

The electrocardiogram made (really) easy: Using small-group tutorials to teach electrocardiogram interpretation to final-year medical students

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Background. Since the 1990s, studies have reported the inability of medical schools to equip students with knowledge and skills to interpret an electrocardiogram (ECG). This has also been the case at the School of Medicine, University of the Free State, Bloemfontein, South Africa, with external examiners in the final examinations repeatedly commenting on the poor performance of students with regard to interpreting ECGs. Subsequently, the Department of Internal Medicine designed small-group tutorials using animations and analogies as methods to improve the ECG interpretation skills of students.

Objectives. To improve students' ability to interpret ECGs and assess their perceptions of the tutorials.

Methods. A questionnaire was administered to 67 final-year medical students after their internal medicine rotation in 2012. The objective of the questionnaire was to obtain feedback on students' experiences and perceptions of ECG tutorials.

Results. Although the results do not provide evidence that the abovementioned methods improved the students' competency to interpret ECGs, the limited findings from their perceptions might assist in the further use and improvement of such an approach to facilitate learning.

Conclusion. This article highlights the responsive efforts and willingness of registrars in the Department of Internal Medicine to improve the teaching of a major and frequently used investigation such as the ECG, and how registrars formalised these two methods into tutorials.

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Despite being one of the most frequently used investigations in medical practice, studies in the 1990s revealed that some doctors lack basic skills when interpreting an electrocardiogram (ECG).^[1,2] These findings were disturbing, as the optimal management of a number of potentially life-threatening conditions requires prompt and accurate interpretation of an ECG. Recommendations were made to improve the teaching of ECG interpretation.^[1] Regrettably, even in the 21st century, studies suggest that medical schools struggle to equip students with the knowledge and skills to interpret ECGs.^[3-5] This has also been the case at the School of Medicine (SoM), University of the Free State (UFS), Bloemfontein, South Africa, with external examiners in the final examinations repeatedly commenting on the poor performance of students in interpreting ECGs.

One of the reasons why students struggle to interpret ECGs could be that most medical education teachers have primarily had lecture-based experiences, with no role-models who employed other strategies, such as tutoring.^[6] Because of limited training on how to teach students, these teachers are more proficient as traditional lecturers and subject matter experts. Understandably, they tend to feel uncomfortable in assuming the role of a tutor. When they assume this role, they become passive and uninvolved, which is contrary to the principles of tutoring, which require active learning strategies.^[6] These are student-centred strategies that engage students in learning activities, providing opportunities to reflect, evaluate, analyse and synthesise information, thus improving memory and test performance.^[7]

Generally, most tutor programmes are peer facilitated and led, with senior students assuming these roles. There has been debate on whether tutors should be content experts, with some arguing that a number of content experts do not necessarily have the skills to facilitate the process of learning.

However, the main focus in tutoring is to combine the process of learning and mastery of content;^[8] hence the importance of training tutors. At UFS, all the tutors undergo compulsory training, during which they are equipped with skills to apply active learning strategies. This is also the case with registrars who tutor final-year students with regard to ECGs.

Context

Undergraduate training for medical students at SoM, UFS is offered as a 5-year programme, leading to a degree in medicine (MBChB) and is structured in three phases. In phases I and II, the content of the curriculum is arranged in thematic or system-based modules, while phase III is devoted to clinical medicine. Students commence clinical training in their 3rd year, during which they are introduced to internal medicine, surgery, paediatrics, obstetrics and gynaecology, and psychiatry. Training in ECG interpretation includes formal lectures on electrophysiology during the preclinical years, and didactic ECG interpretation lectures during the clinical years.^[9]

New academic tutorial programme

In an attempt to improve final-year medical students' knowledge and skills in ECG interpretation, the Department of Internal Medicine developed a tutorial programme in 2011 to form part of the New Academic Tutorial Programme (NATP). NATP is one of the university's support programmes established in 2007, designed to provide students with the opportunity to receive feedback on their understanding of concepts and further help them to develop the required skills to maximise their chances of success in module-specific assessment. The design and implementation of the programme is based on the principles of supplemental instruction.^[10] This is an academic support programme that was developed at the University of

Missouri, Kansas, USA in 1973, with the objective to specifically increase academic performance of students in traditionally 'high-risk' subjects as opposed to 'high-risk' students.^[10,11]

Unlike the peer-facilitated model used in supplemental instruction and other departments at the university, where senior students tutor junior students, tutorials in the Department of Medicine are facilitated by registrars. All the tutors in NATP, including registrars, are trained, equipping them, for example, with skills to facilitate learning using active learning strategies. At SoM, the programme is customised by using small-group tutorials to equip students with knowledge and skills to interpret an ECG. Although the attendance is not compulsory, all final-year students attend the ECG tutorials.

Initially, only one tutorial session per small group was offered, but on demand by the students, it was later increased to two sessions on consecutive days. In the first session, the electrophysiological principles behind ECG tracings of common cardiac conditions are reviewed. Methods such as animations and analogies are used to facilitate learning and promote retention of knowledge. The second session is more practical and various ECG examples are interpreted by applying principles learnt in the previous session.

Small-group tutorials

Small-group tutorials have been advocated as a way of promoting active learning for medical students, thus providing opportunities for interactive demonstrations,^[12,13] as is the case for medical students at UFS. This method of teaching is an important component of medical education, especially in curricula that employ problem-based learning.^[13] Steinert^[14] identified characteristics of small-group teaching that include the following: (i) tutor characteristics; (ii) a non-threatening group atmosphere; (iii) group interactions; (iv) clinical relevance and integration; and (v) pedagogic material that encourages problem-solving and thinking. Moreover, small-group teaching is one of the common features of teaching in the clinical years, especially when facilitated by a respected staff member who is a role-model.^[15,16] Clinical medical teachers seem willing to facilitate small-group teaching.^[15,17] However, the challenge facing medical schools is to implement programmes that allow these teachers to act as role-models and mentors for students.^[18] Opportunely, in the case of SoM, NATP has provided an environment for willing registrars to act as tutors and become role-models and mentors. Small-group discussions have been found to enhance retention of knowledge, while positively affecting motivation and activation of prior knowledge.^[19] In combination with these tutorials, the registrar/resident responsible for teaching ECGs incorporated animations and the use of analogy to assist students in gaining knowledge and skills in ECG interpretation.

Animations

Teachers are constantly looking for ways to integrate theory and practice by using new technology, thus helping students to experience innovative, more attractive and effective forms of learning.^[20,21] Using methods such as animations, phenomena that might be difficult to visualise can be illustrated, with the possible added advantage of depicting dynamic information explicitly.^[20-23]

Computer animations can be used effectively in medical education by illustrating dynamic changes over time and location, while facilitating understanding of complex concepts, systems, or structures, thus allowing visualisation of relationships among component parts.^[20] The use of animations in teaching and learning contributes to what Ruiz *et al.*^[23] refer to as cognitive theory of multimedia learning, which purports that 'people receive and process information via two separate but interdependent

pathways, one for verbal (words) inputs and another for visual (images) inputs.' Consequently, learning can be more effective when information is received via visual and verbal inputs. Also, animations can support the knowledge-building process.^[24] The visualisations and symbols enhance human cognitive capacities and facilitate transfer of concepts and information, but they must be accompanied by pre- and post-explanations and discussion to address misinterpretations.^[24] Applying these ideas, the registrar responsible for the ECG small-group tutorials designed animations using Paint (Microsoft, USA) and PowerPoint (Microsoft, USA) to enable students to visualise ECG changes. In particular, an animation was used to explain the prolongation of the PR interval, depicting the heart and its conduction system on the left and an ECG tracing on the right, where the PR interval prolonged subsequent to the impulse delay in the atrioventricular node.

Analogies

Another method employed during the tutorials was the use of an analogy, which is defined as a process where similarities between two concepts are identified. One concept is familiar (the analogue) and the other unfamiliar, usually a scientific concept (the target).^[25] Stated differently, analogies assist in describing or explaining unfamiliar concepts or phenomena by referring to another situation that is similar to the situation being considered.^[25] Bryce and McMillan^[26] also refer to the term 'bridging analogies,' where the learner is taken from the easily understood everyday base analogy to the target concept through a series of intermediate analogies intended to smooth the transition between familiar and unfamiliar concepts. Teachers can therefore integrate analogies in their teaching to assist students' conceptual understanding of a phenomenon, mindful that most students must be familiar with the analogy for it to be effective.^[27]

A familiar analogy was used in the tutorials to create context, provide a general outcome, and bridge unfamiliar and familiar concepts by referring to the popular movie, *The Matrix*, produced by the Wachowski brothers in 1999. Just as the main character Neo and his counterparts were able to discern real-world images in squiggles on a computer screen, a student could, by the completion of the sessions, expect to 'see' what is occurring in the conduction system of the heart by looking at the squiggles of an ECG tracing. During the session, students were often encouraged to go into the 'matrix mode' when dealing with gradually more complex ECG problems. Another successful analogy was used to assist students with the conceptual understanding of a grade 2 atrioventricular block (Mobitz type 1) (Fig. 1).



Fig. 1. *Wenckebach v. the disinterested girlfriend.* In this analogy, a boyfriend sends his girlfriend an email, represented by the P-wave (A). The girlfriend's reply is represented by the QRS complex (B), while the time she takes to reply is represented by the PR interval (C). As the girlfriend loses interest, she takes even longer to reply (the increasing PR interval), until one day, she does not reply (D). Ultimately, the boyfriend gets a new girlfriend (E).

Methods

A questionnaire was administered to 67 final-year medical students after their rotation in internal medicine in 2012. Of these students, 25 were from the English and 42 from the Afrikaans class. Students were requested to write about their experiences and perceptions of the ECG tutorials. A response rate of 100% was achieved. The main objective of the questionnaire was to obtain information on the students' self-perception of the ECG tutorials, which can broadly refer to a variety of variables, such as academic success or failure.^[28] Moreover, students' performance can be associated with how they feel about themselves, with some studies suggesting that there is a positive relationship between self-perception and academic outcomes.^[29] In some cases, students' self-perception can be better predictors of academic performance than objective measures.^[30] In this study, self-perception refers to the final-year students' own perception of how the use of small-group tutorials aided them in interpreting ECGs.

The responses from the questionnaire were read and re-read to obtain a sense of the data, thus discovering meanings, patterns and connections.^[31] Furthermore, the data were coded to break these down into categories and themes, and to conceptualise and link the themes to the students' written

responses.^[32] Three main categories were identified: (i) positive perceptions; (ii) negative perceptions; and (iii) suggestions.

Results

Tables 1 - 3 show the three main categories, themes, number of responses per theme and examples of actual statements from students.

Discussion

Although the results are limited to a small group of students, most of them had positive perceptions about the tutorials. It seems as though the tutorials might have assisted these students to simplify and clarify ECG interpretation. The use of Microsoft Paint and Power Point as animations might have aided in visualising difficult phenomena and making the information explicit.^[20-23] Also, it seems as if the use of animations and analogies within the small-group tutorials provided the students with an approach to and an understanding of the interpretation of an ECG. The use of *The Matrix* movie, encouraging the students to go into a 'matrix mode' and the girlfriend and boyfriend analogy might have aided them with understanding more complex phenomena, thus assisting with conceptual understanding.^[27]

Table 1. Positive perceptions

Theme	Students, n (%)	Actual statements
Tutorials aid in simplifying/clarifying ECG interpretation	27 (40)	'Session was most informative and simplified.' 'The ECG tutorial helped me to understand interpreting an ECG in a much more easy and meaningful way.' 'It gave me a lot of clarity.' 'I enjoyed this method of teaching, it is simple and understandable.'
Tutorials help with an approach to interpreting an ECG	23 (34)	'Very helpful in my approach to ECGs and helped a lot with practical ways to interpret an ECG when you do not have ages to sit in front of the ECG.' 'It gave me a stepwise approach to interpret an ECG. After having these tutorials, I was able to interpret ECGs at the internal medicine morning meetings, anaesthesiology and paediatrics.' 'It helped me in forming a good approach to ECGs and therefore took away the daunting feelings.' 'I am now able to approach all the ECGs because of the teaching I've received.'
Tutorials aid in understanding an ECG	20 (30)	'The ECG tutorials were extremely helpful. I understood more of the interpretation of the ECG than I did in any other lecture.' 'For the first time I understood the ECG and physiology of it and could remember it later on. He was exceptionally practical. Months later I am still applying what he has taught me.' 'It helped me to understand an ECG and gave me a systematic way to interpret an ECG. It was very helpful.' 'ECG has been taught to us since the 2nd year in physiology. I only really understood it after Dr ...'s tutorial.' 'Made ECG more understandable and comprehensive for me; a broader knowledge and allowed me the ability to ask questions in an interactive informative class setting.'
Tutor characteristics	10 (15)	'He is patient with students who are struggling to grasp content and unlike other consultants when he explains.' 'Dr ... was insightful, patient and friendly.' 'Dr ... is an amazing doctor, and his patience with us and willingness to help us, really inspired us greatly!' 'Dr ... was friendly and enthusiastic.' 'The environment was relaxed and you were able to feel comfortable to ask questions'

Table 2. Negative perceptions

Theme	Students, n (%)	Descriptions
Preferred other tutorials	2 (3)	'It was a good session for revision, but the ECG session we paid for presented by people from outside the faculty was of great value.' 'Session presented by Dr ... was a good "recap" on what I already knew, but I think it lacks detail, because I wouldn't have been able to understand it from the beginning.'
No impact experienced	1 (1)	'Not yet - because I had it late in my rotation.'

Table 3. Suggestions

Theme	Students, n (%)	Descriptions
Earlier provision of tutorials	11 (16)	<p>'I advise that the class should be given in the 4th year already.'</p> <p>'Could have been of value to have something like it in the 4th year – for repetition.'</p> <p>'I would have preferred to practise this earlier in the 3rd or 4th year, because it would have helped me much more to interpret ECGs in the ward.'</p> <p>'I would just suggest that it should be presented in the 4th year already and again in the 5th year for revision.'</p> <p>'I feel that the ECGs should be dealt with earlier in the course, since it is asked a lot in the wards, but our knowledge is limited.'</p> <p>'Feel that it would be more of value earlier in the course.'</p> <p>'I think it would have been better if we already had this lecture in our 4th year with Dr ... '</p> <p>'I feel that the tutorial should be presented early in the 4th year at the start of internal medicine rotation; it would be of much greater value then.'</p>
Need for more ECG tutorials	8 (12)	<p>'My only wish is that we could have more sessions with him, not only starting in the 5th year but in the 4th year.'</p> <p>'I think more sessions should be included in the 5th year.'</p> <p>'Would like more sessions with Dr ... '</p> <p>'Perhaps an additional session would help even more.'</p>

Another positive aspect was the tutor's characteristics.^[14] This was possibly supported by the training that the tutor received, combining the process of learning and mastery of content with the tutorials being facilitated by a subject expert who is also a clinical medical teacher.^[8]

Although the majority of this small number of students had positive perceptions about the tutorials, a small number (4%) had negative perceptions. The latter finding must be investigated; more especially the discovery that students have to pay outsiders to teach them.

This study has implications for teaching and learning in the undergraduate medical curriculum at SoM, UFS. Based on responses from students, it is apparent that ECG interpretation tutorials need to be provided earlier in the medical curriculum and the number of sessions must be increased.

Judging from the statements about the need for extra tutorials, introducing these earlier in the curriculum, expanding the sessions into a lecture series, and the appreciation expressed for these sessions, one can conclude that the students had a need for more comprehensive, integrated and practical training on ECG interpretation. They were even willing to seek outside help.

Conclusion

Although the small-group tutorials and incorporated methods such as animations and analogies are relatively new and have only been evaluated in one group, from the limited data provided it seems as if these methods might have assisted towards equipping students with the knowledge and skills to interpret an ECG. As these tutorials are relatively new, there is a need to conduct a longitudinal study to evaluate the impact of tutorials on the academic performance of students. This article further places the spotlight on the responsive efforts and willingness of registrars in the Department of Internal Medicine, UFS to improve the teaching of such a significant and frequently used investigation as the ECG.

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