CONCEPT MAPPING: AN INTERESTING AND USEFUL LEARNING TOOL FOR CHEMICAL ENGINEERING ENTREPRENEURSHIP CLASSES

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Abstracts

This paper describes an ongoing study on the use of concept map in chemical engineering entrepreneurship classes to enhance student learning. The study was implemented in three stages. In the first stage the students were introduced to the idea and construction of concept maps. The second stage involved the construction of concept maps during field work period in which the students were sent to various small companies and home industries with the intention to better understand the reality and application of entrepreneurship. The last stage was the submission of the final reports in which the students were again required to hand in another concept map. The students completed the field work in groups of four to five, and were asked to create both individual as well as collective concept maps.

The present study produced three tentative findings. Firstly, the first stage mostly produced simple concept maps which barely contained basic entrepreneurship principles. These initial maps, however, developed and became more complicated as the students went on completing the field work and subsequently preparing the report. Secondly, it appears that each student wanted his/her contribution in the collective concept map construction be acknowledged. Thus, the students were believed to be motivated. Thirdly, since the concept maps produced were collected and displayed in the department for comparison with the forthcoming classes, the students seemed to get a feeling of continuity, something that is not normally noticeable in the traditional classes. These findings indicate that concept mapping has a positive effect on student learning. This paper ends with a discussion on the study with respect to its pedagogical values and applicability to teaching and learning activities.

Introduction

A concept map is a schematic representation of information. It is constructed to visually explain the relationships among concepts. The concepts are shown in the form of nodes or boxes and the relationships are represented by lines or arcs connecting the nodes. Words or phrases that explain the concepts are put inside the boxes, whereas the lines are labelled to indicate the characteristic of the relationships.

Concept mapping has been used extensively for a variety of purposes in educational field. These purposes include the use of it as an instruction or teaching strategy, as an assessment tool for students' learning, and for curriculum development [1]. The concept mapping is considered

beneficial to both students [2] – [7] and lecturers [8] – [11]. Concept maps require that learners understand the interrelationships among concepts. Thus, concept maps may motivate student learning activities. For lecturers, on the other hand, concept maps may, among other things, help them to "pinpoint" in which areas the students are weak, and therefore, need reinforcement. Additionally, concept maps are considered as a potential tool for lecture planning. They help arrange the material content in a logical manner. The activity of concept mapping can be useful to assess both pre- and post-subject matter knowledge of students.

Chemical engineering courses contain many subjects which require the use of schematic representation such as flow diagrams and process flow sheets. This is evident in both lectures as well as lab exercises. It is envisaged therefore that the use of concept mapping as a learning tool will be appropriate. Although concept mapping is assumed to lead to higher test scores [6], the present study focuses mainly on enhancing or motivating student learning.

Entrepreneurship Classes

The entrepreneurship classes aim to help students be aware of the importance of innovative aspects in real life. In our department it is to emphasize that our society needs more innovative persons and not so much technicians. In the recovery period (after the 1998 economic crisis) it is always asked: where is all the technology-related expertise, what are they doing in the aftermath of the crisis? In addition, creating our own job and running our own companies (however small) are considered necessary even in a highly industrialized country [12].

With the introduction of concept mapping for the entrepreneurship classes the author with the help of the lecturer for this course (i.e. the second author of this paper) introduced the idea and construction of concept maps on the first day of the class. During the introduction the students were encouraged to create concept maps both individually and collectively. Finally, a collective concept map should be prepared along with the report prepared after the field work.

Implementation

A careful instruction is considered necessary for the successful creation of concept maps [10]. The instruction involves exercises during which time the instructor may provide the learners/students with examples on how to create a concept map. The instructor may provide assistance in the form of comments, corrections, ideas, and so on. The introduction was started with the author drawing two diagrams depicting simple concept maps, as shown in **Figure 1**.

As can be seen, **Figure 1** illustrates the hierarchical structure of a higher education institution. The diagram on the left shows a simple structure, while that on the right conveys more details. The students quickly realised, even at face value, that the two diagrams were significantly different in their comprehensiveness. It was explained to the students that both the left and the right diagrams were correct. However, the diagram on the right obviously carries more points. The students were also told that a concept map is not necessarily of hierarchical cluster form [2], and that other forms such as a network structure [1] is also common. In fact, it was explained that a concept map may take any form as long as it conveys understandable and meaningful relationship among concepts.

After the introduction the students were told to create a concept map similar to those depicted in **Figure 1** but related to the content material, i.e. entrepreneurship, and were given the following basic concepts: *hard work*, *team work building*, *innovation*, *creativity*, *perseverance*, *entrepreneurial attitudes*. The students were also asked to select several other concepts related to entrepreneurship. Prior to drawing the concept map, it was emphasised that this is an open-ended work with no single solution, and that the students could ask for help from either the authors or the peer groups. Each group should at least hand in one collective concept map. Submission of many individual concept maps alongside the collective ones (after the introduction) might indicate that the students were motivated. These maps were kept separately as individual contributions and treated accordingly.

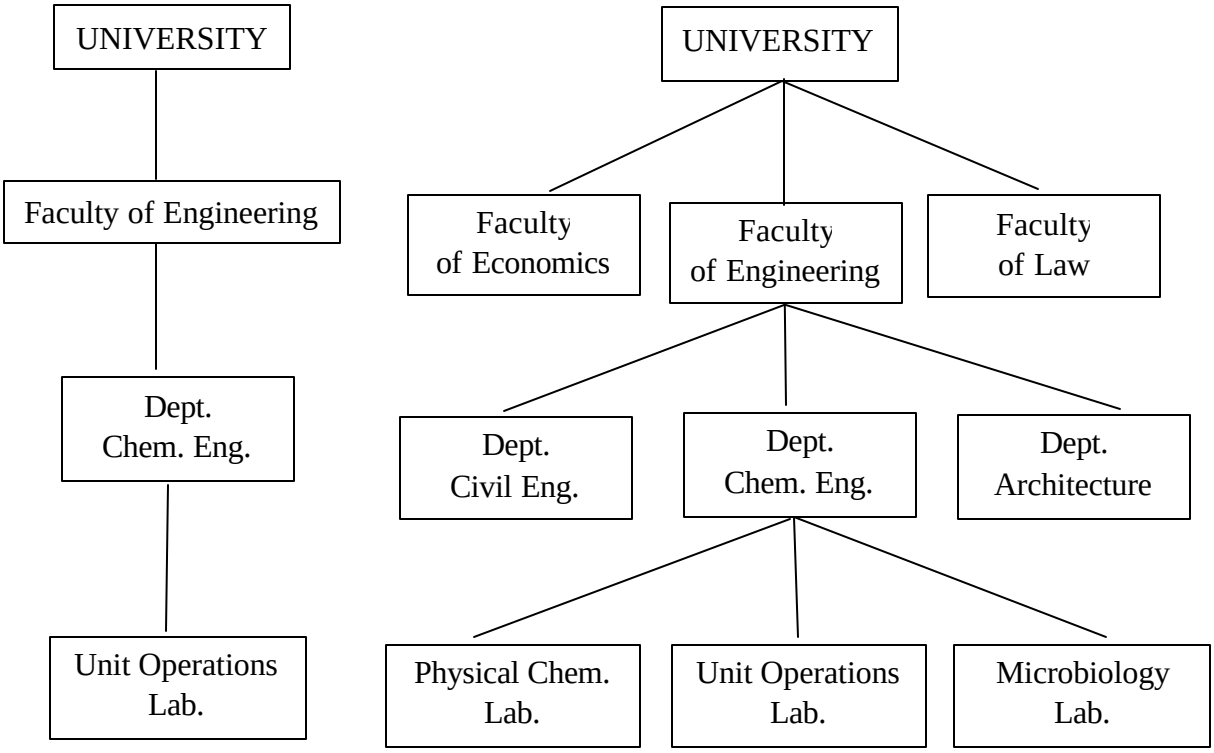

Figure 1 Two comparable introductory concept maps

It was encouraged that each member of a group should feel free to contribute as many revisions to the collective concept maps as possible. Each collective map was drawn on a piece of paper and was then glued to a cardboard or other hard backing. These maps were then hung on the wall of the department and left displayed there so that from time to time the students from the group who owned the concept map might modify or revise them.

Ferry *et al* [10] have used volunteers in their research on the use of concept maps. Their method was also simulated in this work. It was announced that the students were expected to voluntarily participate in an interview which would be conducted in conjunction with this introduction of concept mapping. The interview was intended to examine how the students felt about this new idea of concept mapping.

Analysis of the Student-generated Concept Maps

To date, analysis of concept maps is mainly carried out in an arbitrary manner. Some workers have used scoring criteria to assess the quality of a concept map, while some other workers have applied the "density" criteria, i.e. the frequency of the connecting lines which were used in a concept map [1]. The scoring system requires that values should be allocated on each component of a concept map. Obviously, the allocation of such values can be a subjective process with regard to both the domain of study and the expertise of the instructors. Similarly, counting the frequency with which components or propositions in a concept map arise may also be inappropriate for evaluation purposes. Higher frequency does not automatically represent the intrinsic relationships among components [1]. Since the present study emphasises on the use of concept map as a motivation tool for learning, the analysis was carried out to examine the "extent" of knowledge that the students have in relation to the topic under consideration, i.e entrepreneurship. Thus no values were assigned to the components of the concept maps submitted by the students. In fact, the analysis was carried out with twofold purposes. Firstly, the results of the analysis would be used to encourage student learning. Secondly, the analysis would be part of the authors' intention to experiment with concept mapping in the domain of chemical engineering.

Figures 2a and **2b** display concept maps created by two different groups right after the field work. These figures are typical to many concept maps created during this period. It seems that the groups have made a serious effort in constructing them. However, the two concept maps merely show basic or general knowledge. For example, **Figure 2a** does not depict any meaningful measured quantities, something essential in chemical engineering disciplines. In addition, **Figure 2a** may not correctly show the acceptable arrangement of a block diagram since the usual pattern is for the boxes to contain any description of a process such as "mixing". Thus the box with "Nata de coco" label in that figure is actually a bit weird. The same is true for **Figure 2b** which shows relatively detailed items related to entrepreneurship but says nothing of chemical engineering.

It is also interesting to note that the concepts offered previously during the introduction (*hard work*, *team work building*, *innovation*, *creativity*, *perseverance*, *entrepreneurial attitudes*, etc.) were hardly used by the students. It could be that concept mapping was still something so new; as if coming out of the blue, that the students did not have enough courage to venture into this area. The concept maps submitted were collected and analysed, and were later given back to the groups with comments for improvements.

Figure 3 (submitted by a particular group) illustrates how the concept map on entrepreneurship as previously shown in either **Figures 2a** or **2b** has been altered and developed. It may indicate that in developing the concept the group could have been motivated to work as a team. The students felt the need to show to the lecturers that they were actively involved.

It was observed that more discussion occurred among the students in a group during this activity, thus it is believed that the concept mapping could encourage team building and the critical thinking skills. Based on **Figure 3** it is assumed that the present work was also useful in discouraging rote memorization where students only memorized what they had learned.

Samples of journal entries from students

An interview for the volunteer students was conducted by the first author and some of the results of it are presented in the following journal entries.

1. *I feel motivated since I now begin to realize the connection between theoretical and practical aspects of entrepreneurship taught in chemical engineering studies. The field work exposed me to the real world of jobs to enter once I finished the studies. The concept mapping helps me organizing my thought processes.*

This student valued the concept mapping application for the entrepreneurship classes. In this case, it seems that the application of concept maps made him feel easier to organize his thought processes.

2. *I feel motivated to learn that other students, they are the forthcoming batch of students, would recognize my work. I think my contribution to the drawing will be part of a big continuous project.*

It appears that the application of concept mapping has been able to motivate this student. He feels the need to work properly realising that future students would recognise his work.

3. *The references are useful for other subjects as well. Other students may benefit too.*

4. *Can be used for other subjects.*

5. *I'll try the concept mapping for other subjects. For my own use.*

Comments no. 3, 4, and 5 (from three students) indicate that the idea of concept mapping could be applicable to other subjects.

6. *It's not that easy. You need to understand the relationship among concepts. Well, connecting pieces of information forces you to think hard.*

Many students had this comment (not necessarily with the same sentences). Such a comment is particularly valuable for the authors. It helps them understand the need to further explore the advantages of concept mapping with respect to teaching and learning activities.

7. *Could be more useful if introduced early. The beginning of uni studies.*

This student considered the concept mapping as a useful tool that should be made known to students earlier. The idea of concept mapping was related to effective learning.

8. *I used something like this in high school. I feel comfortable using it.*

One of the volunteers did mention about her previous experience using concept mapping. It seems to be a positive experience.

Evaluation of the Study

Students' response to this concept mapping project applied to entrepreneurship classes is generally positive. They pointed out that such a project could improve their critical thinking skills. Most of the students admitted that their learning skills are still well below that required for

the scientific environment. This is especially noticeable when the author asked the students to write yet another concept mapping for any other courses taught in the chemical engineering programme. The concept map, they stated, was something new to them although on several occasions they had been asked or had constructed something like an organizer or a concept map. During the interview conducted by the first author some students acknowledged how inadequate their understanding on entrepreneurship was, until they faced with creating a concept map. They explicitly mentioned that a seminar on concept mapping could be useful.

The project does reinforce the materials received in lectures. The students were made aware that the project was typically an open ended type with no specific solution. The time spent (apart from that spent for the field work), however, was often underestimated by some students, which made them felt either bored or under pressure towards the end of the project.

The Department response indicates that such a project on concept mapping applied to entrepreneurship classes is beneficial to students. They concern, however, on the marking system since evaluation of concept mapping tends to be subjective in nature. Additionally, instead of a seminar on concept mapping, the Department is inclined to "insert" the concept mapping idea in certain subjects whenever possible. This is due to the fact that the chemical engineering curriculum already contains several concept-like components, such as flow diagrams, process flow sheets, and so on.

This preliminary study on the application of concept mapping indicates that concept mapping can be used as a motivation tool for learning activities in the chemical engineering studies.

Concluding Remarks

This paper has offered lecturers on how to use concept mapping to encourage student learning especially in the area of chemical engineering and entrepreneurship. As concept mapping is visually displayed, it helps students/learners understand the concepts and their interrelationships relatively easier. For the teaching staff, on the other hand, analysing the concept maps may help them to decide which area(s) the students have not fully understood. In addition, concept mapping recalls past content knowledge and/or experience which are useful for other subjects as well. Furthermore, concept mapping helps arrange logical flow of ideas in a visual manner.

The field work to small companies and home industries around the city is also seen as an interesting promotion avenue for our department, with the possibility for an increase in student enrolment. This is evidence from the comments made by the owners of the companies saying that they are not aware of the existence of our department of chemical engineering.

It was felt that application of concept mapping to entrepreneurship classes was successful in enhancing student learning. This could be caused by the familiarity of the students with assignments similar to concept mapping such as the construction of flow diagrams or process flow sheets. Apart from this, it was also observed that the students were motivated which could be shown by their enthusiasm in revising the initial concept maps.

Based on the seemingly positive results of this preliminary study on concept mapping, it was planned to pursue other goals. These goals include application of concept mapping to:

1. *Assess students' understanding of the subject matter knowledge.*
2. *Outline and sequence problem solutions in a logical manner.*
3. *Effectively improve the structure of the teaching materials with regard to instructional design or lecture planning.*

Despite the department's reluctance it was also planned to conduct a regular one hour session each semester for both students and teaching staff, during which time the idea and application of concept mapping would be discussed.

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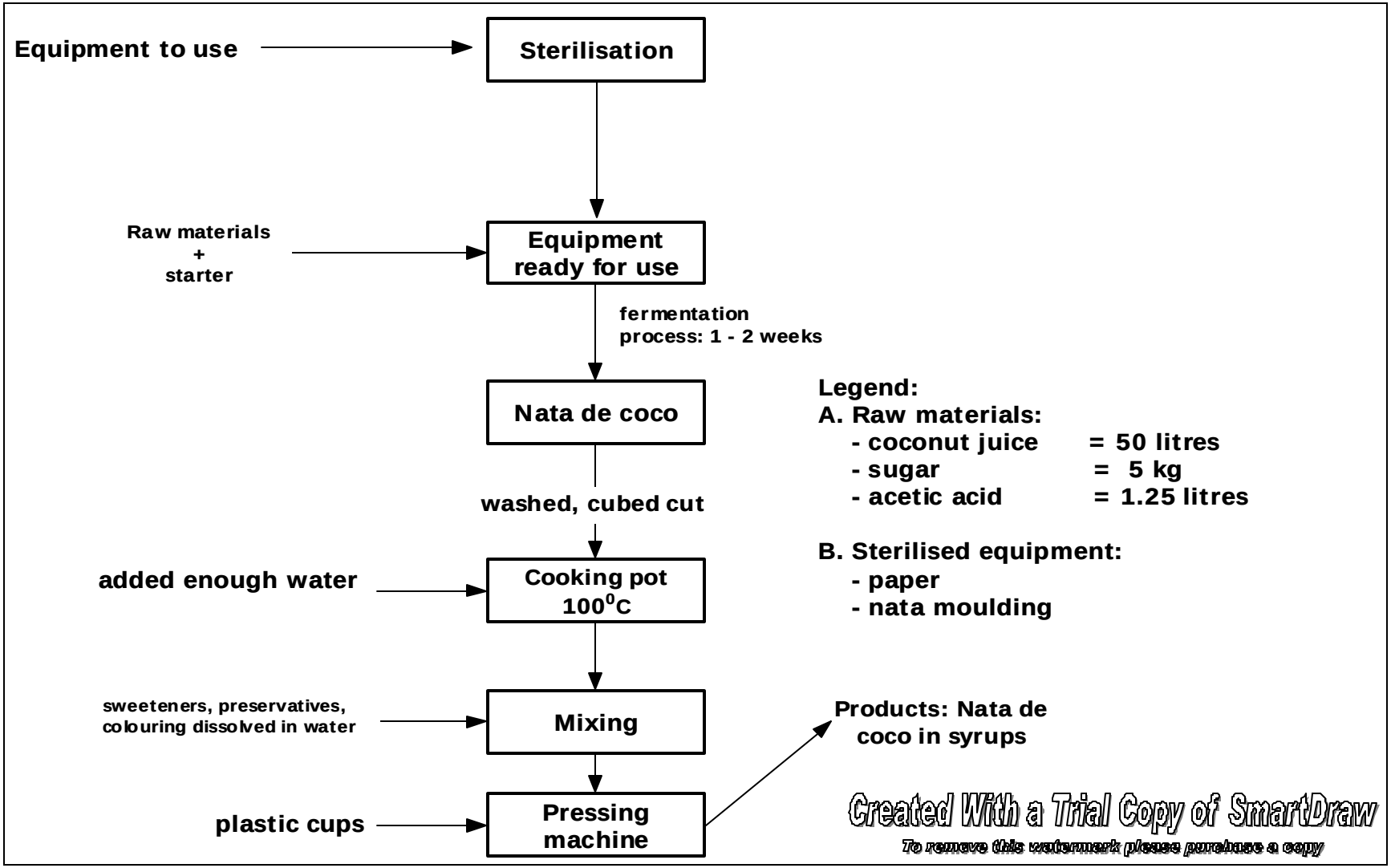

Figure 2a Process flow diagram for the production of Nata de coco

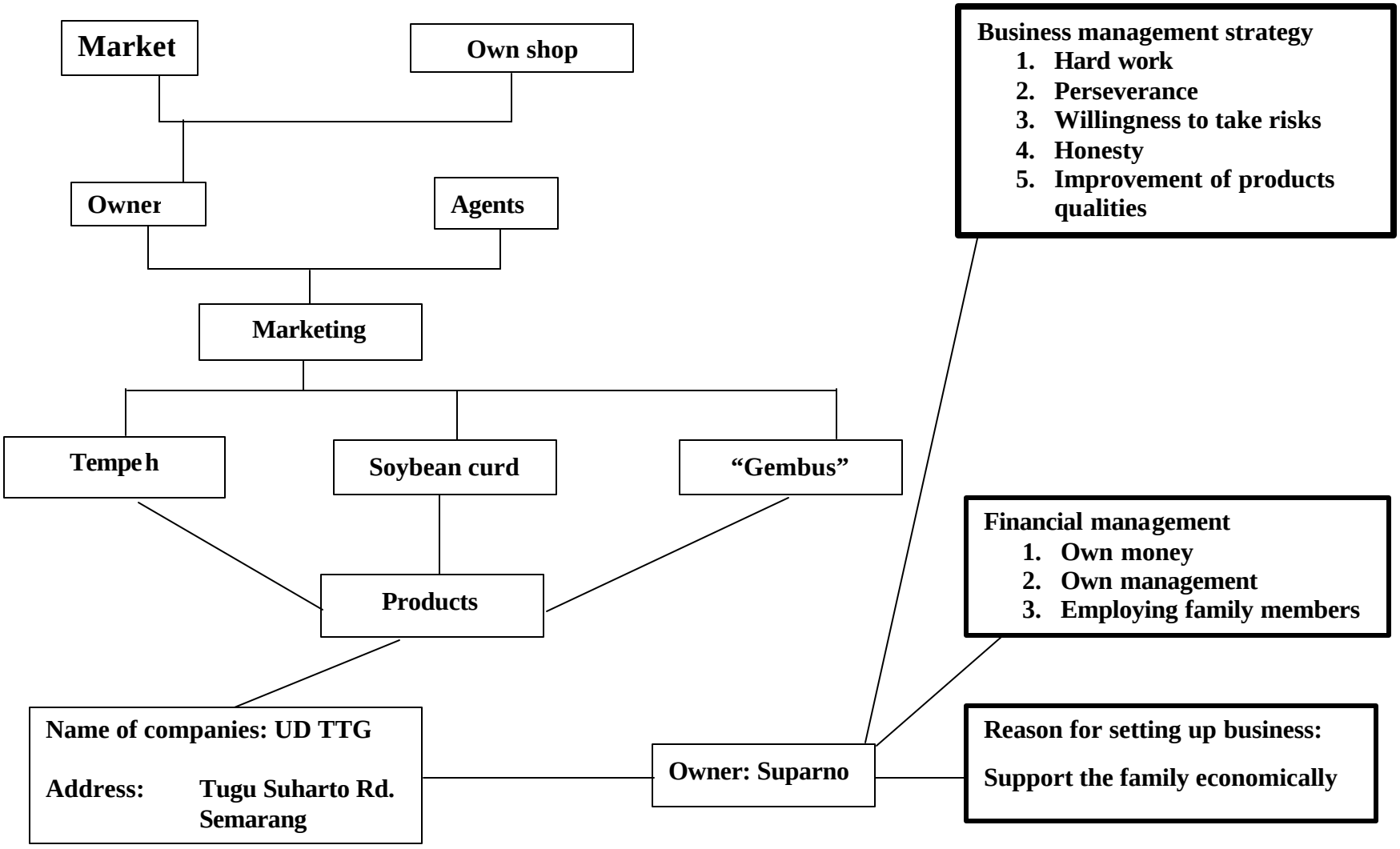

Figure 2b Initial concept map showing aspects of entrepreneurship

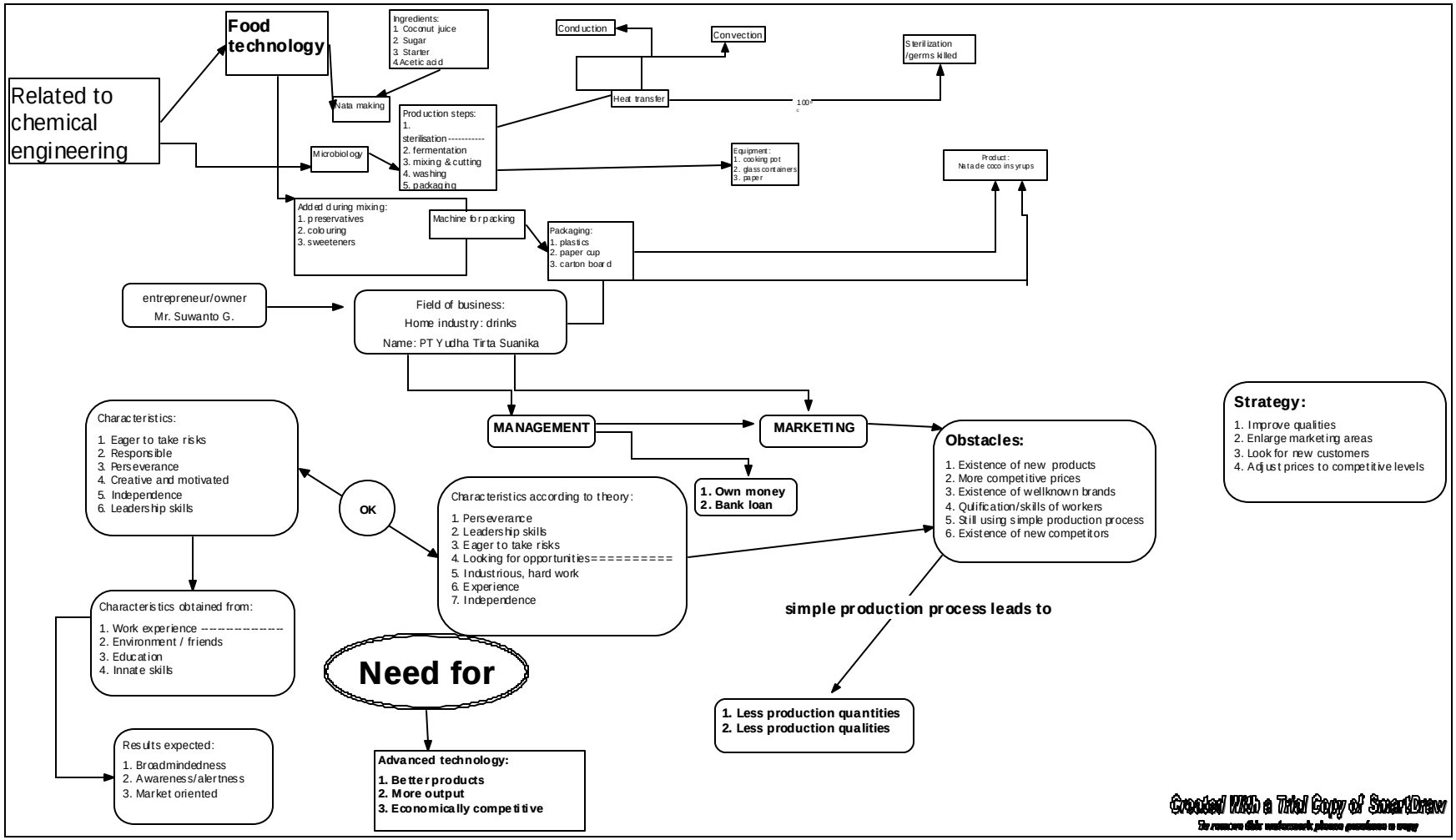

Figure 3 An improved concept map showing both chemical engineering and entrepreneurship aspects