CHAPTER EIGHT

Summary and Conclusions

THE DEVELOPMENT OF clinical competence is the main purpose of medical education. The long road to become clinically competent starts on the first day of medical school, and every institution strives to select the best students. The responsibility of medical schools is to train those students to become clinically competent physicians who are highly qualified and specialized professionals able to function in a constantly changing society that puts continuously growing demands on the medical profession. Understanding clinical competence is therefore crucial not only for medical education, assessment, and licensing examinations, but also for society and its responsibility for the quality of health care. However, there is little consensus about what clinical competence is and how to measure it. A proper definition and a better understanding of clinical competence and its components would serve as a criterion for validating medical educational programs and would assure a minimum level of competency at the end of medical school and beyond during residency.

Each of the previous chapters of this thesis highlights different aspects of clinical competence and its development. In the introductory chapter the lack of consistency in definitions of clinical competence is emphasized and a historical overview is given to shed light on the variety of definitions used over the last decades. The study presented in Chapter 2 explores the effect of level of pre-university performance on preclinical and clinical performance. The study in Chapter 3 addresses the impact of clinical training during clerkships on students' learning. Specifically, the relationship among the nature and volume of patient encounters, quality of supervision, and the learning outcomes were explored. The study of Chapter 4 is directed at the interaction between knowledge and a problem-solving ability during students' diagnostic problem solving at end-of-clerkship examinations. Chapter 5 focuses on clinical competence during clerkships and end-of-clerkship examinations. In this study we explored whether clinical teachers place different values on individual components of competence while students work on the wards or while students are examined during clerkship examinations. The study reported in Chapter 6 investigates how recall of case information changed for different expertise groups under different conditions, while research discussed in Chapter 7 was conducted to find out how the selection of case information by students and doctors during different stages of the diagnostic process is related to different expertise groups. In the present and final chapter of this thesis the main findings of all previous chapters are summarized and discussed. At the end of this chapter, conclusions and suggestions for further research are given.

Summary of the main findings

Part I: Determinants of clinical competence development

During medical school, students go through several stages of development (Boshuizen, 2005; Schmidt & Boshuizen, 1992). The first preclinical phase of medical education emphasizes the acquisition of basic biomedical science knowledge, which serves as a solid foundation for the clinical phase. In this later phase the emphasis shifts towards practice and the application of knowledge in a clinical setting. Learning in a clinical environment is centered on real patient encounters, and a wider set of characteristics are needed and developed during this period of medical education. The study reported in Chapter 2 focuses on the transitions from public preparatory school to medical school and within medical school from preclinical education to clinical education. Of particular interest is whether students are progressing at a consistent level throughout medical school, independent of the phase transitions of the curriculum, and whether this consistency is related to their level of performance before medical school. For this purpose, medical students were classified into three groups—low, intermediate, and high achievers—based on level of performance before entering medical school. Preclinical and clinical performance were determined by students' mean grades over all course examinations within that phase. Performance levels before entering medical school were used as predictors for success in medical school for the whole cohort and the different grade-subgroups, respectively. For the whole cohort the results indicated that level of performance before entering medical school was highly related to level of preclinical performance but much less strong related to level of clinical performance. However, the individual grade-subgroups showed different patterns. For the high-achieving students, medical school performance of both phases, preclinical and clinical, was highly predictable and this subgroup progressed at a consistent performance level throughout medical school. They seemed better equipped for curriculum transitions than low-achieving students. Performance of low-achieving students was least consistent and hence almost not predictable at all. Performance of the intermediate grade subgroup was predictable only during preclinical years, not for the clinical years. It could be concluded that prior knowledge, as represented by level of pre-university performance, may be a necessary prerequisite of clinical competence, but it is far from sufficient. Therefore, perhaps non-cognitive variables, like a professional attitude, interpersonal skills, or communication skills are better indicators of performance in medical school, especially as early indicators for clinical performance (Albanese, Snow, Skochelak, Hugett, & Farell, 2003; Moulaert, Verwijnen, Rikers, & Scherpbier, 2004; Stern, Frohna, & Gruppen, 2005; Webb et al., 1997).

Preclinical education reflects domain knowledge, cognitive abilities, and to some extent, diagnostic problem solving. Clinical education, on the other hand, places more emphasis on diagnostic problem-solving skills and integrates the experiences of the preclinical years with clinical practice and encountering real patients. It is generally assumed that a sufficient number of patient encounters is essential for the development of clinical competence (Neufeld & Norman, 1985; Snell, Battles, Bedford, & Washington, 1998; Witzke, Koff, McGeagh, & Skinner, 1990). Studies that examined the relative growth in knowledge during clerkships reported significant increases (Butterfield & Libertin, 1993; Schwartz, Donnelly, Sloan, & Young, 1994). However, many previous studies were not able to identify a direct relationship between the number of clinical encounters and growing clinical competence (Châtenay et al., 1996; Gruppen, Wisdom, Anderson, & Woolliscroft, 1993; McManus, Richards, Winder, & Sproston, 1998; Van Leeuwen et al., 1997).

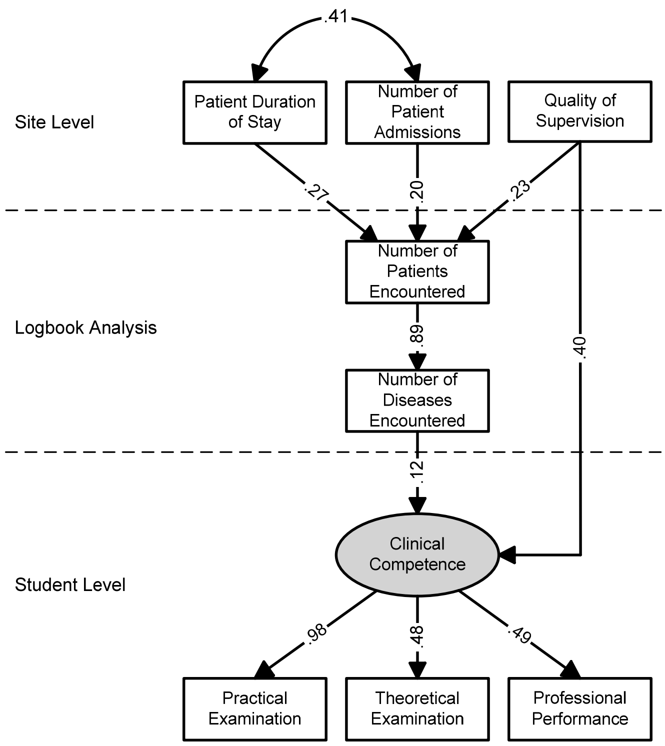

Figure 1. *Clerkship Competency Model*

The study reported in Chapter 3 focuses on learning in the clinical setting. It addresses in particular the impact of patient encounters during clerkships on the development of clinical competence. Clerkship students at several internal medicine sites recorded their patient encounters in logbooks and evaluated the quality of supervision they received. Student competence, the outcome measure, was determined by three independent indicators: practical end-of-clerkship examination, theoretical end-of-clerkship examination, and evaluation of professional performance of the students. Site characteristics that might influence the variation in patient encounters were collected. Analysis of the logbooks confirmed that differences between hospital sites are bigger than expected given the differences within sites. Hospital sites characteristics account for a large amount of the variation in the number of patients encountered by students during their clerkships. The variation in the number of patients seen, however, did not directly affect the development of clinical competence. A finding of particular interest is, as our clerkship competency model (Figure 1) showed, that the quality of the supervision in clinical education counts more than the numbers of patients seen or the variety of diseases encountered. It appears that the clinical supervisor has a stimulating effect on student learning and student learning environment, resulting in more patient encounters. A long period of supervised training is crucial to gradually acquire an increased responsibility in treating patients (Ericsson, 2004; Ericsson & Charness, 1994).

Part II: The nature of clinical competence

Clinical competence in general and diagnostic problem solving in particular appear out to be dependent on either the content or context of the problem (e.g., Elstein, Shulman, & Sprafka, 1978). This discovery in the late seventies had a huge impact on medical education, expertise research, and assessment. It was a largely laboratory-based finding and the question we posed ourselves therefore was: To what extent does this conclusion hold in the practice of clinical training. The study in Chapter 4 contrasts the finding of content specificity in competence with the existence of a general clinical problem-solving ability in end-of-clerkship examinations.

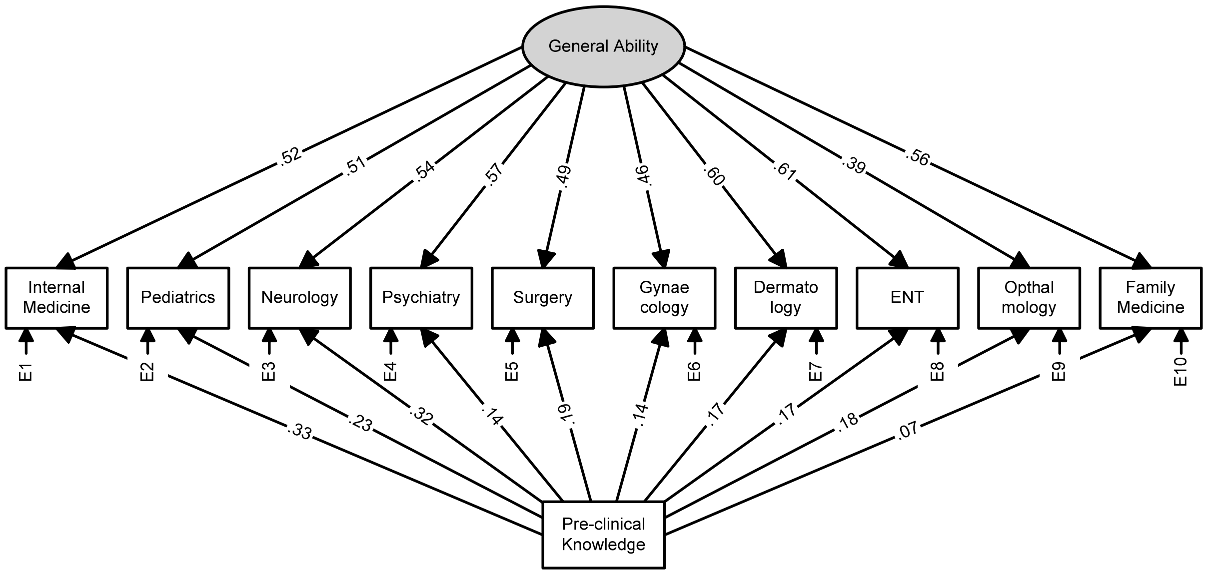

Figure 2. *The one-factor model with preclinical knowledge directly influencing clerkship final scores*

The cohort studied consisted of medical students who successfully completed their preclinical years at medical school and rotated through all clerkships. A correlation matrix was calculated with clerkship final scores from 10 disciplines to examine the magnitude of the interrelations. A confirmatory factor analysis was applied to the corresponding covariances using structural equation modeling to investigate whether scores on finals shared any common variance across clerkships. In the first modeling step of the study three models were analyzed and compared: (1) a general factor model, (2) an independence model, and (3) a combined general/specific factor model. In the next modeling step, two additional models were tested to examine the nature of the relationship between preclinical knowledge and problem solving. In testing and comparing the first two models, we concluded that neither a pure content-specificity assumption nor a pure general-ability assumption could explain the data sufficiently. The performances on clerkship finals were neither fully independent, as would be expected if performance on each final was purely dependent on specific knowledge of that clerkship, nor could a single underlying factor completely explain performances on all clerkship finals, as would be expected if a general ability was responsible for performances on clerkship finals. It seemed that a combination model represented clerkship performance best. In this model clerkship-specific knowledge and a single underlying factor were both related to clinical problem solving. In an attempt to understand these findings in more depth, the second modeling step was taken to determine the nature of the relationship between preclinical knowledge and this general ability. A model relating the preclinical knowledge indicator directly to each of the clerkships was superior (Figure 2). In this particular model, both specific subject-matter preclinical knowledge and an underlying general ability influenced performance on the clerkship finals independently.

So, some aspects of problem-solving in a clinical context seemed, unlike what the early findings of Elstein et al., (1978) suggest, to have general, consistent characteristics across different problems. For example, in the study reported in Chapter 7 we were able to show, with the use of computer-based clinical cases, high levels of consistency across cases in information-gathering behavior in similar stages of the diagnostic process (i.e., history taking, physical examination, laboratory tests, imaging, and procedures). Alexander and Judy (1988) suggest that during problem solving, competent learners weigh their content knowledge against the demands of the problem and then bring in their appropriate form of strategic knowledge in order to solve the problem. It seems logical to conclude that strategies can be executed only in relation to domain-specific knowledge. However, when domain-specific knowledge develops, domain-specific problem solving will become easier and therefore less dependent on general strategies or abilities. Diagnostic problem-solving contains both specific aspects and general aspects, which explain the findings discussed in Chapter 4. For example, diagnoses can be considered a highly specific aspect of problem solving while history taking can be considered a more general skill, as indeed is more often suggested in the literature (Berner, Bligh, & Guerin, 1977; Donnelly, Gallagher, Hess, & Hogan, 1974; Juul, Noe, & Nerenberg, 1979).

Chapter 5 reported the results of a survey given to clinical teachers from the various medical specialties. The survey was intended to explore what competencies were considered important during adequate student performance on the wards and to what extent the same competencies were assessed at examinations. Thus, each individual competency was addressed twice resulting in two separate data sets. Two independent factor analyses were conducted using SEM software to uncover underlying latent relationships among the different competencies for what was considered important for performance on the wards and what was considered important during clinical examinations.

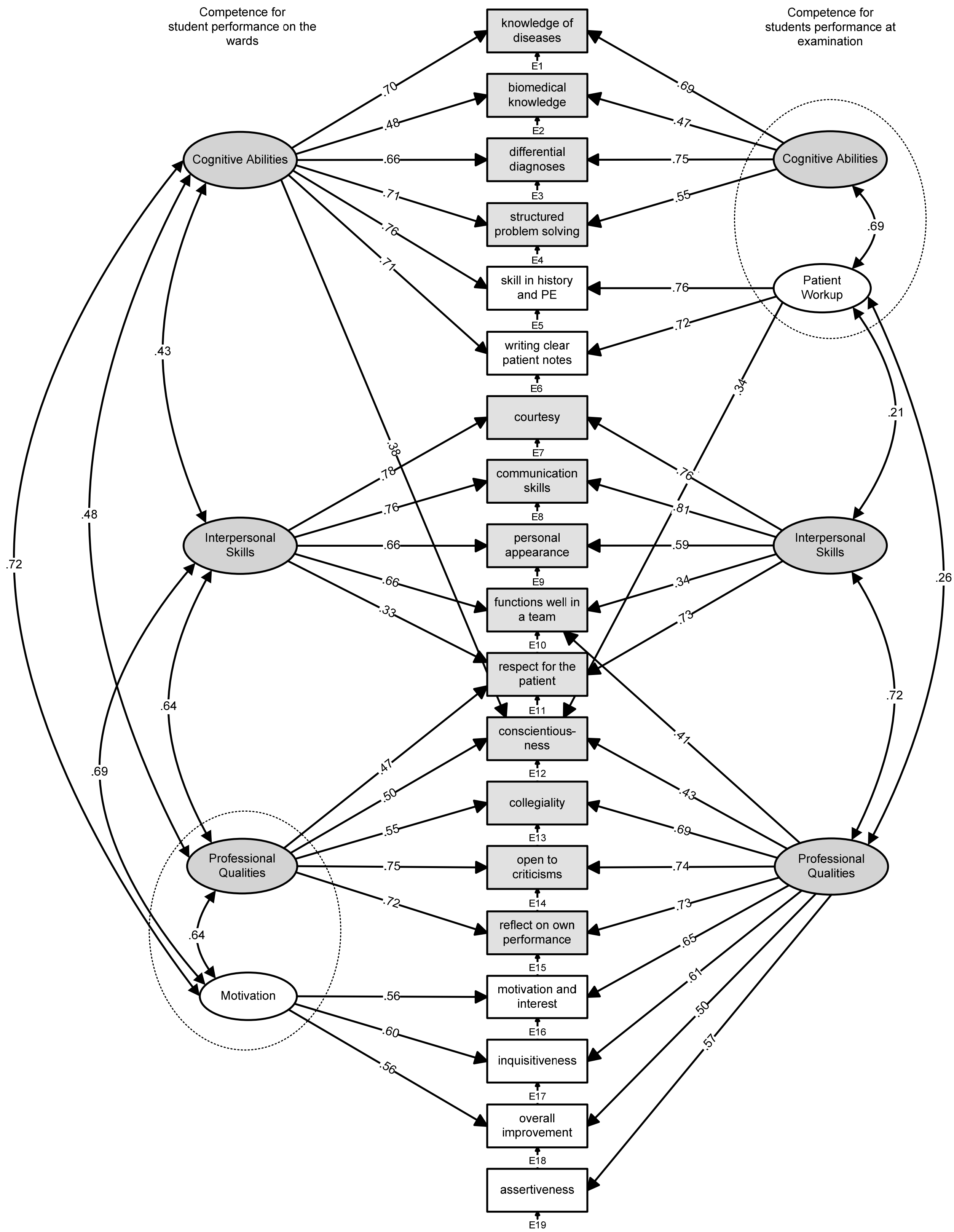

Figure 3. *Conceptualized model of the two four-factor models of the components of competence for student performance on the wards and for student performance at examinations*

Factor analysis revealed a four-factor structure for both data sets (see Figure 3). Comparing the two sets revealed that three of the four factors showed almost identical item structures between both factor models. These three components of clinical competence were in line with the classical categorization into cognitive abilities, interpersonal skills, and professional qualities (Epstein & Hundert, 2002; Forsythe, McGaghie, & Friedman, 1986). However, the results also indicated that different competencies seemed important for student performance while being examined as indicated by level of ranked importance of the individual components of competence and their underlying factor structure. Cognitive abilities were valued as relatively more important for student performance at examinations and interpersonal skills and professional qualities were seen as relatively more important for student performance on the wards. Further differences between the two models seemed to be in the fourth factor in each model: a “motivational” factor during ward performance and a “patient workup” factor for performance on student examination. Student examination seemed to be centered on cognitive abilities and diagnostic problem solving, which were only slightly related to the other factors: interpersonal skills and professional qualities. Competence as perceived during performance on the wards, on the other hand, showed moderate to high correlations among all factors. It was concluded that, based on the perception of clinical educators, what seems important for adequate performance on the ward is not necessarily in alignment with what is required for examination.

Part III: The development of clinical competence

Expertise studies in medical education research serve two main goals. First, understanding how experts solve problems provides information about the representation of knowledge, in particular how their knowledge is organized and structured. Second, comparing experts’ problem-solving capability with that of novices gives information about how expertise develops (Chi, 2006). Medical experts seem, while processing a case, to chunk relevant information into higher level summarizing concepts (or “encapsulations”). When asked to recall a case, experts tend, in contrast to less experienced participants, to recall these condensed concepts rather then the “raw” information. Therefore, less experienced participants seemed to recall more case information after processing a case than experts (or novices): this phenomenon has been termed the “intermediate effect” (Schmidt & Boshuizen, 1992, 1993a/b; Schmidt, Boshuizen, & Hobus, 1988). The study in Chapter 6 was conducted to explore expertise differences in the amount of clinical case recall. For this purpose, participants from three different levels of expertise (i.e., preclinical medical students, clinical students, and expert nephrologists) were divided into three different conditions. In the first condition, cases consisted of a context, history and physical examination, and laboratory data; in the second condition, the context was removed and the cases consisted of laboratory data only; in the third condition, instructions to elaborate on the cases was added to the laboratory data only cases. It was shown that the amount of case information recalled by experts could be influenced by requiring them to elaborate on each of the information units presented in the case. In that particular condition, case recall showed a monotonically increasing effect with increasing levels of expertise instead of an intermediate effect. In addition, removing the context lowered the diagnostic accuracy, but did not affect free recall. It was concluded that instructions to elaborate in combination with laboratory data only cases seem to have induced a deeper, more detailed, analysis of the patient case. Expertise effects in clinical case recall were produced only when the normal processing of patient information was disrupted. Case processing by experts can change under the demands of the task, like by an unusual case format or being forced to pay attention to the information units of the case by giving elaborative instructions. This study uses case recall as research method to contribute to the understanding of how knowledge is mentally represented and organized and how knowledge of experts differs from that of novices.

Another way to get insight into how knowledge is mentally represented is by observing how information is gathered from a computer-based case. Data collection or gathering normally takes place in several successive stages; the history and physical examination are the initial stages. On the basis of this information, a mental representation of the patient's problem is constructed. This process is dependent on his/her scientific and clinical knowledge and previous experience with patients. At the same time, during this cognitive process, a multitude of diagnostic hypotheses are generated and evaluated against new requested and assessed information (Elstein et al., 1978; Kassirer & Gorry, 1978). The study discussed in Chapter 7 investigated expertise differences in data-gathering behavior. In order to trace the process of data-gathering more precisely, patient cases were divided into smaller information units and into more specific stages (i.e., history, physical examination, laboratory tests, imaging, procedures, and consultations); participants of four different levels of expertise (i.e., undergraduate students, fourth-year medical students, pediatric residents, and pediatric faculty physicians) participated in this study. The number of information units selected and the consistency of this process between analogous stages across five cases were explored, and we found that experts spent more time and selected more information during history and physical examination and less information in the later stages of the diagnostic process (laboratory tests, imaging, etc) than the less experienced participants. It could be concluded that selecting more information in the initial stages of problem solving by experts seemed a strategy to reduce the problem space by eliminating a great number of (incorrect) explanations or diagnostic hypotheses. In other words, an experienced physician uses the information of the case to narrow the range of possible disorders. Taken together, two processes seemed to interact during the first stages of the diagnostic process; first, a process whereby information units in the case were used to build an initial mental representation of the problem and formulate diagnostic hypotheses, and second, a process whereby the mental representation was narrowed down by the information given (Coughlin & Patel, 1987). The latter stages (laboratory test, imaging, procedures) were primarily used to verify the diagnostic hypothesis. The less experienced participants, on the other hand, missed the necessary background knowledge to make use of the information given during history and physical examination and continued to gather information during subsequent stages of the cases: laboratory tests, imaging, procedures, and consultations. Another remarkable finding was the consistency of this behavior across five different cases. History taking and physical examination were the most general aspects of the diagnostic process and generating diagnoses the most content (or case) specific.

Conclusions

The main conclusions in this thesis are summarized here. The first conclusion pertains to the role of knowledge in medical education. In Chapter 2 we saw that for the complete cohort the correlation between pre-university performance and preclinical performance was high (r = .54), but the correlation between pre-university performance and clinical performance was much lower (r = .25). In Chapter 4 we saw that the average correlation between preclinical knowledge and performance on individual clerkship finals of 10 different disciplines is .19 (it ranged from .07 to .33). This suggests that the relationship between the preclinical knowledge variable and each of the clerkship finals is low to moderate, and preclinical knowledge plays an inconsistent role with regard to performance in each of the clerkship finals. In fact, the influence of preclinical knowledge seems to decrease over time, as the correlations seem to drop for the later clerkships. Assessment of undergraduate medical students during the preclinical phase has focused mostly on recall of factual knowledge and the application of this knowledge in problem solving. However, clinical competence is more than a process of extending causal knowledge about a domain. And even though there is enough evidence that pre-admission grades (that represented level of prior knowledge) are insufficient for predicting clinical performance, they are still the most frequently used prerequisites for admission to medical school. In addition, examinations based on recall of factual knowledge and the application of this knowledge may fail to document what students will do when faced with a real patient.

A second conclusion pertains to the importance of seeing patients in a clinical setting. The patient encounter is thought to be crucial during clinical education. There is ample evidence about what is exactly learned and how it is learned during clerkships, but more specifically, no previous studies have found a *direct* relationship between the number of clinical encounters during rotations and clinical competence (Châtenay et al., 1996; Gruppen et al., 1993; McManus et al., 1998; Van Leeuwen et al., 1997). The overall assumption that sufficient exposure to patients will in itself lead to clinical competence is not justified by our data (Chapter 3). The number of diseases seen (which is highly related with the number of patients encountered) had a small but nonsignificant influence on clinical competence (identified by practical and theoretical end-of-clerkship examinations, and professional performance), while the quality of supervision had a correlation (i.e., standardized regression coefficient) of .40 with clinical competence and a correlation of .23 with number of patient encountered by students. Clinical supervisors seem to have a stimulating effect on students' learning and students' learning environment, resulting in better performance. The quality of supervision could therefore compensate for a small number of patients (Dolmans, Wolfhagen, Essed, Scherpbier, & Van der Vleuten, 2002); proper guidance and feedback are stimulating factors for learning to occur.

A third conclusion is related to the finding of a general problem-solving ability during clinical problem solving. The study presented in Chapter 4 showes that for performance on clinical examinations a combination of both is needed: content-specific knowledge and general problem-solving skill. Chapter 7 specifies further the generalizability of some aspects of the diagnostic process. The quality of data-gathering behavior seems a consistent aspect of diagnostic problem solving across cases, in contrast to the level of diagnostic accuracy that is more related to a particular case. We reasoned that problem solving is an interaction between content or domain-specific knowledge and general abilities and takes place on a continuum between both. Problem-solving ability is dependent on case-difficulty and level of experience of the participants. The use of general processes may be more important when an individual is confronted with difficult problems as found in fields other than medicine (Glaser, 1984). If problems are too easy, then they may be little more than recall tasks for experts, and one would guess that problem-solving processes would not be generated (see for example, Schuwirth, Verheggen, van der Vleuten, Boshuizen, & Dinant, 2001).

A fourth conclusion is related to the results of the study discussed in Chapter 5. What is important for adequate student performance on the wards is, according to the perceptions of clinical educators, considered less important for examinations. For daily performance of the student on the wards, characteristics like motivation, interpersonal skills, and other professional qualities (e.g., collegiality, working in teams, respect for the patient, communication skills) are more important than cognitive abilities (e.g., knowledge of diseases, problem-solving skills, history taking and physical examination), while for clerkship examination the opposite is true. If we take into consideration that proper assessment is one of the most difficult aspects of clinical education and that faculty skills in assessment methods are often lacking, then every attempt to make more reliable and valid measurement methods will have less chance of succeeding if clinical educators lack the necessary skills or think differently about student examination in contrast to what is required for adequate daily performance on the wards. Taking into account the effects of assessment on learning, this phenomenon could jeopardize the development of clinical competence.

A final concluding remark relates to the importance of history-taking and physical examination skills. The teaching of history-taking and physical examination skills may not always get the attention it deserves (Hasnain, Bordage, Connell, & Sinacore, 2001; Pfeiffer, Madray, Ardolino, & Willms, 1998). Clinical educators very rarely directly observe students taking a history or doing a physical examination on the wards (Pulito, Donelly, Plymale, & Mentzer Jr, 2006). In Chapter 5 we saw that interpersonal skills and professional qualities are considered relatively more important for student performance on the wards than the patient workup, which is relatively more important for student performance at examinations. Nevertheless, the study discussed in Chapter 7 shows that experts are spending relatively more time than novices to collect more information during history and physical examination in contrast to laboratory data. Thus for experts, history and physical examination are considered valuable diagnostic tools. Several studies confirm the importance of history and physical examination. A study by Schmitt et al., (1986), for example, showed that history-based diagnoses could predict final diagnoses 74 % of the time. Laboratory data, on the other hand, provided hardly any diagnostic valuable information (Sills, 1978). The importance of the history and the physical examination to the diagnostic process needs special attention early in the medical curriculum, and those skills needs to be properly observed by supervisors during clinical clerkships.

Suggestions for further research

The studies presented in this thesis lead to several suggestions for further research. In Chapter 2 we saw that subgroups based on differences in pre-admission grades behave differently throughout medical school. Probably, factors other than cognitive abilities are playing an important role during the development of competence within medical school. Therefore, it would be of interest to focus research on which factors or combination of factors could be used to define groups of students with specific behaviors and study patterns. We could, for example, think of personality characteristics that contribute to clinically competent behavior, like emotional stability, empathic ability, adaptability, ability to be self-critical, or conscientiousness (Chapter 5). These personality characteristics might be particularly important in the later clinical years of medical school and residency. We saw in Chapter 3 that simple exposure to patients is not enough to acquire the essential competencies. A combination of factors related to the learning environment seems important (e.g., patient encounters in combination with proper feedback). Of interest is what and how do students learn from patient encounters, and more specifically, what other aspects of clinical supervision are needed for an optimal learning effect? More information is also needed about which other components of the hospital environment contribute to the development of students' clinical competence.

Another finding with consequences for medical education research is the content-specificity of problem solving. We saw in Chapter 4 that performance seems to contain both a general element, related to a problem-solving ability, and specific elements, related to domain knowledge. Clinical problem solving is probably an interaction between a general ability and content knowledge depending on the level of experience of the student, level of difficulty of what is assessed, and which aspect(s) of the diagnostic process or clinical competence is emphasized. Research should be focused on the critical analysis of the interaction between domain-specific knowledge and domain-general strategies or abilities. The models tested in Chapter 4 could be applied to participants with different levels of expertise. Doing so could verify whether an increased level of experience is related to a decreased application of a general problem-solving ability. Furthermore, it would be important to provide participants with problems from different levels of difficulty because it is reasonable to assume that if content knowledge is sufficient to solve a problem, the need for applying general strategies decreases.

Studies emphasizing processing differences between novices and experts have given important insights into the development of competence. In a laboratory setting many kinds of task variations and manipulations of conditions and instructions are possible. In Chapter 6, manipulation of case format and instruction had an effect on the way experts process a case—a strong argument in favor of the knowledge encapsulation theory because only the experts are considered to have developed sufficient encapsulations to deal with everyday cases, and therefore, only their performance is disrupted by the particular treatment. This disruption also manifested itself in the processing speed of the doctors (but not of the students); processing of the laboratory data in the laboratory-data-plus-elaboration condition took almost three times longer than processing the same data in the clinical context condition. One possibility to verify this disruption-of-processing hypothesis is to require participants to elaborate on cases for which intermediate effects have been demonstrated in the past (Patel & Groen, 1991; Schmidt & Boshuizen, 1993b). The prediction would be that expertise effects in recall might be induced for these cases as well. A second possibility would be to ask participants to undertake additional and unrelated tasks while processing a case. This would limit working memory capacity and might also disrupt the skill of expert doctors to automatically translate sets of signs and symptoms into their underlying encapsulations.

Data-gathering behavior, as described in the study of Chapter 7, generated additional interesting suggestions for future research. This study looked at data-gathering differences between novices and experts during different stages of the diagnostic process. Experts in contrast to novices collected more information in the initial stages of processing (i.e., history and physical examination). This phenomenon suggests two possible explanations that are both testable: The amount of information collected serves a role in generating a more elaborate knowledge representation, or it only eliminates solutions no longer deemed relevant. Of particular interest is how those two processes interact with each other. From an educational perspective, the question of to what extent the knowledge representation and/or diagnostic outcome would change if students were 'forced' to spend more time on history and physical examination of a case would be worth considering.

Combining the methodologies used in the studies of Chapter 6 and 7 may lead to new insights. The study in chapter 6 made use of "free recall," while the study in chapter 7 attempted to "track" processing directly. Both methods have advantages and disadvantages. Direct tracking of data-gathering behavior could be combined with indirect methods such as free recall or verbal think-aloud protocols. Could we expect, in this particular case, that experts' free recall would outperform students' free recall of information in the first stages of the case in contrast to later stages? An analysis of think-aloud protocols, comparing and contrasting different stages of the case might be worth considering. The findings of Chapter 5, 6, and 7 have in common that case processing changes under the demands of the task (or demands of the task in combination with instructions). A further specification of what particular demands change case processing is needed. Whether level of case difficulty might be an indicator for a shift in processing needs more clarification.

Chapter five highlights the perceived difference (according clinical educators) between what competencies are considered important for adequate performance during clerkships and what are required to do well on examinations. Cognitive abilities were relatively more important for student performance at examinations and interpersonal skills and professional qualities were relatively more important for student performance on the wards. This difference, for example, could refer to a more commonly addressed problem that clinical educators rarely observe students taking a history or doing a physical examination on the wards. Future research should focus on an explanation for this discrepancy in perception and what the consequences are of this discrepancy in perception for clinical education and assessment. A start can be made by using a qualitative approach to look more deeply into the perceptions of clinical educators.

References

Albanese, M. A., Snow, M. H., Skochelak, S. E., Hugett, K. N., & Farell, P. M. (2003). Assessing personal qualities in medical school admissions. *Academic Medicine, 78*(3), 313-321.

Alexander, P. A., & Judy, J. E. (1988). The interaction of domain-specific and strategic knowledge in academic performance. *Review of Educational Research, 58*(4), 375-404.

Berner, E. S., Bligh, T. J., & Guerin, R. O. (1977). An indication for a process dimension in medical problem solving. *Medical Education, 11*, 324-328.

Boshuizen, H. P. A. (2005). Does practice make perfect? A slow and discontinues process. In H. P. A. Boshuizen, R. Bromme & H. Gruber (Eds.), *Professional Learning: Gaps and Transitions on the way from Novice to Expert* (Vol. 2). Dordrecht / Boston / London: Kluwer Academic Publishers.

Butterfield, P. S., & Libertin, A. G. (1993). Learning outcomes of an ambulatory care rotation in internal medicine for junior medical students. *Journal of General Internal Medicine, 8*(4), 189-192.

Châtenay, M., Maguire, T., Skakun, E., Chang, G., Cook, D., & Warnock, G. L. (1996). Does the volume of clinical experiences affect performance of clinical clerks on surgery exit examinations? *The American Journal of Surgery, 172*(4), 366-372.

Chi, M. T. H. (2006). Methods to access the representation of experts' and novices' knowledge. In K. A. Ericsson, N. Charness, P. J. Feltovich & R. R. Hoffman (Eds.), *The Cambridge Handbook of Expertise and Expert Performance*: Cambridge University Press.

Coughlin, L. D., & Patel, V. L. (1987). Processing of critical information by physicians and medical students. *Medical Education, 62*, 818-828.

Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., Essed, G. G. M., Scherpbier, A. J. J. A., & Van der Vleuten, C. P. M. (2002). The impacts of supervision, patient mix and numbers of students on the effectiveness of clinical rotations. *Academic Medicine, 77*(4), 332-335.

Donnelly, M. B., Gallagher, R. E., Hess, J. W., & Hogan, M. J. (1974). *The dimensionality of measures derived from complex clinical simulations.* Paper presented at the Thirteenth Annual Conference on Research in Medical Education, Chicago, IL, US.

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: an analysis of clinical reasoning*. London, Cambridge, Mass: Harvard University Press.

Epstein, R. M., & Hundert, E. M. (2002). Defining and assessing professional competence. *JAMA, 287*(2), 226-235.

Ericsson, K. A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine, 79*(10 Suppl), S70-S81.

Ericsson, K. A., & Charness, N. (1994). Expert performance: its structure and acquisition. *American Psychology, 49*(8), 725-747.

Forsythe, G. B., McGaghie, W. C., & Friedman, C. P. (1986). Construct validity of medical clinical competence measures: a Multitrait-Multimethod Matrix study using confirmatory factor analysis. *American Educational Research Journal 23*(2), 315-336.

Glaser, R. (1984). Education and Thinking: The role of knowledge. *American Psychologist, 39*, 93-104.

Gruppen, L. D., Wisdom, K., Anderson, D. S., & Woolliscroft, J. O. (1993). Assessing the consistency and educational benefits of students' clinical experiences during an ambulatory care internal medicine rotation. *Academic Medicine, 68*(9), 674-680.

Hasnain, M., Bordage, G., Connell, K. J., & Sinacore, J. M. (2001). History-taking behaviors associated with diagnostic competence of clerks: an exploratory study. *Academic Medicine, 76*(Suppl 10), S14-S17.

Juul, D. H., Noe, M. J., & Nerenberg, R. L. (1979). A factor analytic study of branching patient management problems. *Medical Education., 13*(3), 199-205.

Kassirer, J. P., & Gorry, A. G. (1978). Clinical problem solving: a behavioral analysis. *Annals of Internal Medicine, 89*, 245-255.

McManus, I. C., Richards, P., Winder, B. C., & Sproston, K. A. (1998). Clinical experience, performance in final examinations, and learning style in medical students: prospective study. *BMJ, 316*, 345-350.

Moulaert, V., Verwijnen, M. G. M., Rikers, R. M. J. P., & Scherpbier, A. J. J. A. (2004). The effects of deliberate practice in undergraduate medical education. *Medical Education, 18*, 1044-1052.

Neufeld, V. R., & Norman, G. R. (1985). *Assessing Clinical Competence*. New York: Springer-Verlag.

Patel, V. L., & Groen, G. J. (1991). The general and specific nature of medical expertise: A critical look. In K. A. Ericsson & J. Smith (Eds.), *Toward a general theory of expertise, prospects and limits*. Cambridge: Cambridge University Press.

Pfeiffer, C., Madray, H., Ardolino, A., & Willms, J. (1998). The rise and fall of students' skill in obtaining a medical history. *Medical Education, 32*(3), 283-288.

Pulito, A. R., Donelly, M. B., Plymale, M., & Mentzer Jr, R. M. (2006). What do faculty observe of medical students' clinical performance. *Teaching and Learning in Medicine, 18*(2), 99-104.

Schmidt, H. G., & Boshuizen, H. P. A. (1992). Encapsulation of Biomedical Knowledge. In A. E. Evans & V. L. Patel (Eds.), *Advanced models of cognition for medical training and practice* (pp. 265-282). New York, NY: Springer-Verlag.

Schmidt, H. G., & Boshuizen, H. P. A. (1993a). On Acquiring Expertise in Medicine. *Educational Psychological Review, 5*(3), 205-221.

Schmidt, H. G., & Boshuizen, H. P. A. (1993b). On the origin of intermediate effects in clinical case recall. *Memory & Cognition, 21*(3), 338-351.

Schmidt, H. G., Boshuizen, P. A., & Hobus, P. P. M. (1988, 17-19 August 1988). *Transitory stages in the development of medical expertise: The "intermediate effect" in clinical representations studies.* Paper presented at the Tenth Annual Conference of the Cognitive Science Society, Montreal, Quebec, Canada.

Schmitt, B. P., Kushner, M. S., & Wiener, S. L. (1986). The diagnostic usefulness of the histroy of the patient with dyspnea. *Journal of General Internal Medicine, 1*, 386-393.

Schuwirth, L. W. T., Verheggen, M. M., van der Vleuten, C. P. M., Boshuizen, H. P. A., & Dinant, G. J. (2001). Do short cases elicit different thinking processes than factual knowledge questions do? *Medical Education, 35*(4), 348-356.

Schwartz, R. W., Donnelly, M. B., Sloan, D. A., & Young, B. (1994). Knowledge gain in a problem-based surgery clerkship. *Academic Medicine, 69*, 148-151.

Sills, R. H. (1978). Failure to Thrive: The role of clinical and laboratory evaluation. *Am J Dis Child, 132*, 967-969.

Snell, L. M., Battles, J. B., Bedford, J. A., & Washington, E. T. (1998). Verifying the curriculum of a family medicine clerkship. *Medical Education, 32*, 370-375.

Van Leeuwen, Y. D., Düsman, H., Mol, S. S. L., Pollemans, M. C., Drop, M. J., Grol, R. P. T. M., et al. (1997). Factors Influencing the Growth in Knowledge of Trainees in General Practice. *Advances in Health Sciences Education, 2*(1), 61-70.

Webb, C. T., Sedlacek, W., Cohen, D., Shields, P., Gracely, E., Hawkins, M., et al. (1997). The impact of nonacademic varables on performance at two medical schools. *Journal of the National Medical Association, 89*(3), 173-180.

Witzke, D. B., Koff, N. A., McGeagh, A. M., & Skinner, P. D. (1990). Developing a computer-based system to document and report students' clinical encounters. *Academic Medicine, 65*(7), 440-441.