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Interdisciplinary Research

Designing a Coherence- and Concept-Based Modular Course to Facilitate Students' Understanding of Crosscutting Concepts

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Introduction

Crosscutting concepts (CCCs) is a kind of superordinate conceptual knowledge common across scientific disciplines and is referred to as "key ideas" in the Australian science curriculum standards. These characteristics, with the addition of incoherence of CCCs in curriculum arrangement, challenge its instruction. A desired way to this problem is to design an instructional process that can guide students in constructing coherent understanding of CCCs actively and breaking discipline boundaries during exploration. This study aims to explore an effective way to teach CCCs through course design and implementation, thus focuses on the following question:

What effects can be achieved from the modular course that aimed at promoting students' understanding of CCCs?

Methodology

- Modular Course Design

The modular course is designed on the basis of coherence and conceptual understanding with the goal of promoting students' understanding of CCCs. First of all, set the course structure by determining all the CCCs to be taught and dividing them into different units according to coherence, then allocating periods. The coherence is embodied not only intra unit but also inter units, as shown in Figure 1.

Afterward, each lesson is designed with the combination of two conceptual understanding strategies, "concept-based instruction" and "5E instructional model." It is a four-step process: listing concepts, asking questions, selecting teaching activities, and assessing students' understanding. The lesson plan of "Absolute scale" serves as an example to detail each step in Figure 2. Conceptual understanding strategies can help select and organize various teaching activities of different disciplinary contexts conforming to the students' cognitive development logic. And students learn a CCC through inquiry activities in one disciplinary context and apply them in another to break the boundaries of disciplines.

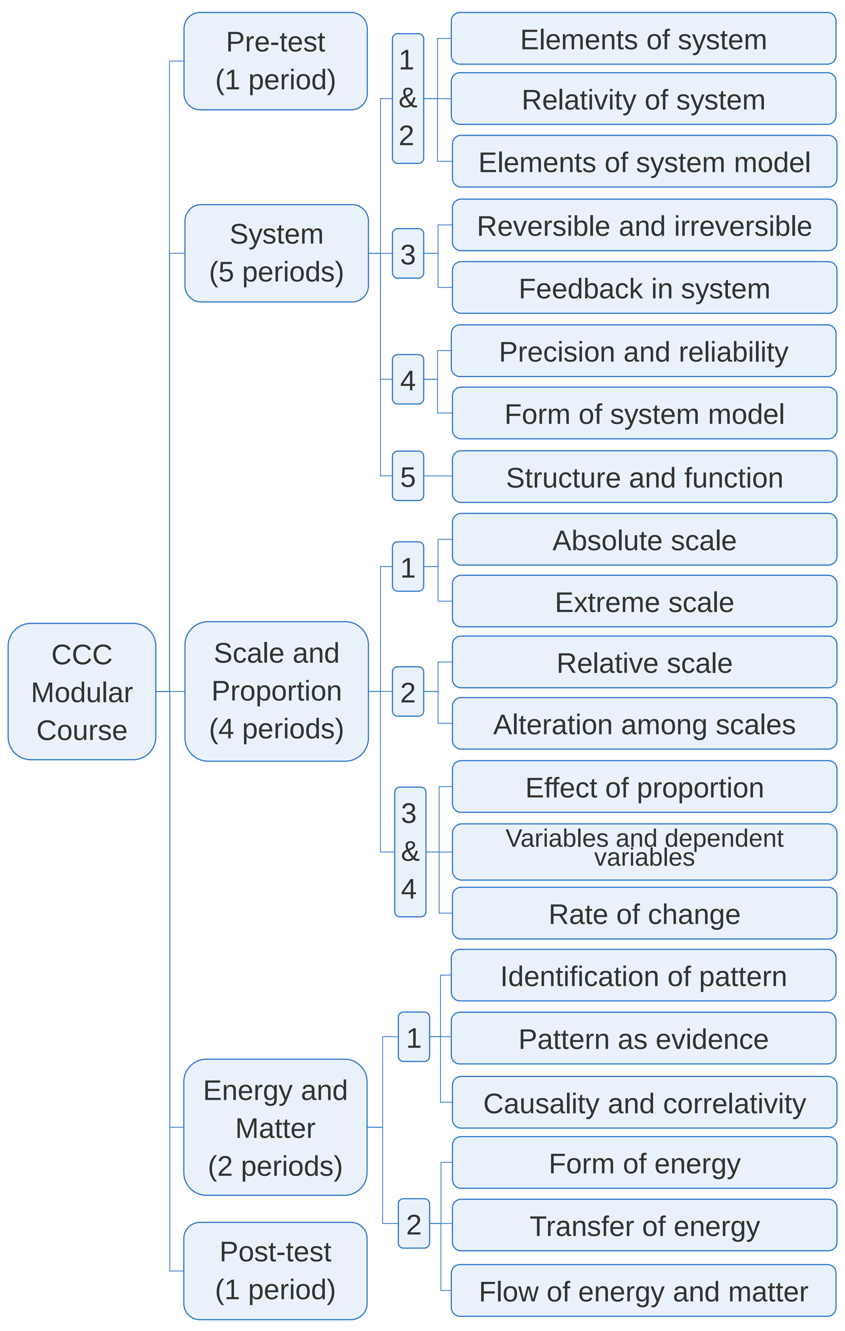

Figure 1. Structure of CCC modular course

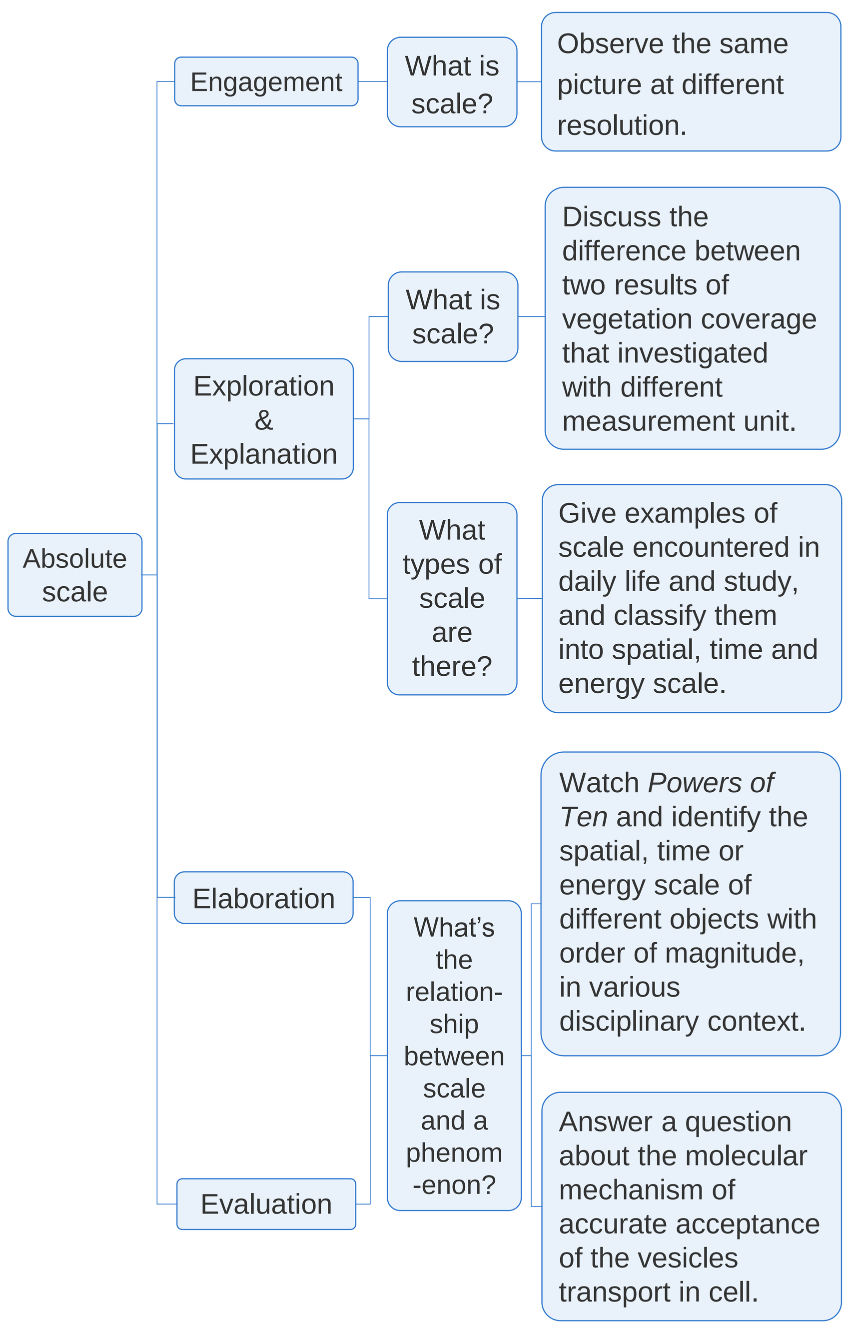

Figure 2. Lesson plan of "Absolute scale"

- Quantitative and Qualitative Assessment Tools

38 high school students (18 boys and 20 girls) took the pre- and post-test in the first and last lesson, respectively. The items in the two tests are the same: there are four context-based short-answer questions, including 13 sub-questions that cover the 21 CCCs in the modular course. In addition, 9 students as a group were interviewed after the pre-test, post-test, and every 2-3 lessons to their understanding of CCCs. The focus group interviews were conducted 7 times, and each lasted 40 minutes on average.

Results

In the quantitative analysis, the t-test of 34 valid paired samples showed that there was a significant difference ($p<0.05$) between the pre-test (18.00 ± 4.41) and the post-test (28.56 ± 6.63).The scoring average of each CCC in the pre- and post-test is shown in Figure 3, and marked with an asterisk if there was significant difference ($p< 0.05$) through Wilcoxon test. The results showed that students' understanding of the CCCs was significantly improved through the modular course. To be specific, students' understanding of 15 CCCs significantly improved, while the other 6 CCCs did not change significantly.

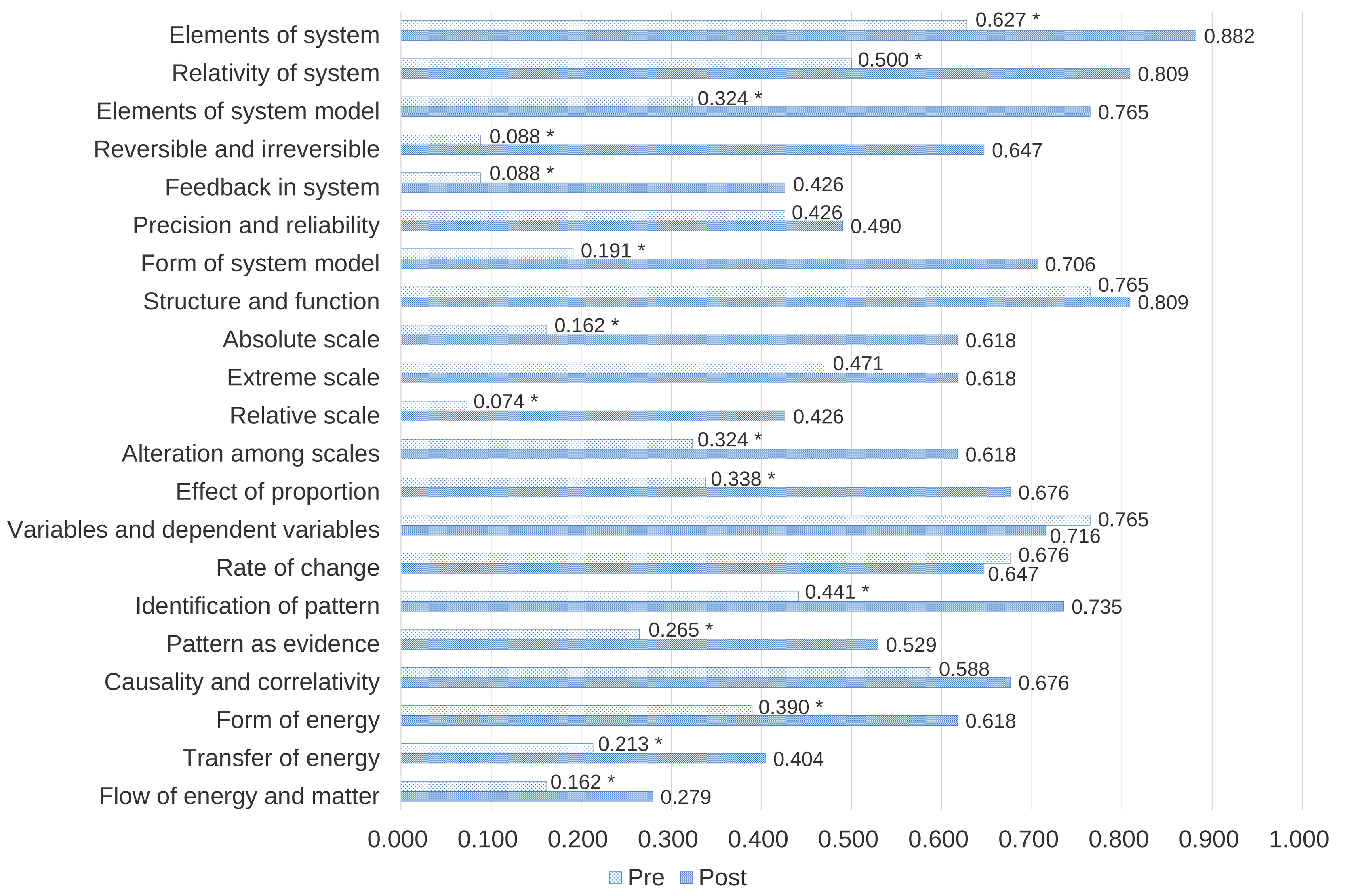

Figure 3. The scoring average of 21 CCCs in the pre- and post-test

Qualitative analysis can explain the results of the unchanged 6 CCCs. In addition to the terms in "Precision and reliability" was too abstract to understand, students have a good grasp on the other 5 CCCs before the modular course. Students also explained how the modular course influences their understanding of CCCs positively (see Table 1), including constructing understanding actively through exploration, clarifying the statement of CCCs, and breaking disciplinary boundaries, etc.

Table 1. The positive effects of modular course on students' understanding of CCCs

Effects of the CCC modular course	Interviews of students
Constructing understanding actively through exploration	"I can see the change, the scale change in the video, then the concept came out in my head. It is very helpful for understanding, that video."
Clarifying the statement of CCCs	"It leads to some symptom, and I related it to the change of molecule, then I think I had the process of thinking imperceptibly through it. And finally you showed the statement on ppt, it made my ideas more clear."
Breaking disciplinary boundaries	"I thought the scale might be measurement units, like some physical units. But now I know that scale has a broader meaning, because it can be also used on a living body or something like that."

Conclusions

With the quantitative and qualitative analysis, we found that participants' understanding of CCCs did improve significantly through this course. Therefore, setting the course structure according to the coherence of CCCs and designing the classroom teaching based on concepts can be an effective way to meet the teaching needs of the three characteristics of CCCs: superordinate, abstract, and common across disciplines. This can be a reference for teachers and curriculum designers.

Main references

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