulated in clinical concepts to the same extent as is the case in experts' knowledge base. The comparison of the concept maps made by the two groups revealed that this hypothesis could be neither verified nor rejected: residents used more basic science concepts, but not significantly so. Overall, residents constructed concept maps that included more concepts, both basic science and clinical concepts. The second hypothesis pertained to the organization of the concepts in the map. In line with our expectations, resident concept maps contained significantly more basic science umbrella concepts that subsumed clinical concepts than experts maps and the latter contained more clinical concepts encapsulating basic science concepts although this last difference was not significant. For the third hypothesis we did not find any evidence. We expected experts, with their holistic views on clinical problems, to use more links between clinical concepts and basic science concepts than did residents. However, resident concept maps contained significantly more links between clinical and basic science concepts than did the expert maps. In addition, the residents linked basic science concepts not only to diagnoses, as was mainly the case in the expert maps, but also to patient history, physical examination and lab research. Moreover, previous concept mapping research has shown that the more expertise on the part of the constructors, the more complex their concept maps. Measuring by our set of features, which partly overlapped with the way complexity is gauged in these concept mapping studies, we found the opposite was true: the resident concept maps were more complex. This can be explained by the process: in previous research concept mapping was an individual activity whereas in our study it was a joint venture of multidisciplinary groups. We also suggest that groups of experts could be more concise in their communication with each other than residents, because they assume that their colleagues possess extensive knowledge of the clinical problem.

We conclude that resident concept maps could be valuable in medical education because of their explicitness, in particular concerning integration of clinical and basic sciences.

The process characteristics that could account for the differences between concept maps of experts and those by residents were investigated in the third study, described

in **Chapter 4**. Following the Design-Based Research approach, we endeavoured to clarify the articulation of integration by means of examination of the process of concept mapping in order to optimize the concept mapping instructions that we designed and asked: *Which factors affect the learning process of interdisciplinary groups of clinicians and basic scientists at different expertise levels, if they jointly construct concept maps guided by instructions focusing on the articulation of integration of clinical and basic sciences?* In addition to the cognitive psychological perspective in Chapters 2 and 3, a constructivist and a cooperative learning dimension was brought to bear on the integration articulated in the concept maps.

After a pilot which showed that a group size of three participants was optimal, we examined the constructivist perspective by comparing the draft and the final version of each concept map, and found that the articulation of integration can be learned. Expertise level turned out to be a relevant context variable: residents proved better to learn the articulation of integration than experts. For the cooperative learning perspective, we analysed notes taken from video tapes of the concept mapping session and field notes by means of an interpretation framework that fit conditions and communication patterns as described in the literature on cooperative learning and consisted of four interpretation categories: (1) motivation, (2) exchange of information, (3) interaction, and (4) the decision making process. This data source helped us to understand why residents articulated integration to a higher extent: their communication pattern differed from that of experts. Whereas residents interacted with each other right from the beginning of the session, i.e., asking each other questions, explaining concepts to each other, experts were more reluctant in their interaction. Compared with the communication of residents, experts' communication pattern relied more on exchange of information. They started to interact only when joint decisions had to be made. Hence, decision making and interaction were not only factors that separately affected the learning of articulation of integration as proposed in the theoretical discourse of cooperative learning, but they also seemed to be related. Moreover, we asked the participants about their views on the theory-based instructions for the construction of concept maps. The experts were more positive about the instructions than the residents and expressed more motivation, as also became clear from the analysis of the video tapes. The three data sources enabled us to combine the products, i.e., the concept maps, communication during the process of concept mapping, and participants' views, in order to understand the articulated integration. The perceived usefulness of the instructions and motivation appeared to be irrelevant factors for the articulation of integration in concept maps: experts were highly motivated, but their articulation of integration lagged behind that of the residents. However, integration turned out to be a relevant factor for the articulation of integration.

In the fourth and last study, described in **Chapter 5**, we adopted another perspective. Whereas the first three studies focused on concept maps themselves and their construction process, in this study we were concerned with the usefulness of the concept maps for educational programs as perceived by medical teachers, i.e., *Is the perceived usefulness of preconstructed concept maps, constructed collaboratively by groups of clinicians and basic scientists, affected by (1) teachers' participation in the construction of the concept map, (2) the degree to which non-constructing teachers share the content of the concept map, (3) teachers' prior experience with schematizing or concept mapping, (4) teachers' need for change to improve integration in their own teaching practice, and (5) the degree of articulated integration of clinical and basic science?* Our goal was to get an impression of the extent to which articulated integration of clinical and basic sciences in concept maps was transferable from one teacher to another. Because the concept maps were constructed by multidisciplinary groups, which implies that they were always the product of consensus, they might be suitable for use by other teachers. By means of a questionnaire whose questions were based on literature on educational use of concept maps, we asked the constructors of the concept maps, and medical teachers affiliated to all eight academic medical centres in the Netherlands, about the usefulness of both the expert concept maps and the resident concept maps.

Medical teachers who had not been involved in the construction process valued the usefulness of the concept maps significantly less than the teachers who constructed them. An explanation can be found in the degree to which they shared the content of the map. Evidently, teachers have difficulty accepting other teachers' concept maps. The fact that the concept maps were based on consensus did not contribute to their being accepted. None of the other factors affected the perceived usefulness significantly. Previous experience with concept mapping nor experienced need to improve integration in teachers' own teaching practice, nor the degree that integration was articulated in the concept maps affected the perceived usefulness. We suggested that the non-constructing teachers did not consider articulated integration in the concept maps an advantage because integration of clinical and basic sciences did not seem a major theme in their day-to-day practice, as the survey showed. This is underlined by the finding that the concept maps, which visualized integration to a greater extent, that were the resident maps, were considered to be slightly less useful for medical education than the expert maps. The concept maps valued least were those that contained the most basic science concepts. Remember that all the concept maps revolved around a clinical problem and were therefore clinically oriented. Articulated integration in concept maps did not seem to be an advantage to teachers who had had no part in the construction. We argued that the

importance teachers attach to integration in their own practice and the degree to which they value the articulated integration in concept maps seem to be a matter of actively sharing knowledge by means of communication and thus sharing content. The teachers who assessed the usefulness of preconstructed concept maps lacked this experience.

Furthermore, constructors perceived the concept maps as equally useful for curriculum development, preclinical, and clinical student learning, whereas teachers who did not construct the concept maps differentiated between various functions and targets of their usefulness: they valued them more highly for clinical student learning than for curriculum development and preclinical learning. This seems to imply that the complexity of the concept maps is not the reason why teachers are not inclined to use preconstructed concept maps of clinical and basic science. Because these complex maps could serve as a source of information for curriculum development, complexity would not be a disturbing factor. Our fourth study suggested that integration in medical education is a matter of actively sharing knowledge and communication.

## Conclusions and discussion

In **Chapter 6** we have assembled the conclusions of the four studies, and discuss them along three research lines that could be distinguished throughout the research project: (1) the development of a framework of features by which to describe integration articulated in concept maps, (2) the development of instructions to support medical teachers to articulate integration in concept maps, and (3) the description of the perceived usefulness of these maps.

*Ad (1).* We describe the features of the framework by which to measure integration and drew conclusions about which features to include and exclude in the framework, taking into account the findings in Chapter 2 and 3. The framework as described in Chapter 2 was used again for the study described in Chapter 3, and consequently its validity increased. The framework appeared to be suitable to describe differences between the articulated integration in the expert concept maps and those of residents, which led to the conclusion that residents were able to articulate integration to a greater extent, and to relate basic science concepts to more phases in the clinical reasoning process, than experts were. We explain the difficulties inherent in establishing the concurrent validity of the framework. Moreover, we discuss some explanations of why some of our hypotheses regarding the expertise differences could be verified and another not. A possible explanation is the 'intermediate effect'. Based on this intermediate effect, we hypothesized that residents would articulate more basic science concepts in their concept maps than experts would do. However, the intermediate effect not only showed up when

residents chose their basic science concepts, but also seemed to play a role in the linking of clinical and basic science concepts.

*Ad (2).* The instructions intended to help clinicians and basic scientists articulate integration in concept maps are discussed against the background of the phases as distinguished in Design-Based Research, which makes it possible to present an overview of the development of the instructions. We explain how the first study generated the research questions for the second one, which in turn evoked the third study, aimed at clarifying the articulated integration in the concept maps of experts and residents. In Chapter 6, this research line ends with a proposal for concept mapping instructions and a suggested procedure for the articulation of integration of clinical and basic sciences, which are both theory-driven, and empirically grounded. In addition to generating a set of instructions that result in concept maps with the desired articulated integration, we also wanted to understand why these instructions work and under which circumstances. Hence, we set our conclusions against a theoretical perspective we have not discussed yet, i.e., the theory of team based learning, to deepen our insight into the factors that explain the degree of articulated integration. This theoretical perspective points to the information gap, which seems to be bigger between highly specialized experts than between residents.

*Ad 3.* Regarding the third line, we summarize our findings concerning the perceived usefulness of preconstructed concept maps and the factors to which these findings could be attributed, and discuss the findings again from the theory of team based learning. In the fourth study it became clear that disseminating preconstructed concept maps did not encourage non-constructing teachers to 'cross boundaries'. This term is used in team based learning to indicate the process of bridging the information gap between participants. Boundary crossing within the constructing group proceeded more easily than between constructors and non-constructing teachers, probably resulting in a reluctance on the part of the non-constructing teachers to accept the content of the concept map. The keyword for boundary crossing seems to be 'interaction'. We argue that interaction could be an effective way to improve the perceived usefulness of the preconstructed concept maps. Interaction might for example be evoked by the task of adapting the preconstructed concept maps in multidisciplinary groups of teachers.

This last chapter summarizes what we consider to be the strengths and limitations of the research project. As strong points in the explorative studies of this thesis we mention the variety of theoretical views (cognitive psychology, constructivism, cooperative learning, team based learning, Design Based Research), the combination of different methodologies (description and measurement of products, surveys, qualitative research on process), also within one study, and the diverse groups of participants (different expertise levels, affiliated to different

academic hospitals and curricula). Limitations are those mostly inherent in explorative studies, and concerned the generalizability of the empirical findings because of the limited number of participants, concept maps and contexts of the experiments. We further explain potential biases and how we counteracted these. We describe the research agenda resulting from this research project. Three research paths can be distinguished: further development and validation of the framework of features for describing articulated integration, refining the concept mapping instructions, and measuring the effects on student learning when students use the preconstructed concept maps. In conclusion, the educational implications are elucidated, which all revolve around the principle of explication.