Furthering the Application of Empirical Modelling in Teaching Human Biology

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Abstract

This paper primarily deals with the potential of using Empirical Modelling (EM) as a tool to aid Biology students in their learning about human organ functionality. It extends previous work done on the subject. An EM model of the kidney's internal workings is referenced throughout to support the EM ideas. It is concluded that there are many dependencies in the human body that are heavily involved within human organ functionality and EM is a very useful tool to better explain these functionalities. It is also found that the constituents of the blood provide a perfect universal base for exploring the dependencies between these organs.

1. Introduction

The human anatomy is a very complex one and one that involves 3 main systems: the blood circulatory system, the digestive system and the nervous system. The organs in the body interact with all three of these systems in many ways whether directly or indirectly and must do so in order to carry out their specific roles; ultimately, allowing us to live.

This paper builds on the conclusions made in 'Empirical Modelling and its Application in Teaching Human Biology' on how Empirical Modelling(EM) has many ties with human biology and can thus be used as a tool for facilitating students' understanding of the subject matter (Warwick, 2007). It builds by firstly investigating the potential of EM as a useful and benefiting approach in teaching students the more complex functionalities which occur within the body organs on a more magnified scale. And secondly, by exploring how the causes of diseases within the body can be experimentally detected using such a technique.

To aid with this assessment, an EM model of the kidney's internal function has been created using the EM tools. Although the model is not quantitatively accurate, it demonstrates correct behaviour in terms of the relative levels of the active observables involved. Also, in contrast to the Lung model which deals mainly with the initial stages in providing energy to cells, this paper's model deals with the later stage which is the removal of wastes from the body.

How each of the main EM concepts (observables, dependency and agency) is present within the micro level of describing organ function will now be discussed using the model example.

2. Modelling Organ Functions using EM Concepts

There are many observables that can be identified when studying human organs. From a macro level one can observe the health, output, input, size, temperature etc. When looking at the micro inner workings of an organ there are even more observables identified. These observables depend more on the particular functionality of the organ and thus become less universal.

In the case of the kidney, we understand that it is mainly involved in the control of water retention within the body (Osmoregulation) and in the removal of waste products from the body in the form of urine (Michael Roberts, 2000). These 2 functionalities carry multiple observables such as the Glomerular filtration rate, the amount of water filtered out of the blood and the amount of urea reabsorbed back into the blood.
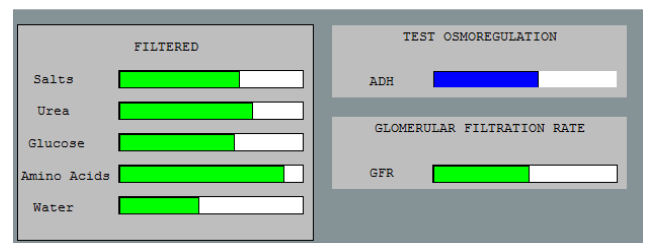

Figure 1: Some observables

Figure 1 shows the kidney model. It can be clearly seen that the observables are in the form of measured bars against the relative substance.

In the case of dependencies there are again many involved even at a magnified level within an organ. For example, the amounts and what organic substances are ejected from the body in the form of urine are dependent on how much of each are reabsorbed back into the blood after filtration which in turn is dependent on what are the relative amounts of these constituents in the blood entering the kidney nephron in the first place. These types of real life dependencies can be easily modelled using EM and an example is shown here in DONALD.

$$reab\_value\_s = percent\_s * var1$$

$$excr\_value\_s = var1 - reab\_value\_s$$

Here, the reabsorbed value of salts is a specific percentage of the filtered salts value and the remaining amount of salt is excreted in urine. Procedural programming is not suitable for this purpose as it makes it very difficult to integrate, add on and change dependencies.

As mentioned before, human biology, especially at such a magnified level, is a haven for many dependencies. By using EM and integrating these dependencies with ease, organ functionalities can then be experimented with, and analysed. Additional dependencies can then easily be incorporated if required when the functionality is not quite correct yet.

In the case of the model in question the main agent which can make changes to the observables is the student user but there are also other agents which make the dependency changes to other observables via interaction by the student. Without this interaction the model would remain static (Warwick, 2007).

3. The Identification of Disease

There are also another set of observables present within the model which expand the EM concept of what is possible when the user has different intentions or takes a different role. These observables are warning messages output on the model of possible risks of disease or conditions with the current state of the model. For example, if the user increases the glucose content in the filtration box above a critical value then some glucose appears in the urine which triggers the message warning of diabetes to appear.

There are other possible messages that can be output which are all related to changing the values of observables and the linking dependencies. "Urine tests are very useful for providing information to assist in the diagnosis, monitoring and treatment of a wide range of diseases" (Pillinger, 2008), because of the presence of or the varying amounts of these blood constituents in the expelled urine. Thus there is great scope within such a model for many more new dependencies to be added with regard to identifying other diseases and outputting these results from the model to the user.

This extra functionality within this model shows that it can also exhibit observables which expand the knowledge base of the user further while allowing him or her to experiment with the model to learn the kidney's main functions; something not considered in the behaviour of the 'lungs model'[1]. This very important addition is only made possible through the use of EM, which increases the educational value and extends the scope of the model through non-verbal means.

4. Future Potential

Enabling a student to add new realised definitions with ease, increases the openness of the model and flexibility, thus encouraging greater creativity from the user (W.M.Beynon, 1997). With this in mind, there are clearly many more dependencies that could be added to the kidney nephron model and these additions would increase the flexibility of the model. This follows nicely into how the model of an organ could have dependency links with other organ models. The main area within this model where this dependency potential can be found is by focusing attention on the filtration box within the model. As mentioned before, this is where the user can interact with the model and can see all the solutes of the blood which are filtered by the kidney nephron. These solutes in addition to red blood cells and large proteins make up the quality of the blood as it enters the kidney.

Blood is the main form in which oxygen, hormones, proteins etc are transported to all cells in the body and thus to all the organs. Therefore, if these filtration levels were altered by a different agent instead of the student user such as a model of the human liver, then we suddenly have 2 models which are

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[1] The 'lungs model' was the EM model constructed to aid the 'Empirical Modelling and its Application in Teaching Human Biology' paper

connected to each other via the blood constituent values. With the kidney functions now dependent on the liver functions we have here the foundational concept of building the whole human biological system in this manner.

Perhaps this could be an area for extension in building more models representing the behaviour and functions of different organs before connecting them through some dependencies on common observables. This concept of linking models was mentioned briefly in a previous paper of how a cigarette model could be linked to the 'lungs model' to experiment with the effects of smoking.

In terms of the actual model at hand, there are still many dependencies that can be added or even adjusted in moving closer to comparing the behaviour of the model with the real organ itself. And these include the dependencies related to the cause /detection of other diseases such as diabetes insipidus or the Glomerular diseases which involve a breakdown in the functioning of the Glomerulus. These again could be in the form of warning messages as a result of the over accumulation of a substance, or to really expand the current model, as a result of part of the nephron structure breaking down.

5. Conclusions

With the work of a previous paper showing how EM concepts are intrinsically related to the thinking of human biology, this paper has furthered the potential of EM modelling as an educational tool by investigating how complex kidney behaviour can be reproduced in the form of an educational model for students. The inclusion of disease warnings within the model means that students are not only learning about the kidney processes but also learning about social factors that may affect how they look after their kidneys in the future. This is merely part of their experience while experimenting with the model and thus developing new construals.

During the course of these assessments, an additional discovery was found with regard to the manner in which models of human organs could be linked together.

It is the blood that flows around the body and that is linked to every cell. So, it is only natural for one trying to model this phenomenon to want the blood to be the set of observables which links these organ models together with dependencies. This is indeed

possible through the use of EM tools as the "central concept of EM is to elaborate a model of phenomenon with reference to a projected causal account" (W.M.Beynon 1997).

References

Michael Roberts, M. R. (2000). Excretion and Water Balance. In M. Roberts, *Advanced Biolody* (pp. 280-289). Delta Place: Nelson.

Pillinger, D. J. (2008, November 27). *Urine Test*. Retrieved from netdoctor: http://www.netdoctor.co.uk/health_advice/examinations/urinesample.htm

W.M.Beynon. (1997). Empirical Modelling for Educational Technology. *Proc. Cognitive Technology '97* , 54-68.

Warwick, S. a. (2007, June). Empirical Modelling and its Application in Teaching Human Biology. *The First Warwick Empirical Modelling Bulletin (WEB-EM-01)* .