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Education in Clinical Reasoning: An Experimental Study on Strategies to Foster Novice Medical Students' Engagement in Learning Activities

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Abstract

Purpose: Clinical reasoning forms the interface between medical knowledge and medical practice. However, it is not clear how to organize education to foster the development of clinical reasoning. This study compared two strategies to teach clinical reasoning.
Method: As part of a regular clinical reasoning course 333 students participated in a two-phase experiment. In the learning phase, participants were randomly assigned to either the conventional strategy (CS) or the new strategy (NS). Participants in the CS solved a clinical case using a written description of a patient encounter and individual study. Participants assigned to the NS solved the same case using a video patient encounter and group discussion. One week later, all participants took the same diagnostic performance test. Performance on the diagnostic test and differences between the groups regarding their interest, cognitive engagement, appreciation of the educational activity, and time investment in self-study were analyzed.
Results: There was no significant effect of teaching strategy on diagnostic performance ($p = .23$). Students in the NS condition showed more interest during the session ($p = .003$) and were more appreciative of the course when assigning an overall grade than the students in the CS condition ($p < .001$). The NS students reported having spent fewer hours studying the clinical case individually before the group session than the CS students ($p < .001$).
Discussion: The NS resulted in more students' involvement and higher appreciation of the learning activity compared to the CS. There was no difference in diagnostic accuracy, but the NS seems more efficient: to achieve the same performance, the NS students needed only half the preparation time before the learning session than the students working under the CS. This higher efficiency may be due to the benefits of small-group learning, but clarifying this finding requires further investigation.

Keywords: Clinical reasoning; Medical education; Medical students; Educational strategies

1. Introduction

The capacity of solving clinical problems through clinical reasoning forms the interface between medical knowledge and medical practice. Over the last 30 years there has been a growing attention towards both research on the mental processes involved in clinical

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reasoning and on how to optimize application of research findings in medical education in order to provide students with adequate diagnostic competence.[1] The uncertainty remains, however, on how to translate what we know on how doctors reason to make diagnoses into instructional approaches to teach clinical reasoning.[2]

Medical education and medical practice often show a remarkable opposition in the way in which medical students learn the process of problem solving by clinical reasoning and the mechanism applied for that by both beginning and expert practicing physicians. [3,4] Whereas medical education traditionally embraces the analytical pathway in teaching clinical reasoning it appears more and more that there is a non-analytical base of clinical reasoning. Analytical processes proceed in a conscious way. They refer to a controlled and systematic consideration of features and their relation to potential diagnoses whereas the non-analytical pathway refers to rapid unconscious processes such as pattern recognition that provides a valid alternative mechanism to diagnostic decision-making.[5]

Recognizing the correct diagnosis, because of similarity to one that has been seen in the past, this form of reasoning describes much of the activity in which both experts and novices engage,[6] the former of course provided with an extended content of cases. This is why practicing doctors seldom exploit the analytical route deliberately.[7] Moreover, they pay much greater attention than novices to conditions that may contribute to or protect against acquisition of a specific disease. These enabling conditions[8] are included in the so-called illness scripts.[9] "These are mental representations of diseases consisting of scenarios of patients with a particular disease, with the relationship between its sign and symptoms, its causal mechanisms, and the conditions under which the disease is likely to occur".[10] Activation of scripts requires a virtual or real patient encounter and consists of a largely unconscious popping up of hypotheses, immediately followed by conscious access to a set of attributes and expectations that guide the deliberate search for evidence to confirm these hypotheses or to rule them out.[3,6]

However, illness scripts only develop in students' memory as they start to repeatedly apply previously acquired knowledge of the causal mechanisms of diseases to understand patients' problems. In the early years of their education, students rely largely on an analytical way of reasoning, trying to apply their theoretical – mostly biomedical knowledge and gradually more clinical knowledge – to solve clinical problems. Gradually, these cause-effect relationships between the pathophysiological mechanisms and signs and symptoms of a disease become "encapsulated" into broader, simplified causal models that support the adjustment and application of the illness scripts. Novices will have a need for speaking out their analytical considerations, whereas experts apply these in a tacit, "encapsulated",[3] way. Nevertheless, both theoretical biomedical knowledge and clinical knowledge are indispensable not only for novices but also in lifelong professional practice of experts.[11] Besides that, scripts acquisition reflects the integration of biomedical knowledge and clinical knowledge that is why it is of utmost importance to help medical students right from the start of their training in the development of their embryonic illness scripts and their enclosed procedure of verification by allowing them to work with patient problems.[12]

To sum up, education in clinical reasoning might emphasize both the acquisition of biomedical and clinical knowledge, both indispensable in forming students' illness scripts, and aim at fostering in students both the analytical and the pattern recognition modes.[5,13] If there seems to be a consensus about these notions, it is not clear however how they should be put into practice. The literature does not provide us with clear guidance concerning how to organize the teaching of clinical reasoning in a way that encourages especially beginning medical students to be passionate to reap the benefits of this two interwoven strategies.

In recent years, many medical schools have established special courses to teach clinical reasoning, starting sometimes already in the first year.[14] This applies also to our institution, which has a clinical reasoning course running from the first to the fourth year. As in many other schools, this course consists basically of having students working individually through written clinical cases, step-by-step, with feedback from the teachers provided (in our case in small group meetings) by the end of the whole process. This teaching model, in its general characteristics, is not peculiar to our institution but rather common. Within such a model, two easily modifiable factors might positively influence students' interest in and engagement with clinical problem solving, without changing the overall focus on both analytical and non-analytical reasoning.

The first factor refers to the format of the presentation of the clinical problem. Instead of a written presentation, we decided to make use of a short videotape presentation, where a patient is telling his or her complaints to a general practitioner. The second factor refers to group-wise opposite to individual

approach of the problem solving. Instead of individual homework based on written assignments, leading to delayed feedback from a teacher, students were encouraged to reason aloud in a group of peers and provided with immediate feedback from the teacher and from their peers.

Our hypothesis was that this new form of practice with the clinical problem would increase students' interest and engagement with the problem solving, consequently fostering their learning relative to the old approach. The video form of the patient encounter might facilitate a sense of being a real doctor among students, leading to a greater involvement of the students in the case in comparison to a written presentation, and possibly to higher satisfaction with the training. The motivational and cognitive effects of small group learning have been well demonstrated,[15] and we expected them to act also here. The group discussion, by requiring students to explain their own reasoning, directing attention to eventual flaws, providing immediate feedback, and allowing for learning from the direct input of the colleagues, might foster knowledge restructuring, which may eventually help in developing illness scripts that students start to build in memory.

The purpose of this study is to compare a set of outcomes of the two aforementioned approaches for practice with clinical problems during clinical reasoning training. Specifically, the study aimed to determine whether there is any difference in diagnostic accuracy, interest, cognitive engagement and appreciation of the educational activity, and time investment in self-study between beginning medical students who work with a video patient encounter and group-wise training and those who work individually with a written clinical case.

2. Method

2.1. Overview

The study took place as part of a regular, mandatory, course in clinical reasoning that the medical school offers to first-year undergraduate student. The experiment had two phases: a learning phase, which consisted of studying a clinical case by following either the existing conventional strategy (CS) or the new strategy (NS), and a test phase run one-week later. In the learning phase, all students worked with the same clinical case, either under the CS or under the NS conditions, depending on the experimental condition to which they were assigned. One week later, all students took a diagnostic performance test.

2.2. Participants

All first-year medical students ($n=352$) were invited to join the study, which was part of their regular course, and those who completed the whole experiment ($n=333$) were included as participants. No incentive was provided for participation. The ethics review committee of the Department of Psychology, Erasmus University Rotterdam, approved the study. As the nature of the experiment prevented disclosure of its objectives beforehand, participants were informed about their tasks and debriefed later.

2.3. Materials

The materials for the learning phase included.

2.3.1. Clinical case for the learning phase

During the learning phase students discussed and diagnosed one clinical case, describing a patient with the chief complaint shortness of breath. The case consisted of a description of a patient's present complaints, history, and findings from physical examination and tests. The case was prepared by four general practitioners (A.L., G.E., A.dV., D.P.). The case was constructed in such a way that it had a single correct working diagnosis (i.e., the most likely diagnosis for the case), which was pneumothorax, and one most appropriate differential diagnosis. In addition to the written case description, two other materials were prepared to present the case to the NS condition: a short video of a simulated patient reporting the patient's chief complaint, and a print screen of the patient's general practitioners file displaying recent changes. The video case contained the exact same information as the case description.

2.3.2. Measures

2.3.2.1. Individual interest measure. The measure of individual interest was intended to measure pre-existing interest in clinical reasoning among the medical students involved and consisted of seven items. Examples are: "Outside medical school I read a lot about clinical reasoning" and "I watch TV-programs related to medical diagnosis." Students could respond to these items on a five-point Likert scale ranging from "Not true at all" to "Very true for me".[16]

2.3.2.2. Situational interest measure. Situational interest is a construct that measures interest aroused in response to specific educational interventions such as problems or puzzles. It differs from individual interest in that it is considered more fleeting. The measure consists of six items such as "I think this clinical case is interesting" and "I want to know more about this topic".[17]

2.3.2.3. Situational cognitive engagement measure. This measure evaluated the extent to which students were cognitively engaged with the learning task during the group session. The measure consists of six items such as "I am engaged with the topic at hand" and "I am so involved that I forgot everything around me".[18]

The reliability of the individual interest, situational interest, and situational cognitive engagement measures has been demonstrated to be high, as expressed by Hancock's coefficient *H* that ranged from .78 to .87 in previous studies.[17,18] While the individual interest measure was administered before the learning phase, the two other measures were administered twice, in the start and hallway the group sessions. Each measure took less than 60 s to be administered.

2.3.2.4. Twelve written clinical cases test phase. Eight of the test cases displayed patients with shortness of breath/chest pain as chief complaint and other diagnoses different from the practice case used in the learning phase (which was pneumothorax). The diagnoses of these cases were the following: heart failure; community-acquired pneumonia; pulmonary embolism; viral pericarditis; acute myocardial infarction; atrial fibrillation; chronic obstructive pulmonary disease exacerbation; and hyperventilation. Four cases consisted of other, non-related diseases: acute pyelonephritis; acute pancreatitis; aortic dissection; and nephrotic syndrome.

2.3.2.5. Program evaluation questionnaire. The program evaluation questionnaire measured the student's perceptions of the various elements of the course including, besides their general impression, the clinical case used in the learning phase, the role of the small group and the teacher, and study behavior.[19] The questionnaire consisted of 38 items, which, except for the 4 last open questions, were to be responded on a five-point Likert scale ranging from "Not true at all" to "Very true for me". Appendix A presents examples of the items. A similar version of the questionnaire, addressing the same elements of the course, measured the teacher's perceptions of their quality.

2.4. Procedure

2.4.1. Learning phase

In the learning phase, students were randomly assigned to one of the 12-student working-groups. Subsequently half of the groups were randomly assigned to study the problem under the CS condition and the second half under the NS condition. The 17 available teachers to be involved in the training were randomly assigned to conduct the group sessions under either one or the other condition.

Students working with the case under the CS condition received a booklet describing the patient's complaints and containing questions about each component of the case (history, physical examination, laboratory results). They were asked to engage in individual self-directed study, and were required to submit responses to the questions presented in the booklet via Blackboard, an electronic study support system (© Blackboard Inc.). After the students submitted their answer, they would be able to access subsequent information provided via Blackboard (successively, on the patient's history, physical examination and lab tests) until they could complete the case and arrive at a working diagnosis. They then participated in a two-hour group session to discuss the case and their responses with a teacher (See for a Description of the procedure Appendix B).

Students under the NS condition were presented with a short video of the patient's complaints, together with the print screen of the patient's electronic health record. They had to prepare individually a list of five most plausible diagnoses from a broad list of possible diagnoses and a list of which information on the patient's history they needed to narrow the differential diagnosis. Subsequently, they participated in a group session to further work on the case under the guidance of a teacher, a general practitioner who was trained to conduct the NS. During the session, students worked on the case in a sequential fashion, addressing each of the case components (history, physical examination, laboratory tests) while working in triads to prepare the responses to the questions similar to those presented in the CS condition. They had to present and discuss their responses to the questions and obtained further information to be addressed by the triads. (See Appendix B for a detailed description).

Before the learning activity started, students were requested to answer the Individual Interest measure. At the beginning and at the end of the group session students were asked to respond to the Situational Interest and the Situational Cognitive Engagement

Table 1
Mean scores (range 1–5; standard deviation into brackets) of situational interest in the study topic and cognitive engagement in the task in the group session as a function of experimental condition.[a]

	Conventional strategy	New strategy
Situation interest halfway the session	3.81 (.48); $N=134$	3.97 (.48); $N=120$
Situation interest at the end of the session	3.76 (.49); $N=134$	3.93 (.46); $N=120$
Cognitive engagement halfway the session	3.41 (.43); $N=147$	3.49 (.46); $N=124$
Cognitive engagement at the end of the session	3.40 (.46); $N=147$	3.51 (.45); $N=124$

[a]N=number of participants, which is not equal because not all responded to all measures.

measures. The Program Evaluation Questionnaire was administered immediately after the test both to the students and to the teachers who conducted the group sessions.

2.4.2. Test phase

One week after the first learning session, all students took the diagnostic test consisting of the 12 written clinical cases. They had 30 min to complete the test. They were asked to read each case and write down the most likely diagnosis for the case.

2.5. Data analysis

The Individual Interest and the Program Evaluation questionnaires were analyzed through one-way analysis of variance (ANOVA), whereas repeated-measures ANOVAs were performed to analyze the Situational Interest and the Cognitive Engagement measures. Independent variable was the condition under which the students worked: CS or NS, and all the analyses were carried out using the program SPSS for Mac version 23. Significance level was set at .05 for all analyses.

Six board-certified general practitioners (3 groups of 2 general practitioners) evaluated the accuracy of the diagnoses provided by the participants to each case in the test phase. A diagnosis was considered correct and scored as 1 according to the predefined correction model when the diagnosis (i.e. the main/core diagnosis) or a synonym of that diagnosis appeared in the diagnosis indicated by the participant. Responses that did not meet this criterion were evaluated as incorrect and scored as 0. The raters agreed in .910 and the overall Kappa value was $\kappa=.794$. Disagreements were solved by consensus. Mean scores of the accuracy of the diagnoses were computed for the cases solved by students who studied under the CS and the NS conditions. Three scores were computed, aggregating all criterion cases, only the cases of diseases studied in the learning phase, and only the cases of new diseases with the same chief complaint. Three separate one-way ANOVAs with experimental condition as independent variable were performed to analyze these data.

3. Results

Students from the CS and the NS performed equally well when diagnosing the cases in the test phase. The mean diagnostic accuracy scores (range, 0–1) did not differ between the two conditions (CS: $N=171$, Mean=.31, Standard deviation=.17; NS: $N=162$, Mean=.29; Standard deviation=.16), $F_{(1,331)}=1.42$; $p=.23$), indicating that the two strategies led to similar learning results.

Students' pre-existing interest in clinical reasoning was similar in the CS (Mean=3.50; SD=.45) and the NS condition (Mean=3.53; SD=.42), $F_{(1,320)}=.67$; $p=.41$.[a]

Despite their equal prior interest in clinical reasoning, students from the two experimental conditions were found to significantly differ in their engagement in the learning process. Table 1 presents the scores of situational interest and cognitive engagement halfway and at the end of the group session. Students who practiced with the clinical case under the NS reported higher interest in the topic of their study throughout the group session than their colleagues who practiced under the SC, $F_{(1,252)}=8.78$; $p=.003$, $\eta^2=.03$. A significant main effect of the moment of the measurement was also found, $F_{(1,252)}=4.95$; $p=.027$, $\eta^2=.02$, due to a decrease in interest across the session among all students. There was no significant interaction between experimental condition and moment of the measurement, $F_{(1,252)}=.23$; $p=.63$. Although not statistically significant, students from the NS rated their engagement in their tasks across the group session marginally higher than the students from the SC, $F_{(1,269)}=3.50$; $p=.06$. Ratings of cognitive engagement did not significantly differ across the group session, $F_{(1,269)}=.21$; $p=.65$, and no significant interaction between experimental

[a]Not all students responded to all measures, which is the reason for the different number of participants in the several analyses.

Table 2
Mean scores (range 1–5; standard deviation into brackets) of students' perceptions of various elements of the course as a function of experimental condition.

	Conventional strategy ($N=159$)	New strategy ($N=133$)	p-Value
General impression of the course	4.00 (.33)	4.12 (.38)	.003
Clinical case used in the learning phase	3.83 (0.39)	3.94 (.41)	.02
Group session	3.78 (0.45)	3.99 (.38)	$<.001$
Teacher's performance	4.19 (0.47)	4.28 (.40)	.067
Study behavior	3.05 (0.66)	2.88 (.59)	.023

Table 3
Mean amount of hours studying topics related to the practice clinical case before and after the group session as a function of experimental condition.[a]

	Conventional strategy	New strategy	p-Value
Time spent studying individually before the group session	3.59 (2.02); $N=156$	1.83 (.97); $N=132$	$<.001$
Time spent studying with colleagues before the group session	1.11 (1.51); $N=151$	0.43 (.89); $N=130$	$<.001$

[a] N=number of participants, which is not equal because not all responded to all measures.

condition and moment of measurement emerged, $F_{(1,269)}=.57$; $p=.45$.

Students' perceptions of the several elements of the course, which emerged from the program evaluation questionnaire, are displayed in Table 2. Students' general impression of the course was significantly better when they studied under the NS than under the CS, $F_{(1,290)}=8.76$; $p=.003$. This more positive perception of the NS was also found when specific elements of the course were evaluated. Relative to the CS students, the NS students rated the group session significantly higher ($F_{(1,290)}=17.56$; $p<.001$), as they did when evaluating the clinical case used in the learning phase, $F_{(1,290)}=5.51$; $p=.02$. The two conditions did not significantly differ in students' perception of the performance of the teacher conducting the group session, $F_{(1,290)}=3.39$; $p=.067$. When requested to give a mark to the course on a 10-point scale, students from the NS condition rated the course significantly higher than those from the CS condition, respectively 7.94 vs 7.38, $F_{(1,295)}=22.04$; $p<.001$.

A different pattern was found in the students' evaluation of their own study behaviors prior to the group session, with higher ratings coming from the CS relative to the NS students, $F_{(1,290)}=5.23$; $p=.023$. These ratings, expressing the extent to which the students actively engaged in preparing for the group session, are in line with the students' estimation of the amount of time invested in studying before the group session (Table 3). The CS students reported having spent more hours studying the clinical case individually before the group session than the NS students ($F_{(1,286)}=83.89$; $p<.001$). Similarly, the CS students also studied the case with colleagues for more hours than their colleagues from the NS condition ($F_{(1,279)}=19.80$; $p<.001$).

Teachers' perceptions about the course are presented in Table 4. A non-significant tendency towards experiencing the group session as working better under the NS than the CS emerged, $F_{(1,15)}=2.97$, $p=.10$. No significant differences were found when the teachers evaluated other aspects of the course. Teachers who worked under the two conditions did not differ in the overall mark attributed to the course, $F_{(1,15)}=2.50$, $p=.13$.

The teachers reported having spent more time to assess the students' assignments in the CS (mean=2.05 h, standard deviation=.88) than in the NS (mean=1.04 h, standard deviation=.77), $F_{(1,15)}=5.87$; $p=.03$. A similar though not significant difference was found when the teachers estimated the number of hours spent in preparing for the group session (CS: mean=2.47, standard deviation=1.49; NS=1.37, standard deviation=.95), $F_{(1,15)}=3.16$, $p=.10$.

Table 4
Mean scores (range 1–5; standard deviation into brackets) of teachers' perceptions of various elements of the course as a function of their experimental condition.

	Conventional strategy ($N=9$)	New strategy ($N=8$)	p-Value
General impression of the course	4.11 (.26)	4.19 (.46)	.67
Clinical case used in the learning phase	3.72 (.36)	4.00 (.41)	.16
Group session	3.87 (.26)	4.17 (.46)	.11
Teacher's performance	3.95 (.21)	4.14 (.47)	.30

4. Discussion

4.1. Main findings

The present study compared the effects of two different strategies employed in the training of clinical reasoning of beginning medical students – video patient encounter and group-wise training opposite to written patient encounter and working individually- on students' interest, cognitive engagement, appreciation of the educational activity, time investment in self-study and diagnostic accuracy.

Our findings confirmed our hypothesis that the new form of practice with the clinical problem would increase students' involvement in the learning process. Students' situational interest in clinical reasoning and appreciation of the educational activity was significantly higher in the NS than in the CS group. The cognitive engagement with the task did not significantly differ between the groups. There was also no significant difference in diagnostic accuracy between the two groups: they performed equally well both on cases of previously studied diseases and of new diseases with the same chief complaint. In this context it is remarkable that the NS group achieved the same level of diagnostic accuracy using only half of the preparation time that the CS group needed.

4.2. Interpretation of the results

4.2.1. Increased situational interest

Students working under the NS conditions come to their learning session with less concern about the appreciation of their homework. The preparation of their assignments takes place merely group wise in a safe environment where there is emphasis on reasoning more than on the outcome of their individual considerations. The assignments they perform at home intend to be a start of the discussion in the learning phase, not only a tool for assessment. This may make the students feel more at ease, which allows them to listen and argue more open minded and, in that way, with a greater situational interest. Possibly, this interest tends to be focused "externally" instead of in their own performance, being related to new information about the clinical case rather than related only to prior knowledge that they needed to show. Notice that students' interest in clinical reasoning prior to the activity did not differ between the two groups. It was the group-based activity that made a difference. In addition to the influence of the group work, it may have been that the presentation of a real patient's videotape surpasses a written case report in fostering student's interest in arriving at a solution for the case.

4.2.2. Similar cognitive engagement

As we mentioned in the Introduction, in the NS as well as in the CS strategy the focus of problem solving is on both analytical and non-analytical reasoning. The presentation of the clinical case leads students in the two strategies to the same pathway of hypothetical deductive reasoning based on their prior knowledge, which makes them reflect on what they do know and what is new to them. In both strategies, this reasoning process requires students to match the patient's signs and symptoms to those expected in possible diagnoses for the case, explaining sometimes the underlying pathophysiological mechanisms of these findings. Medical students are used to take their tasks seriously, and this process seems to be attractive enough for them to produce an equal degree of cognitive engagement in both groups.

4.2.3. Appreciation of the educational activity

Students' general impression of the course was significantly better when they studied under the NS than under the CS, and the group session was rated significantly higher in the NS group. Several reasons can be considered to explain why the learning activity under the NS condition was more appreciated in comparison with the CS group. The first reason is possibly the abovementioned sense of safety in the NS group: here the emphasis is on encouragement of thinking aloud more than on judgment of correctness of written assignments. Students do not have to worry about their answers or questions being good or false. The central idea is to consider alternative diagnoses while justifying their reasoning, as shown by the questions employed by the teachers, for instance: "Why do you ask this question?", "What makes you think of including/excluding this possibility?", "What in the patient history is in favor of your opinion?", "If this diagnosis is true, what information do we expect to be present, but is absent in the case?". This feeling of being respected as a participant in a constructive discussion that students encounter when they elaborate the case with their teacher and peers may be important for their overall sense of well-being. A second reason for their higher appreciation of the NS strategy might come forward from the use of a videotape to introduce the patient to the students. This makes it easier for the students to put themselves in the patient's position and confirm them in

their role as a doctor. This method is likely to be more successful in awakening the student's perception of acting as a real doctor compared to the encounter of a written case report, and so this method does increase their satisfaction of the entire course.

4.2.4. Investment in self-study

The students in the NS group spent half of the time that students of the CS group allotted to study topics related to the practice clinical case. This finding might cause opposite reactions. There will be teachers (and students, of course) who will be attracted by the fact that despite spending only half of the preparation time, the results that students obtained in the diagnostic accuracy tests are the same, as we will discuss below. This would mean a substantial increase in educational effectiveness. On the other hand, among some educators, this finding may raise concern about the depth of students' engagement with the study material, feeding fears of a shallowness of knowledge to appear as a result of a too little time investment. The literature may offer some relieve to those educators who are worried about any disadvantage regarding knowledge acquisition in the CS group. There seems to be a broad consensus in the literature on the view that developing clinical reasoning depends not only on acquiring more knowledge but relies to a large extent in the (re) organization, (re)structuring of knowledge, to make it accessible and applicable in a convenient and adequate way.[6,14] Simply gaining more knowledge could be a consequence of an educational activity aimed at developing clinical reasoning, but this is not its direct purpose: its direct purpose is to enable students to better use the cues offered by patient's signs and symptoms that are important to find the right diagnosis. Knowledge of all possible facts and mechanisms linked to the underlying disease is of course important, but applying this knowledge during the process of clinical reasoning needs to meet the specific context of the presentation of the patient's complaints. Of course, we would need to investigate further the effects in long term, but the equal outcome of the test on diagnostic accuracy in the two groups seems to confirm the optimistic view of those who interpret the finding referring to investment in self-study as an increase in educational effectiveness.

4.2.5. Equal diagnostic accuracy

As already mentioned above, the results of the diagnostic accuracy test in the two groups have been similar. This outcome suggests that students in both groups have similar knowledge[14] at their disposal. How can it be that students in the NS group in half of the preparation time spent by their colleagues in the CS group obtain similar knowledge? Apparently the extra time invested by the CS group in learning as a cognitive surplus, possibly about related topics, did not produce a better diagnostic performance than learning of these topics that has taken place during the NS discussion group. So what might have eliminated the imbalance in time investment conveyed by the equal results in diagnostic accuracy?

The most probable explanation might refer to the notable difference between the two strategies that emerges from the nature of the group discussion. The students who had a learning phase in the NS group did benefit not only from their own and/or their teachers' knowledge but also from the knowledge triggered to come forward as a result of the group discussion, especially since in this discussion complementary concepts from peers come out, proven to be right or wrong. This variety of perspectives may bring the possibility to learn from one's own or others mistakes in a safe climate, which is compatible with an increased appreciation of the educational activity explained earlier, can be considered to favor enrichment of students' knowledge networks. It seems reasonable to assume that making use of the well-known advantages of motivational and cognitive effects of small group learning[15] in the NS group counterweighs the extra time invested in individual study by the CS group. However, it might be stressed that in the CS group there is also a group discussion as a result of the elaboration of the individual homework assignments. So we would need to explain more specifically what the difference is between the discussion in the CS and the NS group that may account for a higher efficiency of the discussion in the NS group in building knowledge networks. We can only make conjectures here but, in our opinion, this important difference might refer, first, to the starting point of the discussion and, second, to the way the discussion is organized. The starting point in the CS group is the debate on the homework assignments, (for instance, the student may think: did I write down the good answers regarding this problem? Am I going to get a good mark?) whereas the starting point in the NS group is the discussion of the students' first impressions, of the diagnoses that they are taken into account (the student may then ask himself: did I consider the proper questions? what considerations do my colleagues have on this problem?). Clearly, the latter approach possibly invites students to a more objective approach of the case because of less preoccupation with their own

performance, which may then be followed by increased situational interest. Due to its more exploratory character, the way the discussion is organized in the NS group gives more space for students to think aloud freely, with the above-mentioned advantages of a richer causal spectrum as a consequence. In brief, it seems that the quality of the group discussion in the NS group was higher, leading to equal diagnostic accuracy in comparison to the CS group that spent more preparation time in gathering knowledge.

4.3. Limitations

This study had some limitations. In the first place, the study was conducted as part of the regular curriculum, which unavoidably limits control over the conditions under which students work. Admittedly the teachers operating during the learning phase had the same background, as they all were general practitioners, but there was a wide variation among them concerning teaching experience and didactic skills. So some groups could have benefited from a well-equipped, experienced trainer, while other groups might have suffered from the lack of educational expertise of a less experienced teacher. However, the randomization of teachers to the different conditions might have controlled for that. Second, in the course of the three months prior to the study, all students had already experienced two learning sessions according to the CS model. So their experience with the old model might have affected their overall capacity to solve clinical problems and this would make a comparison of two strategies less correct. Notice, however, that this could bring a benefit to the students from the CS rather than to the ones in the NS strategy who had still to learn their way through a new approach. Third, there was only one single learning session to compare and to measure results. Despite the high number of participants in this research, one can ask questions on the validity of the outcomes, because it still has to be proven that this outcome can be repeated. Future research with more learning sessions included in the comparisons and with different levels of complexity carried through the same year of education is required. Finally, students from both conditions scored very low in the diagnostic test, which confirms their status as novices. Whether similar findings would be observed with more advanced students remains to be determined.

5. Conclusions

In sum, in our clinical reasoning course we investigated the effects of changing the format of the presentation of the patient's problem used for practice and of changing the way students approach this problem. We replaced the written case presentation by a patient's videotape and from individual learning through homework assignments we moved to group-wise learning. Our findings suggest that these changes caused an increase in student's involvement in the learning process and in the appreciation of the learning activity. There was no increase however in diagnostic accuracy, but students' investment of time in self-study seemed to be more effective: to achieve the same level of accuracy during the test, the students working under the new strategy needed only half the preparation time before the learning session.

We see the increase of student's satisfaction of the course and the decrease of preparation time without affecting diagnostic accuracy as a benefit of the changes that have been made. The diminished preparation time required opens the door for including more practice with clinical cases, which has been shown to be important for the development of clinical reasoning.[7] In addition, there turned also to be a decrease in preparation time for the teachers and a greater satisfaction about their teaching activity. How to improve student's diagnostic accuracy right from the start of their training requires future research.

Ethics

The ethics review committee of the Department of Psychology, Erasmus University Rotterdam, approved the study.

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Other disclosures

None.

Appendix A. Examples of the items in the program evaluation questionnaire

General impression of the learning activity (8 items)
"The objectives of the learning activity were clear to me"
"I have learned a lot during this learning activity"
The clinical case (8 items)
"The clinical case was suitable for using a systematic approach"
"The clinical case helped me in integrating the basic with the clinical sciences"
The group session (6 items)
"Everybody actively contributed to the discussion"
"The group session stimulated self-directed learning activities"
The teacher (9 items)
"The teacher's questions stimulated the discussion"
"The teacher used his subject-matter knowledge to help us"
Study behavior (3 items)
"While preparing my assignments, I consulted mostly learning resources available on the Internet"
"I studied with colleagues while preparing for the group session"
Open questions (4 items)
*"How much time on average did you spent in **individually** studying the clinical case **before** the group session?" (Fill in the answer in whole hours)*

Appendix B. Procedure under the conventional strategy and the new strategy

Conventional strategy condition (CS)	New strategy condition (NC)
Individual work:	Individual work:
• Presentation: clinical case	• Presentation: video of a patient + patient dossier
1) Individual study: 3 possible diagnoses + 2 questions per diagnoses for anamneses + reasons	1) Individual study: 3 possible diagnoses + 2 questions per diagnoses for anamneses + reasons
• Presentation: additional information (anamneses)	Group session (with a teacher):
2) Individual study: refine DD, order of likelihood and justification, PE to be performed and why	2) Triads: DD -> plenary (teacher's "why questions")
• Presentation: additional information (PE)	• Presentation: additional information (anamneses)
3) Individual study: refine DD; tests to be ordered and why	3) Triads: refine DD, order of likelihood and why, PE to be performed and why -> plenary (teacher's "why questions")
• Presentation: additional information (tests results)	• Presentation: additional information (PE)
4) Individual study: refine DD; working hypothesis; how to manage the case	4) Triads: refine DD; tests to be ordered and why -> plenary (teacher's "why questions")
Group session (with a teacher)	• Presentation: additional information (tests results)
	5) Triads: refine DD; working hypothesis; how to manage the case -> plenary

References

1. Norman G. The epistemology of clinical reasoning: perspectives from philosophy, psychology, and neuroscience. *Acad Med* 2000;75(10):S127–S133.
2. Eva KW. What every teacher needs to know about clinical reasoning. *Med Educ* 2005;39(1):98–106.
3. Schmidt H, Boshuizen H. On acquiring expertise in medicine. *Educ Psychol Rev* 1993;5(3):205–221.
4. Boshuizen H, Schmidt H. On the role of biomedical knowledge in Clinical Reasoning by experts, intermediates and novices. *Cogn Sci* 1992;16(2):153–184.
5. Ark TK, Brooks LR, Eva KW. Giving learners the best of both worlds: do clinical teachers need to guard against teaching pattern recognition to novices? *Acad Med* 2006;81(4):405–409.
6. Norman G. Research in clinical reasoning: past history and current trends. *Med Educ* 2005;39(4):418–427.
7. Schmidt H, Rikers R. How expertise develops in medicine: knowledge encapsulation and illness script formation. *Med Educ* 2007;41:1133–1139.
8. Hobu P, Schmidt H, Boshuizen H, Patel V. Contextual factors in the activation of 1st diagnostic hypotheses – expert novice differences. *Med Educ* 1987;21(6):471–476.
9. Barrows H, Feltovich P. The clinical reasoning process. *Med Educ* 1987;21(2):86.
10. Mamede S, van Gog T, Sampaio AM, de Faria RMD, Maria JP, Schmidt HG. How can students' diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. *Acad Med* 2014;89(1):121–127.
11. Watling C, Driessen E, Van der Vleuten C, Vanstone M, Lingard L. Understanding responses to feedback: the potential and limitations of regulatory focus theory. *Med Educ* 2012;46(6): 593–603.
12. Charlin B, Boshuizen H, Custers E, Feltovich P. Scripts and clinical reasoning. *Med Educ* 2007;41(12):1178–1184.
13. Eva KW, Hatala RM, LeBlanc VR, Brooks LR. Teaching from the clinical reasoning literature: combined reasoning strategies help novice diagnosticians overcome misleading information. *Med Educ* 2007;41(12):1152–1158.
14. Schmidt H, Mamede S. How to improve the teaching of clinical reasoning: a narrative review and a proposal. *Med Educ* 2015;49 (10):961–973.
15. Dolmans H, Schmidt H. What do we know about the cognitive and motivational effects of small group tutorials in problem-based learning? *Adv Health Sci Educ* 2006;11:321–336.
16. Rotgans J. Validation study of a general subject-matter interest measure: the Individual Interest Questionnaire (IIQ). *Health Prof Educ* 2015;1(1):67–75.
17. Rotgans J, Schmidt H. Interest in subject matter: the mathematics predicament. *High Educ Stud* 2014;4(6):31.
18. Rotgans J, Schmidt H. Cognitive engagement in the problem-based learning classroom. *Adv Health Sci Educ* 2011;16(4): 465–479.
19. Schmidt H, Dolmans H, Gijselaers W, Des Marchais J. Theory-guided design of a rating scale for course evaluation in problem-based curricula. *Teach Learn Med* 1995;7(2):82–91.

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