

A mathematical representation of the heart

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Introduction

The research reported here aims at providing possible explanations of how students interpret graphical representations of natural but complex phenomena. Mathematical representations such as diagrams, histograms, functions, graphs, tables and symbols normally makes it easier for us to communicate and understand abstract mathematical concepts or other phenomenon described in mathematical terms. Being able to interpret, understand, and work with complex systems involves important mathematical processes which are sometimes underlying that we need to understand and be able to address when facing interpretation challenges.

In mathematics education seen in a K-12 perspective, teachers are working with different representations in order to make it possible for students to understand mathematical objects and concepts. Mathematical representations, structures and constructions are also used in different scientific branches, such as physics or social science. Our investigation concerns upper secondary school student's understanding and interpretations of mathematical representations of a hearts work. To stimulate students' interpretations and investigations, a graphical representation of an EKG measurement was presented to them. Our research questions are:

- How do upper secondary school students interpret a graphical representation of an EKG?
- How do the same students interpret different mathematical meanings of such a graph?

The reason why we selected a graph of an EKG is two folded. The graph in itself is probably one of the most well-known representations for describing a function of the body, namely the work of the heart. Since all humans have a heart, it is interesting per see. We assumed that all students in the study would be able to recognize the shape of an EKG diagram and therefore be able to find interest in the underlying mathematics. The question was part of a test for 18 students in the Natural Science program in upper secondary school. The students are also asked to calculate frequency and periods for EKG signal in the task, something they are used to from their studies both with trigonometrical curves and wave physics. We consider that the EKG task furthermore also test the competencies communication, conceptual understanding, problem solving, procedures, and relevance. The following problem was given to the group of students.

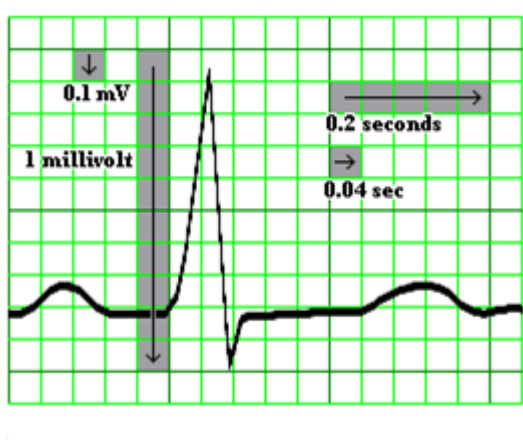


Figure 1. An EKG diagram over 1 period.

The students were asked

- Determine the EKG signal's frequency and period.
- How many heartbeats per minute is the EKG diagram showing?
- When is the signal's rate of change maximal? Explain your interpretation
- Describe in a verbal reasoning your interpretation of the diagram.

Theoretical Framework

Friel et. al. 2001 argues for three different levels of individual understanding of graphical representations: to read data, to read between data and to read beyond data. To read data can be to decode symbols and abbreviations of units and quantities. To read between data requires that the individual can relate units/concepts on the coordinate axis to each other's and to be able to create an opinion about the relation between relevant concepts important for the interpretation. To read beyond data is to be able to set the graph into a real situation, to translate data, to create new representations and the ability to switch between different representations within the same context.

A key challenge to research in conceptual development and learning is to understand how individual constitute aspects of a scientific understanding of a concept. Knowledge acquisition is viewed as a process that involves actively generating and testing alternative propositions. Three main perspectives on conceptual development are discussed by Chi et. al, 2012; the epistemological, the metaphysical and the cognitive perspective. The epistemological perspective on conceptions is based on criteria for difference. Our understanding regarding the world around us and how it is constructed relates to three ontologically "lateral" categories; mental state, entities and processes. (Chi et.al. 2012).