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# How to support pre-service teachers' conceptual understanding using hyperthermia as STEM context: a case study in sciences education department Universitas Sriwijaya

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**Abstract.** This study aims to identify teachers' conceptual understanding in science content using hyperthermia context. The hyperthermia context is used as a pilot project to develop STEM in Mathematics and Science Education Department. This study is a descriptive study involving 42 freshman science pre-service from Biology, Physics and Chemistry Education. The instrument used is 8 essay questions on the context of hyperthermia but requires mastery of radiation, conduction, convection and evaporation on physics content, endothermic and exothermic content on the chemical content and the principle of homeostasis in biological content. From the results of this study obtained data that the pre-service science teacher students (Biology, physics and chemistry) have difficulty to connect issues of nuanced hyperthermia context to the content of physics, biology and chemistry because the prerequisite content that has been learned by the students has never been integrated in the context of hyperthermia, but even though they have difficulty on it, the hyperthermia have a potential to grow intuitive skill.

## 1. Introduction

Establishing a connection material crosscutting on STEM education is a complex task and requires a learning design that is designed carefully and planned by a team of teachers [1]. When the students have little or even nothing about the concepts and ideas of domain specific content then the student will be difficult to apply naturally in the integrated context even apply STEM in daily life. Therefore it is needed relevant scientific ideas in science or mathematics in an engineering or context of technology design [2].

Context can be defined in several ways. Often the context is described as story, topic, practice, problem, and situation [3,4,5]. Context can also be described as situation that helps students make sense of the concepts, rules, principles, and laws [6]. Another definition described context as an activity that helps students make sense of the activities at the school [7].

Contexts on science learning have their own impact on the learning process. The study of impact context on long-term memory of students obtained that the students will understand the content better if the learning context is implemented in accordance with the existing environment around students. On the affective side, context-based learning will improve students' motivation that can be seen from the investment of more time spent by students [8]. Meanwhile, in study on context learning with PBL approach obtained that context-based learning can activate prerequisite knowledge of the context that



is taught [6]. However, there is a possibility that context-based learning has a tendency to be difficult because it has a greater cognitive load than conventional learning [9].

Selection of the right content is the main thing in the process of teaching and learning activities including STEM learning [10]. Based on lecture competency studies on physics, biology, chemistry, and mathematics content taught to pre-service teacher students in Mathematics and Science Education Department as shown in Table 1, the most likely context to be crosscutting concept in this study is about hyperthermia.

**Table 1.** Sciences and mathematics content on crosscutting concept hyperthermia context.

Context	Contents
Hyperthermia	Physics; radiation, conduction, convection, evaporation and thermodynamics
	Chemistry; exothermic and endothermic reactions in thermodynamics
	Biology; body temperature regulation mechanism as part of the principle of balance (Homeostasis)
	Mathematics; shape and surface area.

Based on the description above, the problem in this research is how pre-service teachers' conceptual understanding could solve problems in the hyperthermia context. Data obtained is used to know the potential of hyperthermia context for development STEM lecture for pre-service teacher in Mathematics and Science Education Department.

## 2. Method

This study is descriptive study in the form of an essay test consisting of eight questions. Four questions are about physics content in hyperthermia context and rest of it is about biology and chemistry content in hyperthermia context. Subject of this research was 42 freshman as pre-service teachers student in mathematics and science education department who attended the lectures of basic physics and general biology.

Data that is obtained from essay test that already collected will be digging more deeply with deep-interview. Deep interview is for knowing the reason for the answer that they write in an essay test.

## 3. Result and Discussion

At Physics education department, radiation, convection, evaporation and thermodynamics contents exist in basic physics course in the first semester. Radiation is the movement of energy through the media and space so that eventually absorbed by other objects. There are various types of radiation such as ionizing radiation, electromagnetic radiation and acoustic radiation.

At Biology education department, hyperthermia context exist in general biology course in the first semester. On the concept of homeostasis stated that homeostasis is the mechanism of the living body to maintain a steady state between the internal environment in the body and the external environment outside the body. This homeostatic mechanism is for example at body temperature, blood pH, and the concentration of sugar in the blood [11]. At Chemistry Education Department, the concept of exothermic and endothermic reactions. Hyperthermia context on learning in the chemistry education department is closely connected to the learning in the biology education department. The content will be: Thermoregulation regulated by the hypothalamus which would provide a reaction to the impulse given, for example, when freezing human blood vessel will constrict and there will be an impulse to vibrate (chills), it is one reaction to reduce the loss of body heat and try increase body heat. Simulation Example: the equipment used is quite simple, they are: thermometers, cotton, and alcohol used to measure the human body temperature. In the simulation, body temperature at any activities (wake up middle of the night/ morning, go to bed, bath in the morning, exercise, work, and bath in the night/with warm water) using a thermometer, the data connected with a body temperature to the ambient temperature with the activities that have been done. At mathematics education department, hyperthermia context can go on the content of the course geometry in the first semester.

This hyperthermia context is presented in the form of questions to see the understanding of the concept of pre-service teachers in the first semester. The question is presented in the form of discourse for the biology, physics and chemistry content. When question containing physics content is tested like the question in Figure 1.

If one day when you have the opportunity to visit the region with cold enough temperatures such as Pagar Alam. At the time of going to bath out of bed in the morning, was in the bathroom had a shower available options using warm water or plain water. So that after the bath you can move as in hot climates without a sweater/ jacket, then what is your choice for the water to take a bath? Explain your answer!

**Figure 1.** Question of hyperthermia context in physics content

Problem above is about the concept of thermal equilibrium, but the students' answers are not connected to the concept of thermal equilibrium. 100% of students in Biology Education and Chemistry Education chose the answer shower with warm water with the reason that warm water can increase body temperature. The same thing happened when students answered the questions in Figure 2.

Desert regions like in the plains of Africa and the Middle East are hot climates and rarely rain throughout the year. The air temperature during the day sometimes reaches almost 60 degrees Celsius. Plants are very difficult to grow well, and even if there are rarely found broadleaf plants. People, who live in the area, usually have a tradition to wear white or bright colored clothing, and covering almost all parts of the body. Do you think there is a relationship that tradition with the climate? What do you think if the tradition of the people in the dressing changed as the tradition of Indonesian people dressed? What is the effect?

**Figure 2.** Question of hyperthermia context in physics content

The question in Figure 2, the student answered incorrectly even they cannot connect these events with the concept of black body radiation as a kind of thermal electromagnetic radiation that is around the object in a state of thermodynamic equilibrium. Only one student from the chemistry education department that has begun to respond towards the black body radiation, and also connect it with the concept of a biological cell death, even though the answer was limited to surface as shown in Figure 3.

4. Jika tradisi berpakaian masyarakat Afrika dan Timur Tengah adalah memakai pakaian berwarna putih dan menutupi seluruh tubuh, maka pada saat siang hari jika masyarakat tersebut berpakaian berwarna hitam dan pendek, maka akan menyebabkan suhu tubuh meningkat. Hal ini dapat menyebabkan hipertermia. Jika suhu tubuh meningkat, maka akan menyebabkan sel-sel dalam tubuh rusak. Oleh karena itu, jika tradisi berpakaian masyarakat tersebut berubah menjadi seperti masyarakat Indonesia, maka akan menyebabkan suhu tubuh menurun dan sel-sel dalam tubuh akan rusak. (sangat yakin)

4. If the tradition of dressing in the African and Middle Eastern communities is the same as in Indonesia then during the daytime if the African population uses dark colors then it is likely to cause hyperthermia. The reaction on dark objects in the form of "black radiation" could make the body absorb the heat and also if you use dark and short clothes, the cells in our body will damaged over time.

**Figure 3.** The student's answer about the content of black body radiation in the hyperthermia context.

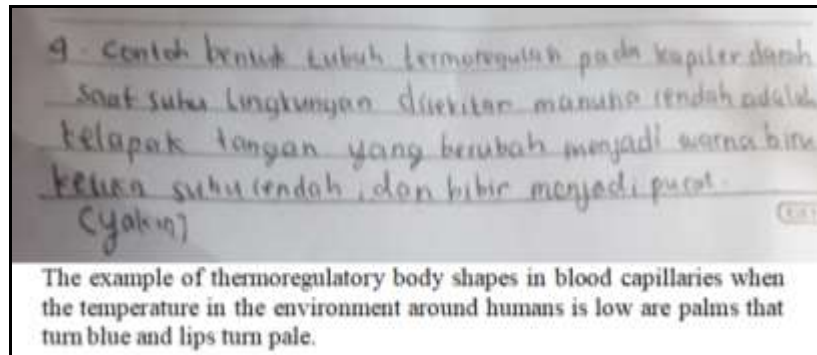
Hyperthermia context in biology content, it is explored through questions in the Figure 4.

Thermoregulation is regulation of body temperature in order to keep the body's core temperature in the range of  $37^{\circ}\text{C}$ . In the process of thermoregulation, reflex response and semi reflex that will affect change in autonomic, endocrine hormones, and behavior. Give examples of thermoregulation in the blood capillaries when the ambient temperature around the human is low!

**Figure 4.** Question of hyperthermia context in biology content.

In a question like this, 14 of 22 biology education's students who join general biology course answer with right reason even one of them answers deeper reasoning. The students answer that the small muscles below the surface of the skin known as muscle arrector Pili muscle contract, lift the hair polikel becomes erect to contract so that it can trap heat and then arterioles carry blood to the blood capillaries under the skin surface constrict thus more heat maintained at the core of the body.

However, most of them answer intuitively based on daily life phenomena, such as in Figure 5.



**Figure 5.** Student's answer about the response of the blood capillaries as a form of thermoregulation.

Hyperthermia context is an actual context familiar to students. In other words, they have experienced it in their daily lives but never formally studied in biology, physics, and chemistry learning in high school. The inability of the students to connect hyperthermia context to physics content such as radiation, conduction, convection and evaporation or biology content can be caused by several things, among others: 1) Students are difficult to solve the context-based question if in the learning is done in the classroom is not based on the context; 2) Content is a prerequisite for mastering context means that students will not be able to master the context well if they do not have prior knowledge related to the context.

Students are difficult to solve the context-based question if in the learning is done in the classroom is not based on the context and not familiarized with questions that are context based. This is reinforced by the study findings which state that is the students are used to being exposed to high-level thinking skills that are usually context based even though they are not through context based learning, they will be accustomed to and able to solve low-level questions and context based high-level questions but if students are used to dealing with low-level questions they will not solve problems with high reasoning [12], it's just that in the repetition to which students will begin to get used to there is no research that reveals about it. In the study on the use of existing contexts in newspapers in science and mathematics learning in 10<sup>th</sup> grade students will spur learning motivation better than conventional learning by using textbooks [13], because the narrative in the learning context will help students have good long term memory so they can remember the content well [14].

Content is a prerequisite for mastering the context so give questions in the form of context would provide excessive cognitive load [15]. There are three types of cognitive load that burdening students, they are the complexity of the content or task assigned to the students, the foreign context for the students and learning model used to study it [16], the context which too complicated, or give too much interesting, but not relevant, the information may be confusing. However, if the context, as it was not part of the daily life of the students, or they do not get involved with that particular social problem, then they might not be quite interesting because the context is too complex will make students are difficult to relate it to the content that have to be learned [16].

#### 4. Conclusion

Pre-service teacher students in Mathematic and Natural Science Education Department have difficulty to connect physics, biology, and chemistry concept integratedly through hyperthermia context if the

content of the prerequisites has never been connected with the hyperthermia context in learning done by teachers in school and lecturers in lectures.

## 5. Acknowledgments

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