

Understanding Learners' Alternative Conceptions through Interaction Patterns During analogical reasoning

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ABSTRACT

The success of vaccine development and distribution has highlighted the importance of immunology as a practical and relevant science. However, studying immunology can be challenging for college students as it requires them to engage with new vocabulary and advanced biological concepts. Due to this, many learners find it difficult to integrate the new material with their prior knowledge and lose interest in the subject when taught through a traditional didactic approach, which can decrease their engagement in the class. Lack of engagement and misinterpretation of instructions are a few of the reasons why learners develop alternative conceptions adding to their learning difficulties. There are various methods a teacher might use in a classroom to identify these alternative conceptions. Analogical reasoning is one such method to understand learners' alternative conceptions. Along with learners' reasoning, log data of learners' interactions can provide insights that can be useful to model learners' behavior. This will enable us to scaffold their learning. This study proposes the development of a technology-enhanced learning environment based on the theories of analogical reasoning through which learners' interaction patterns can be captured and studied with the help of different data sets.

Keywords

Immunology, Human Immune System alternative conception, Analogical reasoning, interaction pattern, log data, Eye gaze

1. INTRODUCTION

Biological education consists of learning many complex systems which are integrated into each other. Learners as well as teachers struggle while learning and teaching respectively about different systems, components, functions, and mechanisms. Human Immunology is one of such complex biological systems made up of sub-systems like the lymphatic system, blood cells, and antibodies. This system is divided into three components 1) the First Line of Defense 2) the Innate Immune system 3) the Adaptive Immune system. The human immune system works at different levels of the organization including cells, organs, tissues, and symptoms at the organism level. Traditional classroom method of teaching typically focuses on the transmission of information, due to which learners face a challenge in the understanding of human immunology. The processes and relationships between many lines of defense are more abstract than other biology topics, and learners typically lack the necessary background knowledge when they first meet the field [3].

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Sometimes they misunderstand the concepts [4]. Alternative conceptions and misconceptions about human biology pose a serious challenge to medical education's emphasis on precise scientific and clinical reasoning

For enhanced comprehension, improved critical thinking, and learner engagement, various pedagogical techniques have been adopted, including case-based learning, team-based learning, and learning through tales and games [8]. Numerous studies demonstrate the usage of simple real-life analogies and metaphors that map to abstract concepts of immunology. In general, a comparison of two objects, or systems of objects, that focuses on the similarities between them is called an analogy [1]. Analogies have been used in many studies to address learners' misconceptions and alternative conceptions. Analogies have been largely used in topics such as protein synthesis, the nervous system, and the immune system. [2]. Analysis of analogical reasoning to understand alternative conceptions has been done using rubrics, frameworks, and interviews [9]. The majority of current research uses multiple-choice pre- and post-tests along with qualitative data to monitor participants' performance or comprehension [10]. However, we would like to triangulate our research investigations using eye gaze data and log data of the interaction. To do this, we have proposed a learning environment based on the analogical process model framework [7]. In this environment, we have designed certain activities which would capture learners' interaction log data. The learning environment will enable learners to interact with different components such as "Stage 1" where the learner will go through a reading task. At this stage eye gaze data will be collected as research in reading can contribute to our knowledge of how learners interpret the educational text. At "Stage 2" we will collect log data to interpret learner interaction. And at the last stage we will collect reasoning in the form of text data. Interviews will also be collected. All this information will help understand the learners learning process and help teachers to develop scaffolds for learning.

2. BACKGROUND

Children come to class already having thought about a variety of events and subjects related to the natural world and try to make sense of their surroundings by constructing mental models. Many researchers use the term "alternative conceptions" since it is value-neutral and express respect for learners' perspectives [6]. There are also other names that have been suggested, ranging from "naive ideas," "prescientific concepts," "preconceptions," and "conceptual primitives," to the complex "limited or inappropriate propositional hierarchies," or LIPHS [11]. One example of an alternative conception in biology is: Because plants cannot move, young children frequently believe that they are not living, and many older learners believe that life forms like seeds are not living [6]. There are a number of reasons why learners may have these different conceptions, one of which is that they attempt to relate newly learned concepts

to existing real-world situations which is by using analogies. In order to comprehend how they link two separate situations, it is important to understand learners' reasoning and thought processes.

The task of understanding and addressing learners' alternative conceptions often falls on teachers. Even while some modern teaching-learning approaches place a strong emphasis on self-learning technologies, teachers still play a crucial role in monitoring, scaffolding, and inspiring learners even while using self-learning resources. Being aware of learners' thought processes through their analogical reasoning will help teachers in understanding their alternative conceptions. Eye gaze data and log data of learner engagement with the system will provide nuanced insights like the specific area where the learner has spent more time. This can inform possible learning difficulties that the learner might be facing, like confusion about a concept. This would otherwise be impossible to capture with merely classroom discussion.

3. THEORETICAL FRAMEWORK

A comparison of two objects, or systems of objects, that focuses on the similarities between them is called an analogy [1]. In biology, the analogy is a similarity in function between parts dissimilar in origin and structure. Analogies can be effective teaching aids since they are believed to aid learners in building new knowledge by connecting it to existing knowledge structures [5]. Analogical reasoning is a cognitive process that involves comparing two or more objects to find their commonalities and differences. The activities in the learning environment will be developed on the basis of an analogical reasoning framework known as the Analogical Process Model (APM). Holyoak and Thagard created this framework for using analogies in reasoning. Finding the source analogy, mapping the analogy's structure, and transferring knowledge from the source analogy to the target problem are the three steps of this method [7]. Fig. 1 shows the steps of the framework.

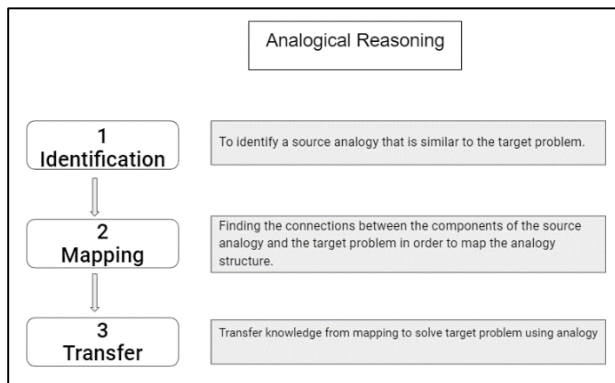


Fig. 1 Three steps of analogical reasoning

4. RESEARCH OBJECTIVE

The objective of this study is to understand learners' analogical reasoning through interaction with the proposed learning environment. The primary research questions to investigate are as follows.

RQ1. What do learners' interaction patterns in the Technology Enhanced Learning environment inform us about their analogical reasoning?

RQ2. What are learners' different alternative conceptions as they reason through different analogies?

5. DESIGN OF THE LEARNING ENVIRONMENT

Considering that this study is still in its early developmental phase, the suggested learning environment will be divided into three main stages. The suggested organization of the learning environment is shown in Fig. 2, along with a description of what the teachers and learners would be doing. Stage 1 of the learning environment will be a reading section where learners are supposed to read the content about a particular concept example such as wound healing. The second stage will be designed on the basis of the Analogical Process Model. One scenario for each concept will be designed with activities based on the three steps of APM. The last stage is the reasoning stage where learners will be asked a few questions and they have to write the reasoning behind their actions in stage 2. All the stages will include reflection spots and scaffolding prompts to complete the activities.

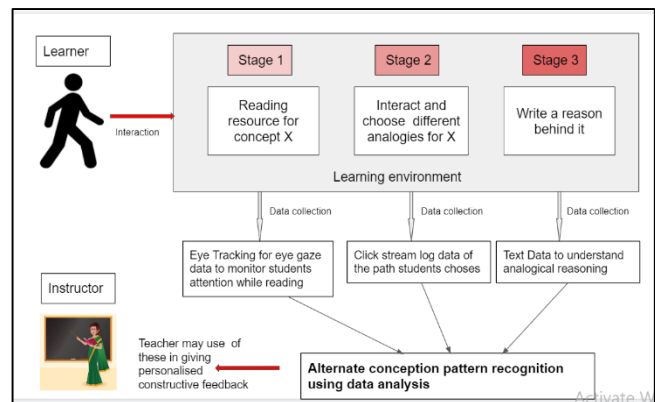


Fig. 2 Study design

6. METHODOLOGY

6.1 Target population and sampling

The study participants would be undergraduate bioscience learners who are taking immunology courses. The first concept introduced in this grade is human immunity. About 10 learners will take part in the pilot trial with the learning environment.

6.2 Data Collection and Data Analysis

In this study, a mixed-methods strategy will be applied. Data of two kinds will be gathered. Utilizing click stream data, text-formatted data, and eye gaze tracker, quantitative data will be gathered. The eye-tracking data will reveal which passages in the text the reader spent the most time reading, missed, or skipped. They will engage with the system in a way that is informed by log data. Additionally, textual data can be handled via keyword search. Collectively, these data can be used to comprehend the patterns of various learners. Additionally, after the study, interviews will be conducted to gather additional data that can be used to support interaction patterns.

7. EXPECTED CONTRIBUTIONS

The proposed study will shed insight into individual learners' reasoning. This will inform us about different alternative conceptions of learners in biologically complex systems, such as the human immune system. Alternative conceptions of learners that teachers might have missed or would miss in the classroom can be informed by the study. It will be easy and beneficial for the teacher to provide tailored feedback to one learner or a group of learners and modify their teaching methods once they have learned where and why their learners have alternative conceptions.

8. ASPECTS OF THE RESEARCH ON WHICH ADVICE IS SOUGHT

The suggested research is still in the planning stages. Advice on how to use and analyze the data gathered to determine how various components of learning might be effective.

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