Strategic choices in curriculum design to facilitate knowledge and competency development
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Acquisition and retention of discipline-specific knowledge during clerkships

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Submitted
ABSTRACT

Introduction Longer clerkship rotations are increasingly advocated in medical education literature. Due to limited time in the clinical phase, implementing longer rotations means that students can rotate through fewer disciplines. Little is known about the added value of visiting specific disciplines. We investigated the effect of clerkship rotations on students’ discipline-specific knowledge and whether it changes over time.

Methods To measure students’ (n=189) discipline-specific knowledge throughout their clinical phase, we gathered their item scores on twelve progress tests in five disciplines: gynaecology & obstetrics, paediatrics, neurology, psychiatry and family practice. For each discipline, we determined which progress tests individual students sat in each of the following conditions: before, during and after their clerkship rotation and, if applicable, during and after their second rotation in the same discipline. We compared students’ knowledge level in these conditions using a multilevel logistic regression for the probability that an item would be answered correctly, with items nested in progress tests which were nested in students. Additionally, we analysed the effect of the time passed since the clerkship on students’ knowledge, using the same multilevel logistic regression. Gender, time passed since the start of the clinical phase, item difficulty, entry level, and personal interest were added as covariates in all analyses.

Results We found a significant increase in discipline-specific knowledge during and after a corresponding clerkship rotation in all disciplines except family practice (odds ratio during and after vs. before= 1.33-2.77; p<.01). After completion of a clerkship, students showed a significant decrease in discipline-specific knowledge of 1-3% per month (p<.01) in three out of five disciplines.

Discussion Our study confirms that a clerkship rotation through a discipline generally increases students’ discipline-specific knowledge, however, it will decrease considerably after completion of the clerkship. Our findings suggest that longer rotations may negatively affect students’ knowledge about disciplines they do not rotate through as a consequence. However, given the significant decrease in discipline-specific knowledge after a clerkship, the impact of not rotating through a clerkship may be ameliorated.
INTRODUCTION

In current medical education literature, the traditional rotational approach to clerkships has been receiving criticism. There is an increasing emphasis on longitudinal attachments with patients, supervisors and departments to facilitate undergraduate students’ learning.1-3 As a consequence, Longitudinal Integrated Clerkships and hybrid models receive increasing attention and support.5-8 The underlying rationale is that longitudinal attachments facilitate learning. From a competency-based perspective, longitudinal attachments help students develop general competencies and attain high-quality formative feedback from their supervisors.5-9 From a socio-cultural perspective, learning could be more meaningful when students are immersed in a specific environment, which requires considerable time spent in that environment.1,2,9 Considering the limited duration of the clinical phase, implementing longer attachments will limit the number of disciplines students can rotate through during clerkships. This may impair students’ knowledge in disciplines they do not encounter. Insight into the relation between rotating through a discipline and students’ discipline-specific knowledge may help us take more informed decisions regarding clerkship design. Therefore, we examined the effect of following a clerkship on students’ discipline-specific knowledge development and retention during their clinical phase, for various disciplines.

The clinical phase is important for students’ knowledge development and retention. Students engage in workplace-based learning in which they do not only learn through modelling, but also through actively participating in situations that occur in the clinical learning environment.10-12 As students participate in medical practice, they apply their previously attained knowledge and, by doing so, develop new knowledge structures and gain a more complex understanding of the clinical problems they encounter.13 Furthermore, they are regularly challenged to actively retrieve discipline-specific knowledge, which has been shown to be one of the most powerful strategies for reinforcing knowledge retention.14,15

During clerkships, students’ discipline-specific knowledge will increase due to application and active retrieval of knowledge. However, this knowledge will probably not be fully retained. The accessibility of knowledge will generally decrease after a goal has been reached – for example, finishing a clinical rotation successfully.16-19 For knowledge to be retained, it needs to be reactivated regularly.14,20 When students rotate through a specific discipline, knowledge concerning other disciplines probably will be less activated and, therefore, it will decline. Knowledge is known to decline according to a forgetting curve in which a rapid initial decline is followed by a period of more gradual decline.17, 21-24 Hence, when investigating how a clerkship affects discipline-specific knowledge, it is important to study the rate of knowledge decline after the clerkship rotation as well.
The call for more longitudinal attachments raises the question how not rotating through a specific discipline during clerkships affects students’ knowledge about that discipline. The effect may depend on the domain specificity of a discipline, because general medical disciplines offer a greater diversity of cases than specialized departments do. A general discipline will offer cases which are likely to be encountered at other departments. Not rotating through a general discipline may therefore be compensated by encountering relevant cases during rotations through other disciplines. As a corollary, one would expect students’ discipline-specific knowledge to increase, even when they have not rotated through a general discipline, and the decline of discipline-specific knowledge to be less pronounced due to regular retrieval. Cases concerning a more specialized discipline are less likely to be encountered in other departments. Therefore, one might expect that not rotating through a specialized discipline leads to hiatus in discipline-specific knowledge.

In the current study, we explored students’ knowledge development and retention during their clerkships. We investigated whether rotating through a discipline affects discipline-specific knowledge and whether and to what extent discipline-specific knowledge changes over time after the rotation.

METHODS

Participants and context

In the Netherlands, undergraduate medical education entails a 6-year competency-based curriculum that consists of a 3-year preclinical Bachelor’s programme and a 3-year clinical Master’s programme. In this study we gathered data about all 189 medical students who started their Master’s programme at the University of Groningen in September and October 2007 (Figure 1).

During their first master year students rotated through four ten-week modules. In each module, a five-week period in the clinical training centre is followed by a five week clinical rotation at the University Medical Center Groningen (UMCG) (Figure 1). During the second year they did 10 four-week clerkship rotations in one of six affiliated
hospitals, sometimes a second rotation in a discipline. During the third year students spent 20 weeks on writing a scientific thesis and 20 weeks on a clinical elective in a discipline of their choice.

Throughout the Master’s programme students sat the Dutch interuniversity progress test four times per year.\textsuperscript{27} Each progress test is administered to all students of participating medical schools and consists of 200 multiple choice questions assessing knowledge in a variety of disciplines. Each discipline is assessed using a fixed number of questions per test (Table 1).

**Data Gathering**
We measured students’ discipline-specific knowledge using their results on the 12 progress tests after the start of their Master’s programme. Additionally, we gathered data on several covariates. From the university administration we extracted information on students’ gender and entry level. Entry level was defined as obtaining the medical Bachelor’s degree nominally (within 3 years), or not nominally (>3 years), or with a biomedical Bachelor’s degree after a transitional year, as described by Cohen-Schotanus et al.\textsuperscript{28} We also collected data on the disciplines of the students’ clinical electives, as an indicator for personal interest.

**Analysis**
From the disciplines assessed by the progress test (Table 1), we first selected disciplines that were covered by sufficient items in each progress test (≥ 7) and that students could rotate through during clerkships. Subsequently, we excluded general internal medicine and general surgery, because departments offering rotations in these disciplines highly differed in their extent of specialization. For example, for an internal medicine clerkship students could rotate through a department of general internal medicine, but also solely through a gastroenterology or pulmonology department. Ultimately, we investigated four specialized disciplines: gynaecology & obstetrics, paediatrics, neurology and psychiatry. One general discipline was selected, family practice.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Questions per progress test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery</td>
<td>17</td>
</tr>
<tr>
<td>Dermatology</td>
<td>5</td>
</tr>
<tr>
<td>Gynaecology &amp; Obstetrics</td>
<td>10</td>
</tr>
<tr>
<td>Family practice</td>
<td>20</td>
</tr>
<tr>
<td>Internal Medicine</td>
<td>29</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>11</td>
</tr>
<tr>
<td>Otorhinolaryngology</td>
<td>4</td>
</tr>
<tr>
<td>Neurology</td>
<td>7</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>4</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>16</td>
</tr>
<tr>
<td>Social Medicine</td>
<td>4</td>
</tr>
</tbody>
</table>

We performed the following procedure for each of the five selected disciplines. For each progress test we determined whether a student sat the test before, during or after the clerkship rotation. If students had done a second rotation in the same discipline, we additionally determined when they sat progress tests during or after their second rotation. Accordingly, each progress test was sat in one out of 5 conditions: before any rotation, during a first rotation, after a first rotation, during a second rotation and after a second rotation. Too few students sat a test during a
second clerkship rotation to achieve enough power for our analysis and, therefore, this condition was excluded from analysis.

We analysed the data using a multi-level model with answers to items nested in progress tests which, in turn, were nested in students. To analyse the effect of rotating through a clerkship on discipline-specific knowledge, we used multi-level logistic regression to calculate the relative odds that students answered a discipline-specific question correctly in each of the four conditions. To analyse knowledge retention after rotating through a clerkship we selected items answered after the first rotation. In addition, we used multi-level logistic regression to analyse how the odds of answering a discipline-specific question correctly were affected by the amount of time passed since the end of the rotation. Gender, item difficulty, entry level, and personal interest were added as covariates in both analyses. Item difficulty was derived from the results of all master students of all medical schools participating in the Dutch interuniversity progress test. Personal interest was a binary variable, indicating whether a student had chosen the specific discipline as a clinical elective in the third master year. Furthermore, time passed since the start of the clinical phase was also added as a covariate to correct for advancement in the curriculum, since knowledge as measured by the progress test generally increases over time, independent of a specific intervention.27, 29-31

RESULTS

For each discipline except family practice, the odds that students would answer a discipline-specific question correctly was 1.33 to 2.70 times higher during and after a first and after a second clerkship, than before rotating through the specific discipline (p<0.01; Table 2). For family practice the odds during a clerkship did not differ significantly from the odds before the clerkship, while the odds after a clerkship were significantly lower than the odds before (odds ratio after vs. before =0.84; p<0.001). After rotating through a first clerkship the odds were lower than during the clerkship, for all disciplines except paediatrics (odds ratio after vs. during between 0.60 and 0.75). After a second clerkship odds for a correct answer were significantly higher than after a first clerkship for neurology (odds ratio after 2nd vs. after 1st =1.43; p<0.01) and paediatrics (odds ratio after 2nd vs. after 1st =1.38; p<0.01).

Discipline-specific knowledge was not affected by time passed since the clerkship for psychiatry and family practice. For the other disciplines, the odds for answering a question correctly decreased significantly with 1-3% per month (p<0.01).
Table 2. Odds ratio of a correct answer to a progress test question in a specific discipline during and after a clerkship rotation and after a second clerkship rotation versus a reference condition.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Reference condition</th>
<th>During first rotation Odds ratio</th>
<th>After first rotation Odds ratio</th>
<th>After second rotation Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gynaecology &amp; Obstetrics</td>
<td>No rotation</td>
<td>2.70*</td>
<td>1.62*</td>
<td>1.92*</td>
</tr>
<tr>
<td></td>
<td>During rotation</td>
<td>0.60*</td>
<td>0.71*</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>After rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paediatrics</td>
<td>No rotation</td>
<td>1.39*</td>
<td>1.33*</td>
<td>1.82*</td>
</tr>
<tr>
<td></td>
<td>During rotation</td>
<td>0.96</td>
<td>1.31</td>
<td>1.38*</td>
</tr>
<tr>
<td></td>
<td>After rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurology</td>
<td>No rotation</td>
<td>2.43*</td>
<td>1.64*</td>
<td>2.35*</td>
</tr>
<tr>
<td></td>
<td>During rotation</td>
<td>0.68*</td>
<td>0.97</td>
<td>1.43*</td>
</tr>
<tr>
<td></td>
<td>After rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family practice**</td>
<td>No rotation</td>
<td>1.12</td>
<td>0.84*</td>
<td>1.43*</td>
</tr>
<tr>
<td></td>
<td>During rotation</td>
<td>0.75*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychiatry</td>
<td>No rotation</td>
<td>1.87*</td>
<td>1.36*</td>
<td>1.53*</td>
</tr>
<tr>
<td></td>
<td>During rotation</td>
<td>0.73*</td>
<td>0.82</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>After rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = Significant at the α = 0.01 level
** = Comparisons with 'during a second rotation' are missing because students can only rotate once through family practice

DISCUSSION

In this study we found a significant increase in discipline-specific knowledge after rotating through a corresponding clerkship in four out of five disciplines. This confirms the theory that retrieval of existing discipline-specific knowledge leads to better retention and that being engaged with discipline-specific cases stimulates knowledge development.13-15,18 We also found that after the rotation the odds to answer a discipline-specific question decreased in three out of five disciplines. These findings show that even though clerkships positively affect students’ discipline-specific knowledge, one should keep in mind that at the end of the curriculum a large part of the knowledge gained may not have been retained, with odds decreasing with 1-3% per month.

Our results suggest that most of the disciplines we investigated are indeed specific and, therefore, a corresponding clerkship rotation has a pronounced effect on students’ discipline-specific knowledge. This is further underlined by the fact that we did not find an effect of rotating through family practice, which is known as a broad discipline. Family practitioners work with a very diverse case load.32,33 Therefore, many cases involving knowledge specific to family practice can be encountered in other disciplines as well. This may explain why rotating through general disciplines did not cause an improvement in discipline-specific knowledge. That the odds to answer a question correctly were
even significantly lower after than before the rotation is probably caused by the correction for general knowledge growth. Given the broadness of family practice, it may well be that declarative knowledge concerning family practice is broader than the questions on the topic in the progress test.

We did not find a significant decrease after a rotation in paediatrics. This may be caused by the relatively small odds increase we found during the clerkship. It implies that rotating through paediatrics may not have improved students discipline-specific knowledge as much as rotating through the other disciplines, which means that students have less knowledge to be retained. Alternatively, this outcome may indicate that paediatrics is not as specialized as the other disciplines but less general than family practice.

Our analysis shows that the decrease was 1-3% per month for the disciplines where decreasing odds were observed. This implies that after one year students have knowledge retention of approximately 70-90% and after three years 30-70%. These figures suggest that a large part of the body of knowledge developed during a clerkship rotation at the beginning of a three-year curriculum may be lost at graduation. However, this finding should be interpreted with caution. On the one hand, we used progress tests to measure knowledge in order to achieve some kind of standardization and comparability between measurement points. However, these tests are taken only four times per year, which means that we have few measurements at or just after the end of a clerkship rotation. Since knowledge most rapidly declines just after a task is finished,16-19 we may have missed the most rapid decline and, consequently, may underestimate the decrease in knowledge. On the other hand, relearning information that is forgotten is more effective than learning completely new information.34, 35 Therefore, we do not presume a direct relationship between the benefit of clerkship rotations and knowledge retention.

Concerning the added value of a second clerkship rotation our results are ambiguous. The results from paediatrics and neurology do suggest that the odds to answer a question correctly are significantly higher after a second than after a first rotation. However, this was not found for gynaecology & obstetrics and psychiatry. This possibly stems from differences between the first two and the latter two disciplines, and may be attributable to students’ motives for a second clerkship. It may be that second rotations in paediatrics and neurology are more often chosen to mend deficiencies, while gynaecology & obstetrics and psychiatry are more often chosen out of interest. Alternatively, the difference may stem from the extent of specialization. Possibly, more cases related to paediatrics and neurology can be encountered outside these disciplines than cases related to the other two. Which factor makes the difference, however, is unknown. Further research is needed into what determines the added value of a second clerkship rotation in the same discipline and, if so, whether this positively affects discipline-specific knowledge.

An important limitation of this study is that we solely focused on factual declarative knowledge. However, research on the development of medical expertise suggests that during medical training a profound
change occurs in the way knowledge is structured. Elaborate causal networks, mainly accumulated during the preclinical years and consisting of declarative knowledge about causes and consequences of diseases, gradually become encapsulated into diagnostic models that are used to explain symptoms and signs. As a result of experiences in clinical practice, this encapsulated knowledge is then reorganized into highly personalized, narrative structures, called ‘illness scripts’, which focus less on biomedical facts and more on clinical information.

Furthermore, in particular during their clerkships medical students learn to integrate knowledge, skills and professional behaviour. Knowledge is only part of the competencies students develop during their training. However, we are just starting to assess competencies and competency development. Our medical school does not have periodical standardized tests for the assessment of competencies available yet. Therefore, we limited our study to declarative knowledge.

This study was also limited to a single medical curriculum. All first-year rotations took place in the UMCG and students rotated through the second-year clerkships in one of six affiliated hospitals. Therefore, we expect that the diversity – in for example teachers or departmental cultures – was well sampled.

How we plan our clerkship rotations affects students’ knowledge development. With a limited time in the clinical phase and increasing duration of clerkship rotations, rotating through one discipline means not rotating through another. The current study shows that not rotating through a discipline during clerkships will negatively affect students’ discipline-specific knowledge, because it will be significantly less. However, the relevance of this outcome should be discussed in the light of the findings that this knowledge will also decrease significantly over time on the one hand and that relearning knowledge is easier than initial learning on the other hand. Furthermore, our outcomes do not lead us to discard the idea of longer rotations. In our study we did not investigate the potential benefits of longer rotations nor did we investigate how clerkship rotations affect other educational outcomes, like procedural knowledge and competency development. A much broader perspective is needed before we can decide how to plan our clerkships. The current study, offers a piece of the puzzle.
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