Context Map: A method to represent the interactions between students' learning and multiple context factors

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In previous research, researchers have identified a wide range of context factors that could affect student learning, either independently or in combination. However, it is not clear how the context factors interact with student learning or among themselves. Thus, we developed a context map that provides a graphical representation of the interactions among context factors and learning. We will show examples and discuss the possible implications of this method for research and instruction.

I. INTRODUCTION

In previous research, it has been found that student learning can be significantly affected by context[1]. In addition, researchers have identified a wide range of factors that could affect student learning, either independently or in combination, referring to them as social, school, psychological, mental, or emotional context, etc.

Dictionary-derived definitions define context as "the whole situation, background, or environment relevant to a particular event." However, as noted by Cole, Griffin, and LCHC[2], context is an extremely complex and polysemous concept. Even though we know a number of context factors that might affect learning, it is still very difficult to answer such specific questions as "how many context factors are involved in a student's learning?" "How do the context factors actively interact with student learning or among themselves?"

Thus, we need a method of representation to show the interactive relations between context factors and learning. The purpose of our research was to develop a tool, which we call a context map, to help us analyze and understand the effects of multiple context factors on student learning in physics classes.

II. THE CONTEXT MAP

In our research, contexts are analyzed in terms of factors embedded in three types of settings, namely, the learning environment, the content knowledge, and certain students' and instructors' internal states[3]. Context factors in the learning environment are the specific settings of the education environment such as the teachers' teaching styles, class formats, classroom climate, etc.

Context factors in the content knowledge refer to certain unique features of the knowledge to be learned by the students. For example, in the topic of classical mechanics, content based context factors can be very specific ones, such as the force, the mass, the energy, etc. of a context scenario related to the learning and teaching. Students' and instructors' internal status are also considered as part of the context and are often called inner factors of students' learning. These may include motivations, attitudes, previous and current knowledge status, past experiences, etc.

The context map is a graphical representation that shows the interactive relations among many context factors as discussed above. Figure 1 shows the structure of a context map. The dashed line represents the boundary between the inner area context factors and the outer area factors for a particular student. The student learning process occurs on this boundary, with interactions between the inner and outer factors. The learning process is

constantly affected by and can contribute to the different interactions. Among the factors of the inner area, the ones closer to the boundary often have more direct effects on student learning. For example, in figure 1, the student's motivation has a more direct effect on his/her ways of learning than his/her previous knowledge. Notice that this tool is used primarily to analyze the process of student learning rather than the actual outcome of the learning process.

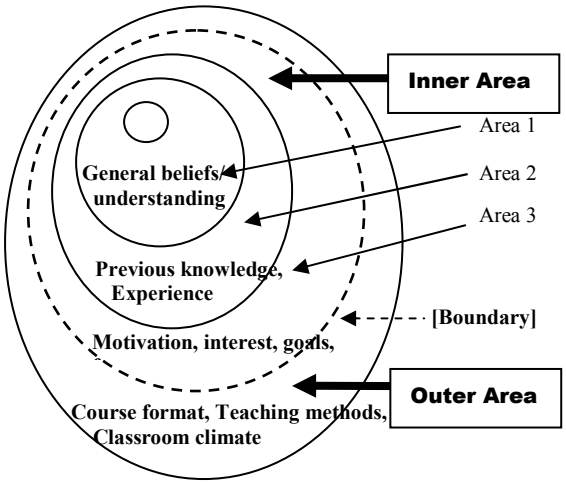

Figure 1. The structure of a context map

The following is a brief description of the procedure for making a context map.

1. We use web-surveys and individual interviews to identify students' typical learning approaches.
2. We ask students to list context factors that affected their learning.
3. We introduce the context map to students and asked them to use this map to reflect how they learn.
4. After this procedure, a researcher and a student construct a context map together.

III. RESEARCH

A. Research Context

This research was conducted in one quarter of a physics sequence for participants in the Freshman Engineering Honors program at The Ohio State University. This 10-week quarter course covered introductory mechanical waves and quantum mechanics. One instructor taught two sections of the course. Eighty-eight students were enrolled in the sequence. We used three web-surveys to measure how students learn physics and to identify the important context factors affecting their learning? (see Table 1). We also observed every class to see how students learn in the classroom. Five students participated in individual interviews on a weekly basis. Each interview lasted 20 – 30 minutes. From these interviews, we obtained a detailed understanding of the students' learning approaches.

Starting from the middle of this course, the main task of each interview was to work with each student to construct a context map that reflects the students' learning in this class. Students placed the important factors that affect their learning into the context map according to the levels of their direct effectiveness. After this, to understand the interactions among the context factors, we asked the students additional questions such as "How do those contextual factors in the context map interact with each other?", "What is the main interaction? and Why?"

Table 1. Selected items from web-surveys

1. For the past 4 ~ 6 weeks, how did you study for this class?
2. Give some details on specific things (methods) you do (use) in your study and discuss the "helpfulness" of those things (methods).
3. For anything you do, there is always a "motivation" associated.
   Please give the major motivations (or goals) for your taking this class.
4. Please discuss any specific things from the teaching and learning that had positive or negative effects on your motivation. (I will then try to do more good things that keep you motivated.)
5. Consider the following factors. For each of them, rate the effects that it has on your learning in physics in this. Select a number between -2 and +2, (-2 for strong negative

effects, +2 for strong positive effects, and 0 for no effects).

Issues about yourself
- General abilities related to learning
- Previous knowledge, past experience related to the present topics or problems
- Interest in specific content topics of the course
- Motivations
- Goals in taking this course
- Fear of not doing well
- General beliefs on how one should learn: e.g., who should be guiding the learning?
- General understandings about the structures of science knowledge and how such knowledge is developed

Issues about the learning environment
- Features of the specific content or concepts you are learning
- Course structure/format
- Amount of time allowed and/or expected for learning
- Teaching methods in this course
- Classroom climate
- Causes of certain kinds of stress (for example, workload)
- Web-survey and homework feedback in this class
- Features of exams (formats, difficulty levels)
- Your expectations for the new homework system
- Expectations of parents, etc.

B. Results

Using the procedure for constructing a context map, we made five students' context maps. Figure 2 shows two of these students' context maps. There are some differences among the context maps. For instance, in the case of student B, he usually tries to understand physics concepts deeply. However, according to him, factors such as fear of failure, interest in the specific physics topic (e.g., the uncertainty principle), and structural understanding have a direct effect on his way of learning. Therefore, his learning often changes depending on these context factors in different learning situation. Moreover, general ability and previous knowledge have some effect but the effects are indirect. As for the interactions among different context factors, interest and goals strongly interact with each other in the inner area. There are many interactions between fear of failure and course stress, and among structural understanding, teaching format, specific concepts, and classroom climate in the outer area. For instance, he said, "When I have stress from a test, I feel fear of failure. But if I am interested in a concept, then it is OK. I study hard."

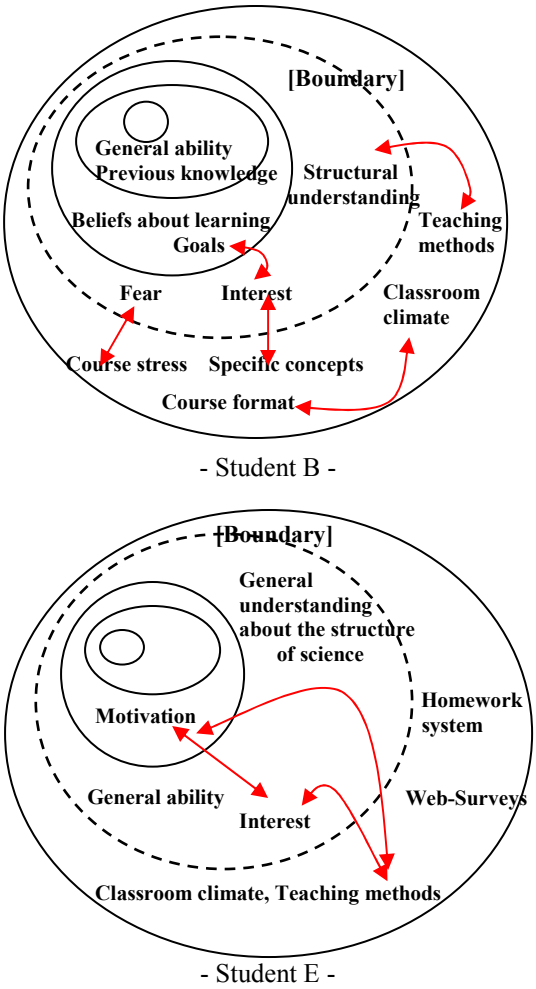

Figure 2. The context maps of two students (B & E)

In comparison to student B, student E has been affected by different context factors. For instance, in the case of student E, context factors such as general ability, interest in physics, and general understanding about the structure of science have direct effects on the student's learning. He is the only one who is significantly affected by one of the personal epistemology, general understanding about the structure of science, that has a significant

effect on his learning, among the five students. Motivation also affects this students' learning. He is actively interested in the course content and tries to manage time and effort effectively to maximize grades. As for the interactions among the context factors, there are close relations between interest, motivation, and teaching methods. For example, demonstrations in the class attract his interest, and increase his motivation to study the materials being taught.

We conducted individual interviews with five students. Although each student's context map has its unique features, we have found some commonalities among the context maps of the five students. In general, in the inner area of each student's context map, affective factors (motivation, fear, interest, goals, etc.) are placed close to the boundary, which means that these factors have direct effects on how the students learn. On the other hand, previous knowledge, beliefs about learning, and general ability are placed far from the boundary, which means that these factors do not have direct effects on how the students learn. In the outer area of the context map, teaching methods, course structure, and classroom climate directly affect the learning process. Thus, as we compare five students' context maps, even though the specific interactions are different, largely, these results are similar to figure 1 (a general context map).

To summarize the discussion about the structure of the context map, in the inner area, area 1 has more abstract factors like general beliefs about learning; on the other hand, area 3 (near the boundary) has more concrete or affective factors, e.g., interest in specific content topics, motivation, goals, fear of not doing well. This result clearly shows that students learn physics differently, depending on the weights of the different contexts that they consider.

IV. CONCLUSIONS AND IMPLICATIONS

From this study, we find that the context map is a useful tool to analyze the effects of multiple context factors on student ways of learning. The research results suggest that affective factors have more direct effects on how a student learns than abstract factors such as epistemological beliefs. The effects of external factors have less commonality and are more dependent on the individual students. We also find several interactions between students' learning and contextual factors and among the contextual factors themselves.

The context map can also be used as tool to help instructors understand the complex dynamics of interactions in student learning, and prepare effective instruction based on this understanding. In our research, we explicitly introduced this tool to the students in our interviews. We found that students can benefit from the context map as it helps students recognize how they learn: What are the important factors affecting their learning? How do those factors interact in their learning process?

Acknowledgements
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1. For instance, in misconception: M. Gomez, J. Pozo, and A. Sanz (1995). Students' ideas on conservation of matter: Effects of expertise and context variables, Science Education 79(1), pp. 77-93. In problem solving: N. Cooke & S. Breedin (1994). Constructing naïve theories of motion on the fly. Memory & Cognition, 22(4), 474-493. In personal epistemology: Hammer & Elby (2002). On the form of a personal epistemology, Personal Epistemology: The psychology of beliefs about knowledge and knowing, B.K. Hofer and P.R. Pintrich, ed. Lawrence Erlbaum, Mahwah, N.J.

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3. Lei Bao (2001). Quantum cognition: Are we ready? Announcer v.31 pp. 67. Gyoungho Lee & Lei Bao (2001). The effects of context on students' epistemological views in learning mechanics. Announcer v.31 pp. 73.