The influence of a digital clinical reasoning test on medical student learning behavior during clinical clerkships

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Research Article

Keywords: clinical reasoning, assessment, medical education, undergraduate education

Posted Date: April 28th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2860264/v1

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Advances in Health Sciences Education on October 18th, 2023. See the published version at https://doi.org/10.1007/s10459-023-10288-x.
Abstract

PURPOSE

Recently, we developed a new digital clinical reasoning test (DCRT) to evaluate students’ clinical-reasoning skills. Although an assessment tool may be soundly constructed, it may still prove inadequate in practice by failing to function as intended. Therefore, more insight is needed into the effects of the DCRT in practice.

MATERIALS & METHODS

Individual semi-structured interviews and template analysis were used to collect and process qualitative data. The template, based on the interview guide, contained six themes: (1) DCRT itself, (2) test debriefing, (3) reflection, (4) practice/workplace, (5) DCRT versus practice and (6) ‘other’.

RESULTS

Thirteen students were interviewed. The DCRT evaluates the students’ clinical-reasoning skills adequately using six different question types. Students use the implicit and explicit feedback the DCRT provides for the improvement of their clinical-reasoning learning practice. By doing so, they show behavior consistent with self-directed learning and lifelong learning. Among other things, the DCRT encourages them to engage more in formal education and workplace-learning during their clerkships. Although the faculty emphasizes the different purposes of the DCRT (assessment of/for/as learning), students predominantly perceive the DCRT as an assessment solely of learning.

CONCLUSION

The implementation of a DCRT leads to successful stimulation of learning and practicing clinical-reasoning skills in the workplace.

Introduction

Being an excellent clinical reasoner is one of the primary qualities of great physicians. Therefore, it is of the utmost importance that (future) physicians develop their clinical-reasoning skills throughout their careers [1]. This lifelong learning process is founded at the beginning of medical education and accelerates during clinical clerkships[2]. To support students in their learning process, institutions often include an assessment of clinical-reasoning skills in their curricula. This increasingly takes the form of an assessment program [3] and can include various assessment formats, i.e. (in)formal, (non-)digital or practice-/education-based[4, 5].

The selection and development of these assessment tools are usually driven by their intended purpose. Keeping these purposes in mind can help educators accomplish their goals with regards to their assessment. One of the most commonly used principles is assessment of/as/for learning [6].
Assessment of learning has the longest and largest tradition within medical education. It focusses on testing for scores and gauging the intended outcomes of a medical curriculum rather than improving learning [6, 7]. These assessment tools are typically summative and positioned at the end of a semester, module or clerkship. Assessment as learning is defined as a situation where learning and assessment are intertwined to stimulate learners’ self-regulating learning behavior[8]. Examples include self-assessment, portfolios, reflection exercises and peer-assessment[6, 8]. The last principle, assessment for learning, is mostly used within programmatic assessment. Within this principle, learners are centralized and assessment is seen as a tool to steer students’ learning by providing feedback on it[9]. To that end, there has been a shift over the past years from assessment of learning towards assessment for learning[6, 7]. Although an assessment tool may be soundly constructed, it may still prove inadequate in practice by failing to function as intended[10, 11].

Recently, we developed a new digital clinical reasoning test (DCRT) to evaluate students’ clinical-reasoning skills. The DCRT is administered six times throughout the three-year master’s curriculum of medical school of the Radboud University Medical Center, each time at the end of a clerkship. The content of the DCRT is determined by the content of the clerkship students just completed. It uses ‘real world’ patient vignettes combined with different question types to help students develop their clinical-reasoning skills. This DCRT is the first tool of this type to combine six different specific question types that have all been studied separately for the assessment of clinical-reasoning skills[12–15].

Thus, to determine the usability of the DCRT, insight is needed into the effects of this assessment tool in practice. To this end, we interviewed students about their experiences with the DCRT. Their answers should (1) provide more insight in the students’ perspective of developing clinical-reasoning skills both by assessment and in practice[2], (2) clarify differences between assessment principles and how they work in practice, and (3) help us understand how integrating the clinical-reasoning practice into assessment can contribute to the clinical-reasoning learning process. Moreover, the results can be used to further develop the DCRT to strengthen its place in the curriculum and its assessment program. Our main research question to achieve these goals was: How does the DCRT influence medical students’ learning behavior, focused on clinical reasoning, during clinical clerkships?

Methods

We used qualitative study methods to answer our research questions. Ethical approval was granted by the NVMO Ethical Review Board, case number 2021.6.6 (Netherlands).

Setting

Medical education curricula in the Netherlands are organized in a Bachelor-Master-structure where each part takes three years to complete. The Master’s curriculum in Nijmegen alternates clinical clerkships with education at the university campus. Each clerkship is preceded and concluded with formal education to respectively prepare students for practice or evaluate their clerkship. The education before clerkships
(EBC) lasts between 1–4 weeks and the education after clerkships (EAC) 1–2 weeks. The first seven clinical clerkships follow each other in a fixed order in the first two years. In the final year, students choose their own department for their last clinical clerkships and their scientific clerkship.

**The Digital Clinical Reasoning Test (DCRT)**

The test we developed and investigated in this research is the DCRT, which has replaced oral examinations in evaluating students’ clinical-reasoning skills in our curriculum. The test is administered at the medical faculty on the first day of EAC. A total of six DCRTs are taken during the first two years of the master’s curriculum. The content of each test is determined by the medical specialty in which they have just completed their clerkship. For example: the first clerkship is Internal Medicine, hence the DCRT after the first clerkship will contain questions about Internal Medicine. The question types used in this test are the same across all DCRTs: script concordance test questions, comprehensive integrative puzzles, extended matching questions, multiple choice questions and short- and long-narrative answer questions. Students discuss the DCRT and their answers with a clinical expert in the week following the test.

After completing the DCRT, students receive three scores: (1) their percentage score and (2) their percentile score of how they performed compared to their peers in both their own group and (3) their cohort (= 12 groups). Although there is no official pass or fail moment, these three scores together determine whether a student scores above or below a predefined cut-off point. In this research we will further refer to this as a ‘sufficient’ or an ‘insufficient’ result.

All students need to reflect on their test outcomes in a reflection report. Students with an insufficient score need to reflect more broadly, subsequently write an improvement plan, set learning goals in this regard, and discuss these with their mentor. If students score insufficiently on two consecutive DCRTs, they will receive extra guidance and attention from their clinical supervisors during their next clerkship.

**Research population**

Students who completed three DCRTs were invited to participate. Besides voluntary enrollment, purposeful sampling was used in order to ensure that both students with sufficient and insufficient test outcomes were included from all years of the Master’s curriculum.

**Semi-structured individual interviews**

We used individual interviews to provide a safe environment for students to discuss the DCRT and their personal experiences without pressure to provide socially desirable responses. The interviews were semi-structured, using a set of predetermined questions that left ample room for other questions emerging from the dialogue. Questions were categorized around six themes: (i) preparation, (ii) learning behavior, (iii) DCRT, (iv) test debriefing, (v) reflection and (vi) DCRT versus practice. The interview guide was iteratively altered as data collection proceeded.

**Data collection**
The research group consists of three medical doctors (LR, MvdP, BS) with clinical experience in various departments (emergency medicine, primary and elderly care, internal medicine and clinical pharmacology), a cognitive psychologist (EC) and an educationalist with medical background (LF). Except one, all researchers are actively engaged in the medical curriculum as teachers (LR, MvdP, BS), curriculum developers (LR, MvdP, BS, LF), clinical supervisors (MvdP, BS), program director (MvdP) or as educationalist (LF). One researcher works as a teacher and curriculum developer in the educational science work field (EC).

This study was conducted between April and June 2022 at the Radboud University Medical Center in Nijmegen, Netherlands. All interviews were conducted and transcribed by the head researcher (LR) and lasted between 20–45 minutes. Interviews were audio recorded and transcribed verbatim within two weeks after the interviews took place. The recordings were deleted afterwards. The names of the participants and any other traceable information was anonymized for confidentiality purposes.

Data analysis

Template analysis was used to process the data to ensure that necessary themes were incorporated in the analysis [19]. The template was based on the interview guide and contained six themes: (1) DCRT itself, (2) test debriefing, (3) reflection, (4) practice/workplace, (5) DCRT versus practice and (6) ‘other’. LR and MvdP constructed a first template, which was further developed through group discussion (LR, MvdP, BS, LF) when everyone was familiarized with the data. After finalizing the template, all interviews were then coded by both the head researcher (LR) and one of the other researchers (MvdP, BS, LF). Subsequently, these codes were discussed in one-on-one sessions between the two coders until consensus was reached. Reports of these conversations were then discussed in a group session and used to start analyzation (LR, MvdP, BS, LF, EC). Analysis continued during the following two group sessions (LR, MvdP, BS, LF). Further modifications to the interpretations were made during the writing process, as well as through continuous discussions (LR, MvdP, BS, LF, EC).

Writing process

Besides utilizing the services of a professional translation agency, ChatGPT was also employed to enhance the linguistic proficiency of this manuscript.

Results

We interviewed 13 students who completed between four and six DCRTs and who had received a variety of results (Fig. 1). First, we will provide the results on the students’ perceptions of the DCRT in general. Further results are categorized around the various iterative stages of the DCRT that students go through each clerkship: preparation, test, test debriefing, reflection, and practice. Quotes are used as a supplement to the data.

The students’ perceptions of the DCRT in general
Students attach great significance to the first DCRT. The two explanations that are used most are not knowing what to expect and wanting to perform well. Over the course of the Master's, the DCRT becomes less important to them. Some strongly believe that completing the DCRT is merely a requirement to obtain their medical degree. Arguments given by the students for this attenuated opinion of the DCRT include its placement in the EAC, their belief that the DCRT sometimes provides an inaccurate representation of their clinical-reasoning skills, and that they consider practice as the golden standard for their clinical-reasoning learning process. Apart from these reasons, students do see and use this test to check if their current clinical-reasoning skills are on course to the expected level for their degree. They also use it to review content and to feed their confidence.

And that it has given me a kind of confirmation that my knowledge is actually good. So that you can build more on that and become a little more confident and that you dare to ask a question more quickly. And that you don't think... oh, this is a very basic question. But that you think ... no, it's not weird that I don't know this.

When students achieve an insufficient result, the DCRT regains some significance. This corresponds with the number of insufficient results. Although one insufficient result is usually not considered a disaster since it has hardly any formal consequences, it did instigate reflection and growth. Two or more insufficient results do increase motivation to be more engaged, but they are also reasons for concern, lower self-confidence and stress, as this means that they will be monitored extra during the next clerkship.

**Preparation**

Students differ in the way they prepare for the DCRT. Some feel it was promoted to them as a test for which no preparation was needed. They assume that completing the clerkship is sufficient, while others carefully prepare themselves.

It's not about passing the test or not, but just to see where your areas of improvement are. So, I think it's actually, kind of...um...a false result if you prepare. Because in real life you don't prepare for every little thing. You go in with the knowledge you have. And I think that a clinical-reasoning test is an excellent opportunity to see how much knowledge you have.

They unanimously see preparation as studying rather than practice. Although not necessarily recognized as such by students, elements of their practice can be labeled as preparation. They talk about independently preparing and seeing patients and talking to both supervisors and peers as strategies to enhance their clinical-reasoning skills.

I just notice, for example, when I see patients or I’m chatting with a doctor about a patient that I’m very much thinking about history, physical examination, management. [...] And that's largely what you see in the test as well. So, during my internship I'm not thinking, 'I'm doing this now, so I'm going to pass that test'. It's more that because I do it so often on my clerkship that during the test I think 'oh yes – this was so because I saw it then and then'.
One strategy students use in preparation is to make lists of subjects they come across during their clerkship that they can study during a quieter moment of their workday. Apart from clinical practice, most students do not do anything special to prepare for the test. They feel they put more than enough time into their clerkship and want to protect their off-work time. Students who study outside of clinical practice mostly do this in the weekend between their clerkship and the DCRT. They study from books both the subjects they did not see in practice as well as the subjects they feel might come up in the DCRT. The university provides a list of topics for this purpose, which not all students know exists.

Well, you know there's always this open-ended question at the beginning [of the test]. You just know that somebody's going to come into the Emergency Department (ED) or General Practice. So then, you can think, ... okay, what would come into the ED or General Practice for Surgery or Neurology. [...] There will always be a question about ‘What kind of diagnostic tests do you want?’ So, you must know what kind of diagnostic tests were brought up in that clerkship. [...] That does help, when you’re prepared like that.

Test

When asked about their performance on the DCRT compared to clinical practice, several different points emerge from students’ comments. First, students differ on the fact that the test provides feedback while they take it. Some find it helpful to know if they are on the right path. If they are not, they then correct their path and move on. However, others find it stressful to see they have already made a mistake, and begin to worry about their result.

Secondly, students have different beliefs about the alignment of the DCRT with practice. Students who score poorly on the DCRT believe that this does not accurately reflect their performance in clinical practice, as they cannot use references during the test to aid their clinical-reasoning process. This difference is particularly evident in questions on (therapeutic) management. Still, they do feel that the way in which the test allows them to use clinical-reasoning steps reflects how they will do it in practice. They find that the steps are smaller in the DCRT compared to practice, where steps are sometimes simultaneously completed. They mention that the smaller steps force them to think more analytically about the problem, which ultimately helps them to do the same in practice.

But then you are actually forced to think ‘what is actually the most essential thing to do’ or ‘what is really the first step you take, what should you really do’. And that is still good to think about sometimes, and to realize ... oh yes, you really do that first, because that ultimately has the most effect on the course of the problem.

Overall, students appreciate the DCRT for its broad spectrum of topics and question types. In contrast, most students also feel that the content does not align with clerkships at the university hospital since the DCRT focusses on general clinical-reasoning skills, while rare or complex cases are seen in academic hospitals. Some compensate by studying topics from the other clinical contexts prior to the test.

Test debriefing
After completing the DCRT, students engage in a supervised debriefing. Experiences highly depend on the supervisor. Some merely display the answers and ask whether there are questions about them, while other teachers elaborate on all the steps to give insight into their own clinical-reasoning process. The latter is more appreciated by students, although both students and teachers struggle with the fact that there is ultimately one best answer. Teachers who fail to clearly explain the reasoning behind the right and wrong answers are unhelpful to students’ trust in the DCRT. Overall, the test debriefing is rated as insightful and helpful as a supplement to the test itself and the students’ clinical-reasoning learning process.

"[...] and that has to do with the fact that during the debriefing people very often say ‘yes, but this can be reasoned both ways. I understand why you said answer b with that explanation, but we only count answer c as correct’. And then I think sometimes… well… what exactly are we assessing here?"

Reflection

Students must reflect on their test results. Students who have had only sufficient results see the reflection report as something mandatory and describe theirs as concise, saying they use the same text repeatedly. After an insufficient result, students reflect more extensively, seeking explanation in both internal and external factors.

There were a number of reasons, in my opinion, why I didn't pass the [test] for Pediatrics; among them, the fact that I had the clerkship at the [academic hospital] and that there are just very complex cases there. Common pediatric cases are not covered there very much. And I had missed the classes on the topics that came up a lot in the test. [...] Besides that, I noticed that I needed to think a little more about problem management. [...] That's what I then focused on a little bit more, so that in the future I could answer [those questions] better.

Most students experience difficulty reflecting properly, seeing as it is currently impossible to view their results in detail. Whether their reflection report is discussed with their mentor depends largely both on how the mentor appreciates the process and the student’s need to discuss it. Students are struggling with the urge to improve themselves on the one hand, and the formal position of the DCRT in the curriculum, on the other. Only a few students mentioned intending to study to compensate for their identified knowledge gaps after the DCRT in order to become better physicians.

We were talking about that test and then my coach said, yes, it is indeed meant to show knowledge gaps of what do you not yet know so much about. But since it takes place after the clerkship, you don't study after it, so to speak. You are then busy with the EAC and then with the EBC.

Practice

Students look for ways to improve their learning, especially when they have received insufficient results. They put more effort into the EBCs, or they purchase a small notebook in which they collect information, questions, and subjects to explore further. These notes guide them in their studying in addition to making
information easily accessible. Students who have had consistently sufficient results usually do not change their learning behavior, as they feel that what they are doing is already enough for them at this point.

*Um, no. I think those two things, distinguishing main and secondary issues and looking for the specific things that make you arrive at a certain working diagnosis. And really explicitly naming what you think about and then explicitly elaborating on your thinking steps and asking for feedback on that. Those are really the only things that changed as a result of this test – or, well, changed... in any case, I have gained these things from this test.*

**Discussion**

This study has identified several ways in which the DCRT influences students' learning practices in a way that can benefit their clinical-reasoning skills. Among other things, the DCRT encourages them to engage more in formal education as well as in workplace-learning during their clerkship. Although the faculty emphasizes the different purposes of the DCRT, that is, an *assessment of/for/as learning*, students predominantly perceive the DCRT as an assessment solely of learning. The shift towards using assessment as a tool for individual learners rather than for institutions may cause confusion in students.

To conduct a thorough analysis of our findings, we will utilize Mezirow's *transformative learning theory*, which posits that learning is a process of altering one's frame of reference [20]. Within this theoretical framework, learners who engage in transformative learning challenge their existing frames of reference by embracing confusion, critically reflecting on their assumptions, and gradually altering them [21]. Ultimately, this process of transformative learning leads to the development of autonomy and responsibility in their thinking [20]. The forthcoming paragraphs will provide an overview of the relationship between the DCRT and transformative learning theory, as well as other pertinent theories.

Our most interesting finding was how the DCRT initiates confusion in students about the different purposes of the DCRT when looking at the framework mentioned in the introduction, *assessment of/as/for learning* [6]. The perception of students towards the DCRT indicated that most of them view it in a manner consistent with assessment of learning [6, 7]. This standpoint is supported by the contextual circumstances of the DCRT, such as its placement in the EACs and the semi-summative approach to the scoring. As a result, students' motivation and the role they assign to the DCRT in their clinical-reasoning learning process are affected. Looking at transformative learning, this transformation is explained by the fact that the DCRT does not fit in the student's current frame of reference, wherein assessment throughout their lives has mostly been summative and set up for what they have previously learned [20, 21]. This confusion eventually has led them to labeling the DCRT as a mandatory requirement imposed by the university.

Opposite to what is stated above, students acknowledge that both the DCRT’s debriefing and reflection report facilitate improvement by offering valuable feedback and insights. This phenomenon is, in turn, linked to assessment for learning [9]. Consequently, the students’ confusion about the DCRT’s purpose can
be attributed to the usage of three different assessment principles and how this translates into practice. This emphasizes the importance of aligning theoretical principles with practical implications to ensure that an assessment is correctly perceived. More help is needed from educators at the practical end to facilitate the necessary transformation in students’ thoughts about assessment purposes in general and the DCRT’s goals specifically[20].

Moreover, our results show a link between lifelong learning and both assessment as learning and assessment for learning. Previous studies highlighting the importance of lifelong learning state that it is a desirable professional attitude when working in the everchanging healthcare system[1]. Therefore, fostering a positive attitude towards lifelong learning is in the interest of medical curricula[22]. The study’s results indicate that despite the placement of the DCRT, some students exhibit lifelong learning behavior, utilizing given feedback to guide their learning practices and setting new learning objectives. Thus, it can be hypothesized that the DCRT contributes to lifelong learning behavior when students use the test as an assessment as learning or an assessment for learning[22–24].

In addition, previous literature states that attitudes consistent with lifelong learning can be activated with practice-based education[25]. Our findings show that the way in which the DCRT allows students to utilize their clinical-reasoning skills is similar to how they would do it in practice. Therefore, it can be hypothesized that assessment tools incorporating practice into education could support lifelong learning as well.

Focusing on the clinical-reasoning learning process, our research revealed that students (un)consciously adapt their behavior in response to the DCRT. First, as they perceive the DCRT to be aligned with the way they would use their clinical-reasoning skills in practice, they also employ the test’s question types in practical settings. This shows that the DCRT can educate students in a way that can be seen as assessment as learning[8]: They undertake measures to aid their learning process and to ensure a deeper understanding of the subjects and processes, for example, by taking notes. Secondly, they transform their knowledge from factual memorization towards contextual problem analyzation to aid their decision-making process through their clerkships, which is a necessary shift in transformative learning[26]. Both these phenomena contribute to bridging the gap between practice and theory, or assessment, and is another example of the DCRT’s influence on students’ learning behavior.

Lastly, the DCRT motivates students to form learning objectives for future internships. These objectives may pertain to specific aspects of the clinical-reasoning process (i.e. ‘I need to allocate more effort towards creating a treatment plan’) or more broadly relate to their learning behavior (i.e. ‘I need to take notes of unfamiliar topics encountered during practice and study them later in the day’). This highlights the DCRT’s ability to promote self-directed learning among students within the clinical-reasoning learning process in clinical context[27, 28], which is a characteristic of assessment tools used for assessment for learning and contributes to lifelong learning[29].

**Strengths and limitations**
The inclusion of a diverse research population represents a significant strength of this study. The composition of the research group also contributed to a broad perspective and various angles during the lively discussions. Additionally, the fact that a single moderator conducted all interviews is considered a strength. However, limitations were identified in the specific context in which the research was conducted, as the behavior of Dutch students may differ from that of students in other regions of the world.

**Implications for practice and future research**

The key takeaways from this study are that despite having a strong blueprint for an assessment tool, its implementation must be aligned with this theory as well, as practice tends to hold greater influence than theory. Furthermore, the findings from this study can be utilized in broader reflective research on the DCRT or other assessment tools.

**Conclusion**

Despite the students being confused about the different goals of the DCRT, this study shows that the DCRT influences students’ learning behavior in a way that can benefit their clinical-reasoning learning process. The DCRT evaluates the students’ clinical-reasoning skills adequately using six different question types. Students use the implicit and explicit feedback the DCRT provides for the improvement of their clinical-reasoning learning practice. By doing so, they show behavior consistent with self-directed learning and lifelong learning. Secondly, this research highlights the importance of aligning assessment purposes with practice in both the development and implementation of assessment tools as well as the content of such tools. In conclusion, the implementation of a DCRT leads to successful stimulation of learning and practicing clinical-reasoning skills in the workplace.

**References**


**Figures**

**Completed DCRTs**

- 4 DCRTs
- 5 DCRTs
- 6 DCRTs

**Test results**

- All sufficient
- 1 insufficient
- ≥2 insufficient

*Figure 1: Balanced distribution among participants in both completed DCRTs and test results*

**Figure 1**

See image above for figure legend

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- Interviewguide.docx