Use of concept mapping to gain insights into student learning in an agricultural sciences course

Frederik van der Bom

Department of Plant and Environmental Sciences
University of Copenhagen

Summary

This article reports on the use of concept mapping to reveal patterns of student learning in the MSc course ‘European Farm and Food Systems’ (EFFS). The course included 23 students who were asked to draw concept maps on the topic “how does a farm function?”. On the first day of the course, the students received a short introduction to concept mapping incl. instructions on how to develop a concept map before drawing their first maps. On the last day of the course students made a new map, upon completion of which they received a copy of their ‘original’ map to compare with. The use of concept mapping as a learning tool was subsequently evaluated in a group discussion. The results suggest that student learning may be observed directly by use of concept mapping, and that comparing concept maps may help students to gain insights into their own learning, including insights into meaningful changes. However, the study also highlights need for further improvements and investigation for these outcomes to be conclusive.

Introduction

The MSc course ‘European Farm and Food Systems’ (EFFS) has a focus on land-based production systems, their environmental effects, and the context they are embedded in. At time of the course conception, there was a realisation that both domestic and international students increasingly enter the MSc programme without a contextual background of “agriculture”. Many students have a solid, but fragmented disciplinary and applied knowledge acquired in courses on plants, soils, water, economy etc., but have difficulties applying their ‘out-of-context’ knowledge (e.g. on soil processes or plant growth) in real-life agricultural contexts commonplace on farms and other plant production environments. For many students this results in concerns whether their knowledge, skills and competencies are sufficient when confronted with reality in a job, i.e. in a lack of professional confidence.

To address this problem, the EFFS course has been developed for students to gain competences and confidence in contextualizing their knowledge. The course is centred around a close collaboration with a partner company in agriculture (a large vegetable producer), where student groups spend time doing field work in the company and engage in real-life cases. This is facilitated and structured, leading students through a process starting with identification of areas of improvement through interactions with the partner, to problem analysis, solution creation and prioritizing, and finally delivering a partner document with proposals for action to the partner. Hence, students are encouraged and supported in applying their ‘out-of-context’ knowledge within the setting of the partner company, and in doing so, they are expected to create value and gain professional confidence.

Broadly speaking, course evaluations and student responses to the EFFS course are positive. Students have expressed that they feel more confident in their own skills and that they have realized new learning needs. However, true assessment in the context of the education remains difficult. In part, finding an appropriate assessment tool has been difficult because the underlying objective (shaping professional confidence) is difficult to quantify.

One way to address the challenge of assessing student learning may be through the use of concept mapping (Novak, 1990). Concept maps are graphical tools for organizing and representing relationships between concepts; and can provide a means to capture and represent student knowledge and the structure that students see among concepts (Novak, 1990). Studies on concept mapping have indicated several potential benefits of concept mapping, including: (i) promoting ‘meaningful learning’, (ii) “empowering” students through knowledge of their own learning, and (iii) documenting and exploring knowledge acquisition and conceptual change. For the latter, it has been proposed that comparisons of successive concept maps (produced by students as they gain new knowledge and skills) may be useful to reveal changes in cognitive structure that result from instructional intervention (Carey 1986). Therefore, the aim of the research presented here was to understand if adoption of concept mapping can deliver greater insight into student learning in the EFFS course. Within this, the potential for concept mapping to provide students with insights into their own learning and/or changing perspectives - by evaluating their own maps – was of particular interest.

Methods

Subjects and course background

Subjects of the study were 23 students enrolled in EFFS at the University of Copenhagen in the academic year of 2023. This course is mandatory in the MSc Agriculture program, specialisation Production and Environment. The majority of students (but not all) were enrolled in this program. EFFS is taught as a full-time, eight week course, to facilitate the on-farm research and group projects. It runs from late April to June, i.e. early season, when the partner company enters into the main cropping season and activities related to crop production start to dominate the actions in and around the farm. All students are expected to have domain knowledge of agriculture and environment, corresponding to a BSc in one of these fields. EFFS is taught in English and typically attracts a mixed national/international audience.

Procedures

Concept mapping

On the first course day, students were given a short presentation detailing concept mapping, including (i) the inclusion of 'core concepts' and 'relationships', (ii) two examples of 'simple' and 'detailed' concept maps, (iii) counter examples i.e. non-concept maps such as flow charts and mind maps, (iv) the proposed process of developing their own concept map, being identification and ordering of core concepts, followed by identification and insertion of relationships and cross-links (Novak &

Cañas, 2007). Students were then given 30 minutes to individually draw their own concept maps, on paper, considering the focus question: “how does a farm function?”. At this time, the students were not explicitly informed that the exercise would return at the end of the course, but they were informed that the exercise would serve as a reference point for the teachers and to help gain insights about and assess learning over the course. On the last course day, after submitting their group reports and partner documents, the students were given a recap on concept mapping and were asked to repeat the exercise.

In addition to the student concept maps, an emeritus professor who had originally designed the EFFS course was also asked to draw a concept map, from heron referred to as the ‘master map’ (Fig. 1).

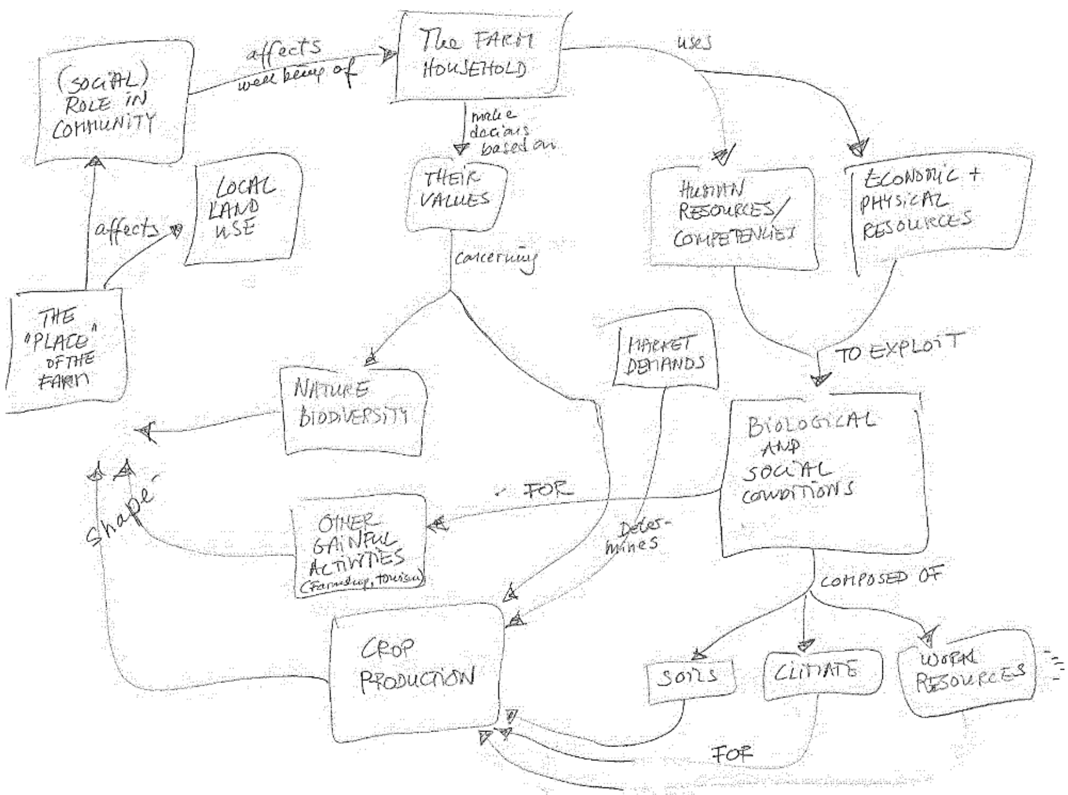

Figure 1: The ‘master map’ with key features including core concepts (boxes) and relationships (labelled, directional arrows)

Data analysis

Map complexity and structure were quantified using relational scoring with the master map, in which a proposition is defined as two concepts connected by a labelled arrow that indicates the relationship between the concepts (McClure et al, 1999). For each map, all separate propositions were scored from zero to three following the scoring protocol (Fig. 2), which considered their correctness with the help of the master map (Fig. 1) as a guide. Related concepts were scored as a single proposition (e.g. fertilisers, manure etc. were considered to relate to 'work resources' in the master map). The final score for each map was then found by summing the scores for each proposition. However, several of the EFFS students did not complete their concept maps with directional, labelled arrows (even though they were instructed about the relevance of doing so – see discussion). It was therefore decided to relax this requirement by accepting unlabelled line-connected concepts as a proposition. This was considered justified considering most of the earlier work on concept mapping did not include labels on the lines that connect concepts (Novak & Gowin, 1984). Nonetheless, the presence of labelled arrows was considered favourable in the scoring procedure and was a requirement for a score greater than one.

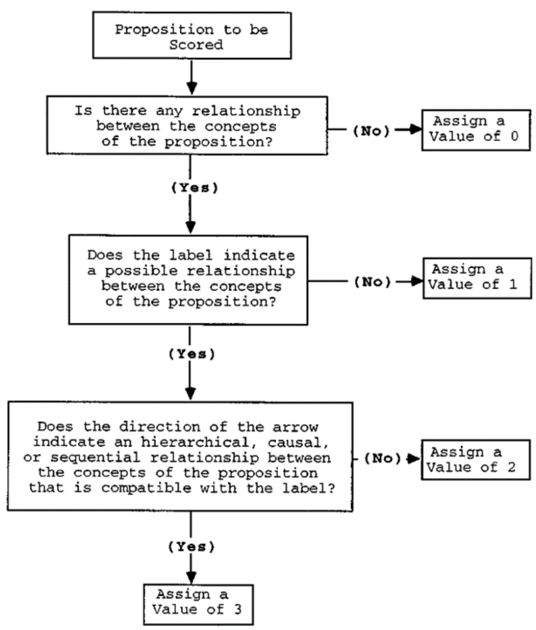

Figure 2: Protocol for the relational scoring method (from McClure et al., 1999).

Absenteeism during the first or second part of the exercise, one student dropping out of the course, and some students not handing in their concept maps (which was voluntary) means that for this analysis complete data, i.e. successive concept maps, were available for 13 subjects (5 male, 8 female). Test scores at the start and the end of the course were compared using a paired sample T-test in R.

Student evaluation
After completion of the second concept map, each student received a copy of their original map and was asked to compare the two maps for 5-10 minutes. All students were then asked to engage in a 20–25-minute discussion about (i) observations about their own concept maps and (ii) concept maps and their use as a tool for gaining insights into learning. The discussion was open-ended, though guided with questions and follow-up questions, whilst discussed topics and conclusions were written on the whiteboard. This approach was expected to be suitable considering the intense course structure had facilitated ample engagement from all students, with activities such as the farm visits and retreat creating a close, inclusive group of students. It was therefore anticipated that group discussion *in plenum* would deliver more detailed feedback than alternatives such as individual or anonymous 'standardized' questionnaires.

Results and discussion

Concept map assessments

The mean scores for the concept maps at the end of the course were slightly greater but there was no significant difference between scores at the start or at the end of the course (Table 1, $P = 0.4395$). As indicated by the large SD, there was substantial variation among the scores, with student maps ranging from a few that did not include any clear propositions to quite detailed maps with many concepts and clearly defined relationships (see Figs. 3 and 4). Specifically, a few maps were more akin to a flow chart or mind map and hardly fulfilled the criteria of propositions in the context of concept mapping. This was unexpected considering the introduction also included a short overview of 'non-examples' that specifically illustrated these visualization methods and their contrast to the exercise objective. It is an indication that more initial training may be required. Indeed, studies often include a presentation of the concept mapping technique, followed by one or several guided practice sessions before subjects are asked to create a concept map (e.g. McClure et al, 1999). This approach may better support student in generating their maps, although a potential downside might be the amount of time that is needed to also incorporate training sessions into an already intensive course.

Table 1: mean scores for sequential concept maps generated by students at the start and end of the EFFS course (n=13). Scores based on the relational scoring method relative to a master map (see Fig 1 and 2).

	Mean	SD
Course start	7.45	7.13
Course end	8.27	6.72

Support for further training needs might also be found in the time needed for students to complete their maps. Although the concept mapping exercise was designed to last 30 minutes, most students indicated that they could have used more time after the first concept mapping exercise. In contrast, all students finished their second map before the end of the 30 min. This was coherent with students asking for clarifications or support during the first exercise, whereas no questions were asked when students were asked to draw their maps the second time. On the other hand, some of the second maps were also less worked out than those at the start.

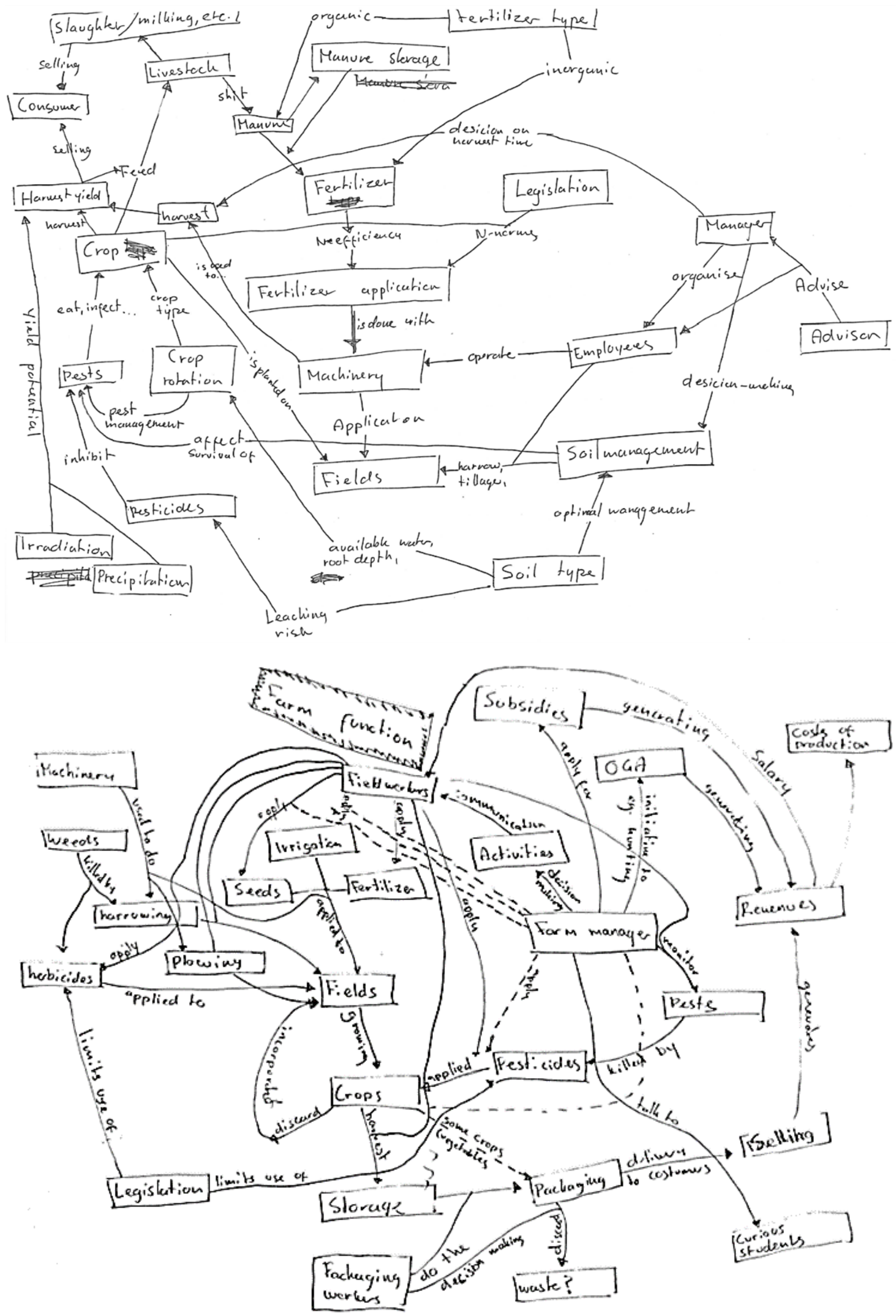

Figure 3: Example I of two successive concept maps at the start (top) and end (bottom) of the EFFS course. Whilst both maps reflect a high degree of complexity and student knowledge, note the change between the initial concept map, which had a relatively technical crop-soil perspective, compared with the subsequent map which incorporates new concepts and relationship related to (i) the farm manager and field workers and (ii) farm economics. Both play a central role in the EFFS course.

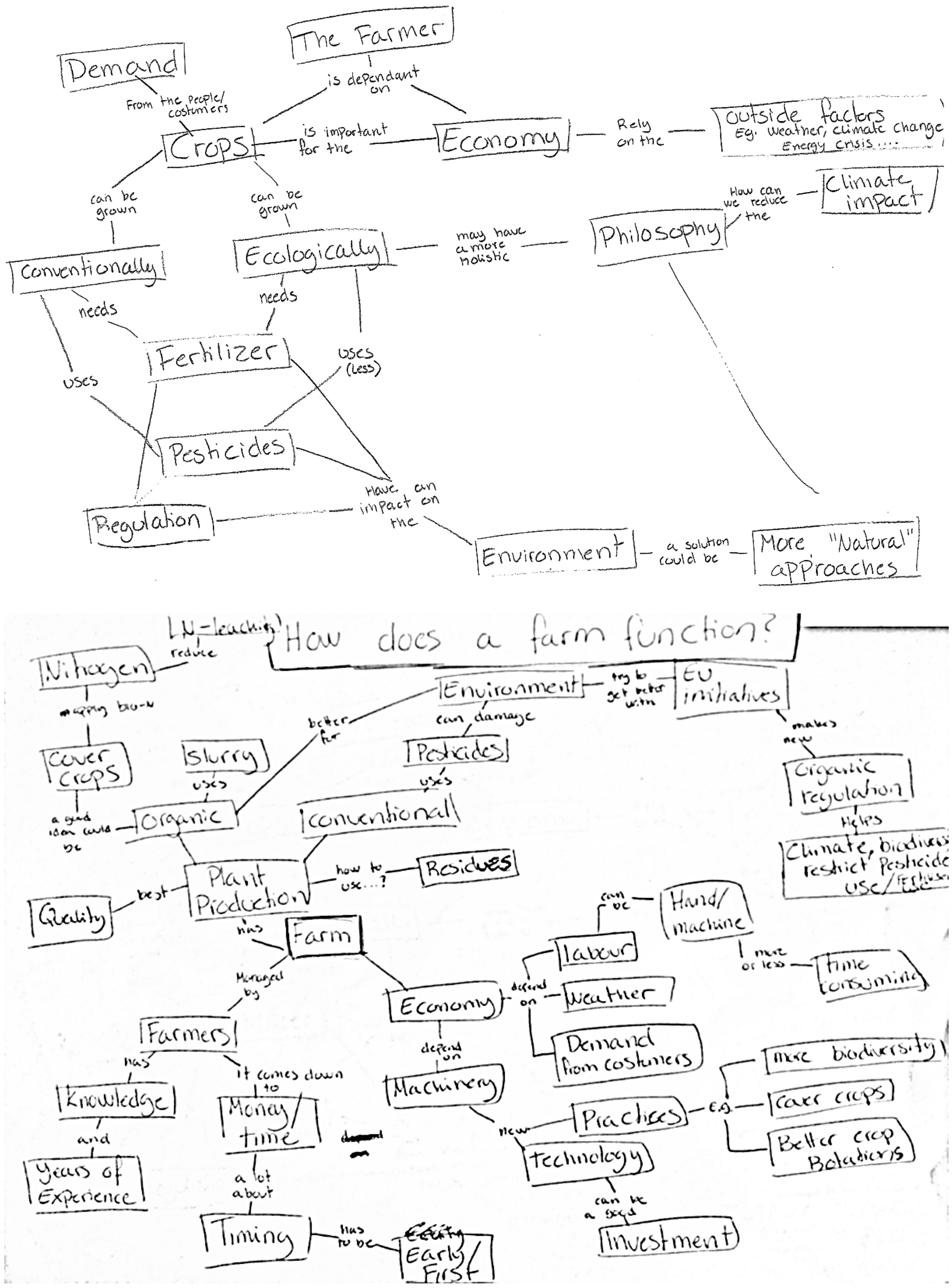

Figure 4: Example II of two successive concept maps at the start (top) and end (bottom) of the EFFS course. The second map expands from the original and tends to include a new level of hierarchy. Similar to the example of Fig. 3, we can observe more concepts and linkages related to the farmer and the farm economy. Noteworthy is also the addition of (EU) regulation and cover crops, which the specific student worked on within the student project.

Student evaluations

Of all participants nineteen took active part in the plenum evaluation of the concept mapping. After discussion, nine (broadly defined) topics stood out:

(i) student observations about their own concept maps

1. In general, students agreed that concepts that had been incorporated in the first mapping exercise also returned in more-or-less similar fashion in the second map. Further, many students noted the introduction of new concepts in their second map, whilst a few remarked that (less important) concepts had been dropped.
2. Students remarked that the second concept map often included more relationships. Within this, students specifically remarked on more/new 'cross-relationships' i.e. new connections among different 'branches' within the concept maps. An example is provided in Figure 3, though it is noted that the original map by this student already demonstrated a high degree of complexity and cross-relationships.
3. Several students noted that the focus of the second concept map had shifted compared to their first one. For example, the second concept maps included more detail (concepts and relationships) about economic incentives (examples Figures 3 and 4).
4. Shifting perspectives: several students noted that their second maps were more 'project focussed', i.e. (new) concepts and relationships that were included in the second maps aligned with their experiences from the course group work. An illustrative example of this is provided in Fig. 4.
5. Increasing hierarchies: Students remarked that the second maps tended to be 'more vertical' as compared to a 'more horizontal' first map.

(ii) concept mapping and their use as a tool for gaining insights into learning

6. In general, students remarked that comparing their concept maps was interesting and could provide them with illustration and insights into their own learning.
7. Students remarked that concept mapping was 'difficult'.
8. The exercise was conducted on paper, but computer-based mapping may be preferred. Specifically, the ability to move around concepts and (un-)connect them could make the exercise less difficult. Along these lines, one interesting observation was that one student wrote

down all concepts first and then cut up the paper, which allowed for the concepts to be shuffled around before adding relationships.

Perspectives on implementing concept mapping and future improvements

Although this study is not conclusive, the evaluation of concept mapping in the context of EFFS highlights both potential benefits and areas where improvement is necessary. In terms of potential benefits: changes could be observed between the first and the second maps that suggest shifted student perspectives (arguably reflecting student learning); and students own comments about the differences suggest this approach can help provide insight into their own learning. Further, a buzzing classroom when students were given their original map suggests that concept mapping can be an enjoyable and interactive exercise. Subjectively, when comparing the concept maps of individuals, there was evidence of student learning in relation to the course objectives, demonstrated by improvement in the complexity and 'completeness' of their maps (e.g. see the examples of Figs. 3 and 4).

The study revealed areas that require attention for the implementation of concept mapping. Some students did not show significant improvement in their second concept map, and a few even regressed, although it can be speculated that this might also be related to student motivation at the timing of drawing the second map (on the very last course day). The variation in outcomes could also be attributed to differences in background knowledge, in which students with a stronger agricultural basis may have found it easier to create more advanced concept maps.

The assessment of the concept maps in itself could be more robust with greater quality maps. As previously discussed, a more structured approach to introducing concept maps and use of computer software may help students improve their mapping skills. Computer-based mapping would be easy to implement considering software such as IHMC CmapTools already exists (and is recommended by Novak & Cañas (2007)). Other options include providing students with more time, encouraging students to reflect upon and reorganise their maps, and further clarification that links between concepts without statements lack meaning.

Conclusions

In summary, although there are challenges to implementing concept mapping, positive aspects, such as student engagement and visible improvements in concept maps in some cases, provide a solid foundation for further exploration and refinement of the approach. With refinements, concept mapping could become a useful tool for gaining insights into student learning in EFFS.

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