Handbook preparation as a tool for self- directed learning process: A case study on endocrine topic

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Received 26 May, 2010
Revised 30 Dec., 2010

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Abstract

This study examines the effectiveness of handbook preparation as a method in the self-directed learning process of student teachers in teaching endocrine glands, and increasing their levels of knowledge. Thirty student teachers were selected from a biology department. A pencil and paper test and a clinical interview procedure were used to collect data. The test had two open-ended questions investigating the knowledge level of the sample about endocrine glands and the basic concepts of the

subject. The interview was conducted to search the effectiveness of the handbook preparation process on self-directed learning of the student teachers. The results revealed that the student teachers had very limited knowledge and also had misconceptions related to the endocrine topic. The handbook preparation method was very helpful for the student teachers to overcome their misconceptions about the subject and to increase their knowledge level. It was suggested that handbook preparation may be helpful for teaching other biology topics as a self-directed learning tool. However, it should be considered that the student teachers had heterogeneity with respect to skills.

Keywords: Self-directed learning, handbook, student teacher, biology education, endocrine system.

Introduction

Learning is a lifelong process, and the ability to learn on one's own has become a prerequisite for living in a dynamic world of rapid change. Promoting the capacity for self-directed lifelong *learning* among students has been growing importance in recent educational policies (Bolhuis and Voeten, 2001; Candy, 1991; Levett-Jones, 2005). During the self-directed learning (SDL) process, the individual decides if s/he is going to do the work by him/herself or ask for help when diagnosing the learning needs, determining tools and resources, choosing the appropriate learning techniques and evaluating the learning outcomes. This means that it is an internalized process related to willingness, self-identity and capacity to manage an individual's own *learning* (Jennings, 2007; Land, 2000).

The characteristics of the teacher, student and the topic are important factors for determining of the use of SDL. For some topics, a teacher or a trainer is necessary. Students' study habits, meta learning skills, etc., are also effective for learning. After these variables are examined, what should be taught, how it is going to be taught and documented are determined to facilitate learning (Gafoor and Shemi, 2007; Patterson et all., 2002).

Over the years, many techniques and strategies for developing SDL skills have been proposed. But, there are limited studies introducing the applications of self-directed learning tools on a specific subject area. Edmondson (1995) searched the developments of self-directed learning in a problem-based curriculum. Seçken (2008) examined the effects of computer-assisted education on the self-directed learning process of pre-service teachers. Sile´n and Uhlin (2008) also used

problem-based learning in order to support and enhance the students' learning process in becoming self-directed. In this article, the effectiveness of the handbook preparation method as a self-directed *learning tool* was explored. *It was thought that learning with a handbook is closely associated with SDL from both the process and personal attribute perspectives.*

Handbook is a teaching tool that has been used to teach basic concepts to young students about subjects like animals, plants, etc. (Yanpar and Yıldırım, 2004). It has a few papers and a cover. The student prepares the handbook, draws or sticks the picture of the concept in the pages and writes one or two sentences of information under it. We believed that handbook preparation could be used as a self-directed learning method for higher-level students. This paper is the first step of the further application of the handbook preparation method. In this model, the teacher sets up the learning objectives, guides the direction of student inquiry, promotes new patterns of thinking and provides "coaching and scaffolding" at critical times. The responsibilities of the students are exploring, discovering and abstracting the information. They will collect the information and design it to prepare their handbook. During this process students are expected to learn definitions and mechanisms not by memorizing, but by drawing, writing, asking, coloring, etc. (URL-1, 2010).

The endocrine system was selected as the study topic. Most of the physiological processes around us are regulated by the endocrine system: a caterpillar becomes a butterfly, a young girl develops into a woman and an adult copes with chronic stress. Many other adjustments of metabolism, growth and reproduction are related with this system. The endocrine system also works closely with the nervous system to maintain the steady state of the body (Solomon et all., 1993).Therefore, teaching this subject requires particular attention in biology education. Despite its importance, hormonal regulation and endocrine glands are generally regarded as difficult for teachers and students because of its large and complex content. Teacher directed didactic teaching methods are most commonly used to teach this subject, and students memorize the concepts of the subject (Bahar, et all., 1999; Cerrah, et all., 2005, 2006; Zöhre, 1999). There has been a continuing agreement that traditional approaches, especially for complex and large subjects, have a limited effect on deep learning (Dikmenli and Çardak, 2004; Calik, Ayas and Coll, 2007).

To date, the relationships between students' willingness and capacity to engage in self-directed *learning* and their ability to think critically has been studied, but the endocrine system and handbook preparation method have not been empirically investigated. The results of this study shed some initial light on these relationships and suggest some interesting considerations for teaching in higher education.

The study focuses on the following questions:

1. What is the student teachers' knowledge level about the endocrine system?
2. Is there a correlation between handbook preparation methods and to cope with the learning difficulties of the student teachers?
3. Is there a relationship between the student teachers' willingness to learn and the handbook preparation method?

Methodology

Sample

A total of 30 final year university students, who have been studying to become biology teachers, participated in this study. In the Turkish teacher education system, the length of the course for subject teachers is 5 years. 3.5-years are spent in the Science and Art departments to learn subject knowledge, and then 1.5-years are spent in the Education Department for pedagogical courses. Related to the research subject, the student teachers took the animal physiology (compulsory) courses in the Science and Art Faculty; and the instructional technology and material design course was taught in the Education Faculty. In summary, the student teachers had the academic competency to design the handbook.

Instruments and Data Collection Procedure

The simple-experimental design was used (pre-test, implementation, post-test) in this study. Student teachers' knowledge levels about endocrine glands were examined using a pencil and paper test. Although multiple-choice questions are commonly used for this kind of research, this method often fails to explore the reasoning process and sources of conceptual problems within subjects. Written tests with open-ended questions may more effectively elicit students' in-depth thinking.

Student teachers were asked two open-ended questions. The questions took into account the objectives of the investigated subjects: the names of endocrine glands (mainly; pituitary glands, thyroid and parathyroid, pancreas, adrenal glands, testis and ovaries), their hormones and functions,asin the National Secondary Biology Curriculum (NBC). The first item of the endocrine test measured student teachers' existing knowledge and misconceptions about these seven endocrine glands. They were asked to draw endocrine glands and to write their functions. The second item measured the student teachers' understanding of the related concepts of the subject. They were asked to explain the concepts of feedback, hormone and homeostasis. The questions were given to experts to comment on their readability and reliability. The endocrine test was administered as a pre and post-test and the student teachers were given 50 minutes to complete the test.

After the self-directed material development process, student teachers were also interviewed one-by-one using a clinical method to diagnose their psychological and mental development, and the interviews were recorded on tape.

Self-Directed Learning Process

The process took a total of six weeks (two hours per-week). After the pre-test administration, student teachers were informed about the results of their test, which was not pleasant both for the lecturer and the student teachers. A class discussion was held on the reasons for their failure. During the discussion, the student teachers mentioned the causes of their learning problems, which included "rote learning, teacher oriented teaching and the difficulties of the subject." Although, the student teachers had been complaining about the weakness of traditional teaching methods, they said that they would use these teaching methods as a teacher. They believe that innovative teaching methods are not practical because of crowded classrooms, lack of teaching equipment and a full demanding curriculum.

After the discussion, handbook preparation was introduced as a SDL method. The student teachers were told that their handbooks would include two parts: general information about the endocrine glands and an assessment for the detection of learning processes. The following steps, which were prepared by using the related literature, were used to start the material development process (Ash, 1985; Bauer, 1985; Brockett and Hiemstra, 1985; Brookfield, 1985; Hiemstra, 1982).

- Previous handbook examples were presented to the sample.

• An atmosphere of openness and trust in order to promote better performance was created. • Student teachers' critical thinking skills were encouraged.

• Student teachers were helped to develop positive attitudes and feelings of independence relative to learning.

• Student teachers were directed to use the Internet, textbooks, journals and newspapers for their handbooks.

• Student teachers were expected to organize the information and to make their personal interpretations, and also expected to discuss relevant scientific issues with their peers outside of class.

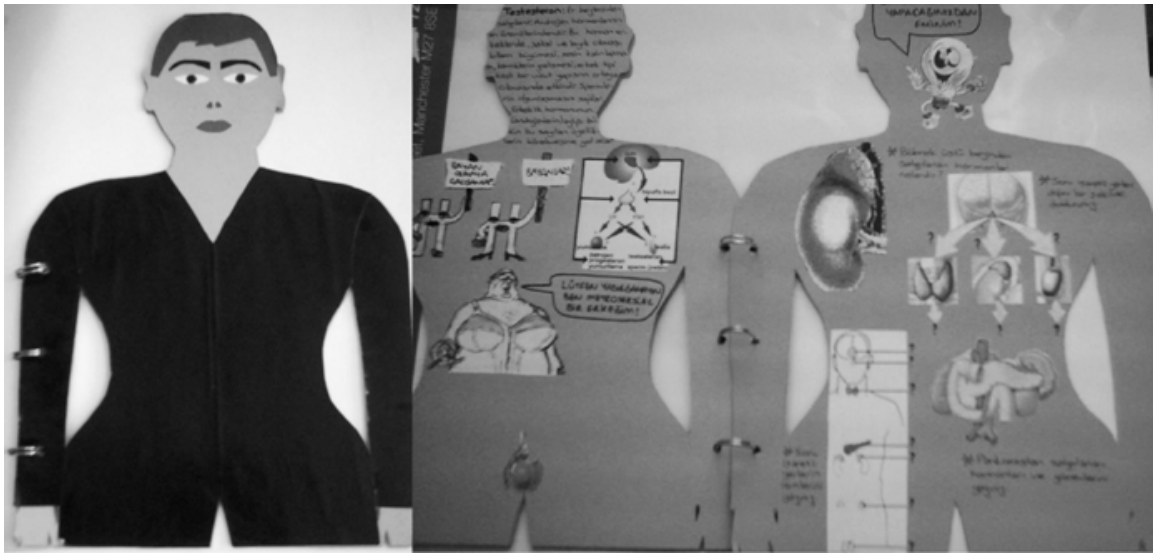

Figure 1. *An example from the student teachers' handbooks. The cover of the handbook (A) and two pages of it (B).*

Figure 2. *A different example from the student teacher's handbooks.*

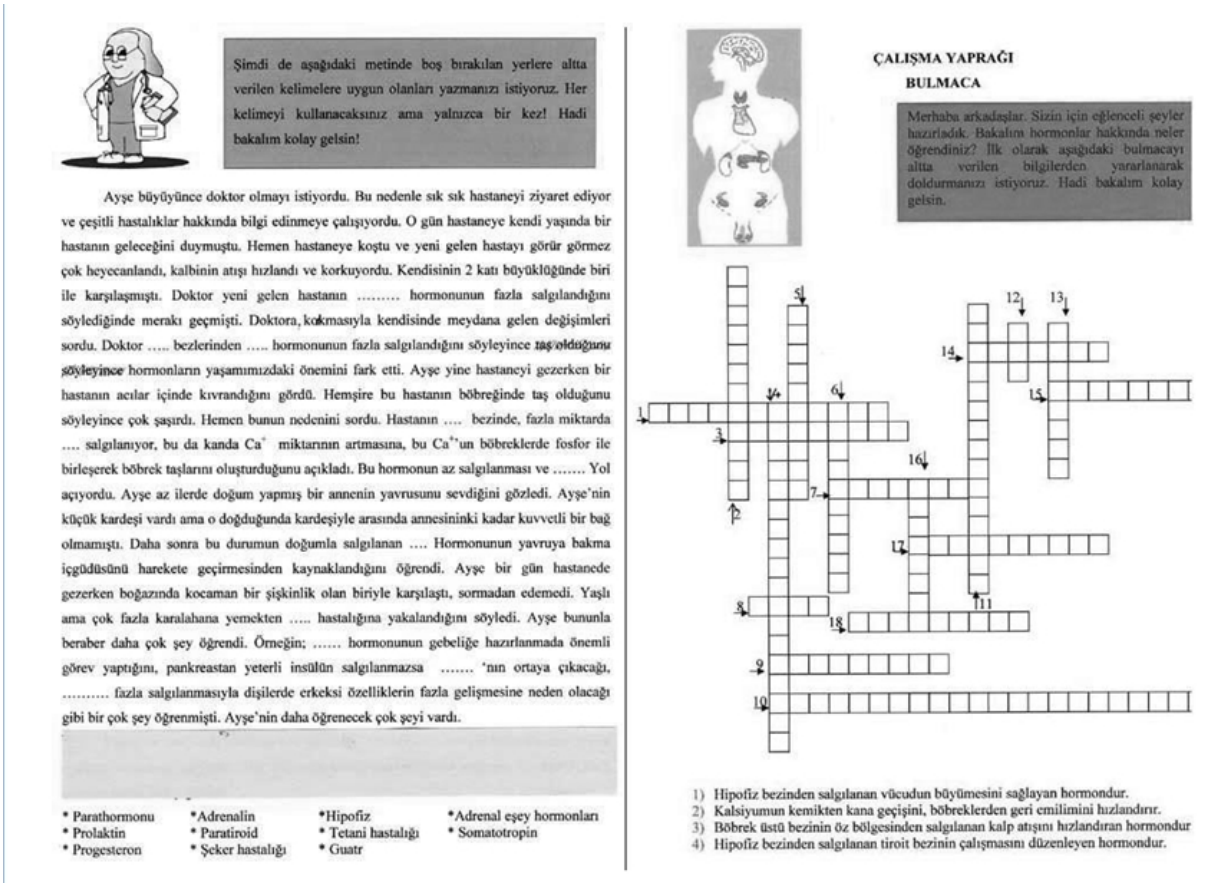

Figure 3. *Two examples of assessing parts in the student teachers' handbooks. A story about the endocrine glands and their functions, the user will fill the blanks with the given concepts. A puzzle related with concepts of endocrine system.*

Data Analysis

Both qualitative and quantitative data was obtained in this research. The qualitative data attempted to describe the effectiveness of the handbook preparation process on student teachers' self-directed learning. The quantitative data was used to determine the significance of any changes between scores before and after the material development process. The data obtained from the test was analyzed using simple categorization. The answers of the student teachers were scored by each of the authors as "correct," "wrong" and "don't know" categories. The answers were discussed until a category was agreed upon. Wrong categories were separately coded to examine the student teachers misconceptions about the endocrine system.

The categories and the points used for the analysis of the questions are given in Table 1.

Table 1. *Categories and points used to analyze the student teachers' responses.*

Categories	***Explanation***	***Points***
Correct	Responses that included all components of the scientific response	3 points
Partially Correct	Responses that included at least one of the components of the scientific response, but not all the components	2 points
Misconception	Responses that are partially correct, but also had one or two alternative conceptions	1 point
Incorrect/Blank	Responses that included illogical or incorrect information/no answers	0 point

These categories provided an opportunity to classify student teachers' responses and compare their levels of knowledge. Drawings of endocrine glands were scored according to its presence (1 point) and function (ranges 0-3 points in Table 1). This means that if an endocrine gland was drawn but its function was not described, it was categorized as "blank"and given 1 point for the drawing and 0 points for the absence of the function. If an endocrine gland was drawn but its function was described incorrectly, it was given 1 point for the drawing and 0 points for incorrect function. The total score of a student teacher for this item may range from 0 to 28 points.

For the second item, the student teacher may earn 0-3 points for each concept. The analyses were carried out by two biology experts and one experienced biology teacher. They classified the answers into categories. The authors then compared their evaluations and looked for agreements and disagreements among the classifications of each member. If at least two of three members agreed on a response in a category, the answer was put in that category.

The data collected from the interviewers were categorized in accordance with their similarities and differences and some of the student teachers' comments were illustrated directly.

Results

Responds to Drawing Endocrine Glands and Writing Their Functions

The percentages of student teachers' pre-test and post-test answers about endocrine glands' functions are given in Table 2.

Table 2. *The percentage of student teachers' answers about endocrine glands' functions.*

Endocrine Glands	Categories	Pre-test (%)	Post-test (%)
Pituitary Glands	Blank	10	3.3
	Incorrect	-	-
	Partially Correct	16.7	36.7
	Correct	**-**	**53.3**
Thyroid	Blank	23.3	20
	Incorrect	-	-
	Partially Correct	3.3	46.7
	Correct	**-**	**33.3**
Parathyroid	Blank	6.7	20
	Incorrect	-	-
	Partially Correct	3.3	16.7
	Correct	**-**	**46.7**
Adrenal Glands	Blank	26.7	16.7
	Incorrect	*Estrogen, progesterone (3.3)*	-
	Partially Correct	6.7	60
	Correct	**-**	**23.3**
Pancreas	Blank	6.7	13.3
	Incorrect	-	-
	Partially Correct	-	3.3
	Correct	**3.3**	**70**
Testis	Blank	6.7	13.3
	Incorrect	-	-
	Partially Correct	-	33.3

	Correct	**-**	**53.3**
Ovaries	Blank	3.3	13.3
	Incorrect	-	-
	Partially Correct	-	46.7
	Correct	**-**	**40**

*40% of student teachers drew the endocrine glands, but not all of them wrote the functions, so the percentages in the first column of the Table do not total 100%.

After analysis of the pre-test papers, it was seen that 60% of the student teachers could not answer this question. As seen in the Table 2, 40% of the student teachers who drew endocrine glands had very little knowledge before the material development process. In the pre-test, the most frequently drawn endocrine glands were the thyroid, adrenal glands and pituitary gland. But respectively, 3.3%, 6.7% and 16.7% of student teachers wrote partially correct functions of these endocrine glands. Ten percent drew the liver and 3.3% drew the brain as an endocrine gland. Additionally, 6.7% had misconceptions about the function of the liver such as “liver secretes insulin and glucagon.” One of the student teacher's indicated that the “adrenal glands secrete estrogen and progesterone". Furthermore, 6.7% of student teachers had a misunderstanding about the name of the sexual glands, for example, calling them “reproduction glands,” and 3.3% wrote they had a reproductive function.

As can be seen in the pre-test column in Table 2, although student teachers drew endocrine glands, only a minority described their functions. But, as seen in the post-test column of Table 2, there is a significant increase in the ratio of the correct answers. After the handbook preparation process, the student teachers mostly gave the correct and partially correct answers. In the pre-test, only 3.3% had scientifically accepted knowledge about the function of the pancreas, whereas after the material development process, 70% wrote the correct answer. Similar situations are valid for the parathyroid glands, testis and ovaries. These results can be interpreted as student teachers remedy their lack of knowledge about the endocrine glands during the handbook preparation process.

Responds to Writing Descriptions of Concepts of Feedback, Hormone and Homeostasis

Analysis of the students' papers showed that student teachers did not have problems about the concept of *homeostasis.* The student teachers' response to the concepts of feedback and hormone are given in Table 3.

As seen in the pre-test column of the Table 3, the student teachers had learning problems about the concept of feedback. Fifty percent of student teachers couldn't explain feedback, and 20% wrote incorrect answers. In the pre-test, only 10% gave correct answers. After the material development process, they changed their incorrect knowledge and replaced it with scientifically accepted ideas; and the ratio of the correct answers increased to 90% in the post-test.

As can be seen in Table 3, 40% of the student teachers partially defined the concept of hormone as a "protein" or "steroid." Ten percent made partial explanation, which contain one misconception such as "fluid" or "secreted by the organs". As the percentage of correct answers was 40% in the pre-test, this ratio rose to 63.3% in the post-test.

Table 3. *The percentages of the student teachers' answers about the concepts of feedback and hormone.*

Concepts	Categories	Pre-test (%)	Post-test (%)
Feedback	Blank	50	3.3
	Incorrect	The body absorbs the necessary matters before the excretion. For example, absorption of some of water in the urine (10) When it is necessary, the body use the storage and waste matters (6. 7) Absorption of some of the wastes to prevent the food lost (3.3)	-
	Misconceptions	3.3	-
	Partially Correct	16.7	6.7
	Correct	**10**	**90**

Hormone	Blank	10	3.3
	Incorrect	-	-
	Misconceptions	*Fluid (3.3)* *Secreted by the organs (3.3)* *Protein structured matter, it's secreted insufficiency of another matter (3.3)*	*Fluid (3.3)*
	Partially Correct	40	30
	Correct	**40**	**63.3**

Students' Views about the Learning Process

After completion of the study, the student teachers were interviewed to identify particular issues that emerged and concerning their perceptions effectiveness of the material development process on their self-learning. The results from these interviews generated seven advantages:

A1. *The material development process forced the student teachers to be mentally active, and they also enjoyed the material preparation and learning. Some of responses from the student teachers as follow:*

> **ST8:** "We wrote poems, songs, drew pictures, prepared puzzles and educational games to make our materials more interesting and instructive. We played our games with our peers and sung our songs, it was very enjoyable."
>
> **ST5:** "I prepared a PowerPoint CD with my handbook. The CD had questions about the endocrine glands. I have never used the computer to prepare such a material, I wanted help of my friend as I learnt to prepare the PowerPoint programme; it was both very challenging and enjoyable."

A2. *The student teachers became more meta-cognitive with respect to the material development process involved in the construction of subject knowledge. They commented that they were aware of wrong ideas when they prepared their handbook. The following interview excerpt illustrates this:*

> **ST1:** "We didn't know much more about the endocrine glands and the related concepts. When we were preparing our handbooks, we searched from books,

newspapers, magazines and the Internet. We learned different and interesting things. We exchanged our incorrect knowledge."

A3. *The student teachers became more confident to teach endocrine system.*

ST18: "This subject is really very difficult and I did not have self-confidence to teach this subject to my students before preparation of the handbook. But now, I believe that I had the basic knowledge and if I read once more before, I can teach this subject effectively in my class. I have also learnt many things about illnesses related with hormones."

A4. *The material development process changed the reliance of the student teachers on the traditional methods. The responses are typified by the following comments:*

ST25: "We have not been taught like this, we have been familiar with listening and memorizing. If we have responsibility of our learning by using different methods, we do not easily forget. Before this study, I believed that the lecturing was the best way to teach some of biology subjects like endocrine system or nervous system and etc. I will use these kinds of student-oriented methods when I am teacher."

A5. *This process developed the social learning of the student teachers. During the material development process they were affected by their peers' materials and tried to prepare themselves better. This increased their motivation. The following comment illustrates this:*

ST30: "I prepared my handbook, but after I had seen my friends, I did not like mine and I changed it."

A6. *This method increased the student teachers' oral presentation skills and problem solving abilities.*

ST12: "As we were designing our materials we thought very much about how we could make these materials more instructive, which pictures, illustrations we should use and how much information we should give. This kind of study developed our creativity. I understood that teaching was a very difficult profession."

A7. *Handbook preparation method, broken the monotony of the topics and facilitated the student teachers' memorizing.*

In summary, the handbook preparation process activated the student teachers to participate in their own learning and this facilitated their learning. However, 13.3% of the student teachers stated that the material development process was not effective on their learning because of their learning styles and carelessness.

One of them mentioned that, "I read the information in the biology books and copied them into my material directly and I didn't learn much, so that I forgot them easily." Another commented that, "because I prepared my handbook the night before the deadline, I couldn't do interesting things. We are not familiar doing homework."

One also said that, "I paid more attention to the appearance of my handbook and its instructive aim fell behind. I only remember the messages which I wrote in the balloons or other striking things."

These learners perceived the handbook preparation as a task or a demand and engaged in surface processing activities that resulted with very limited learning. However, they emphasized that they changed the beliefs about the practicality of the new teaching methods.

Discussion

The results of pre-test of the study showed that student teachers had incorrect and limited knowledge about the endocrine glands, their hormones and functions and feedback. It can be said that most of these problems are results of the traditional teaching strategies (Dikmenli and Çardak, 2004). Teachers and students are agree that the endocrine topic is difficult because of Latin words, gland functions and microscopic and abstract concepts (Bahar et all., 1999). On the other hand, in all grades of education, from elementary to university, teaching strategies used to teach the endocrine system couples didactic lecturing with questioning. Students' responsibilities are listening and taking notes. But this traditional instruction does not support students' self-study. They do not take the responsibility for their own learning. This causes surface and rote learning; hence, the students forget what they learned in a short period of time (Cerrah, et all., 2006; Chi, 2005).

The results of the study showed that 60% of student teachers neither drew the endocrine glands nor wrote about hormones in the pre-test. Forty percent of the student teachers who drew the endocrine glands wrote very limited information about their hormones and functions. Student teachers mostly drew the thyroid gland without writing its function. Since, having goitre is a common sickness in the study region, they knew the gland-sickness relation, but they did not know the hormones or functions of it. The sickness is a reality of their life. They have experiences related with it, but the function of the thyroid is just boring details for them. They also mentioned this situation verbally during the class discussion. A minority of the student teachers held misconceptions about the functions of the adrenal gland, pancreas and sexual glands. Like endocrine glands, they had misunderstandings about the concept of feedback. The incorrect explanations may be result of the "back" word in this concept. They may have interpreted this word as "absorption of the matters for reuse."

After the handbook preparation process, it was seen that there was a significant difference between student teachers' responses on pre and post-tests. The ratios of the correct answers increased (Table 2 and 3) after the intervention. These results may be interpreted as the handbook preparation process is effective to overcome the deficiency of knowledge and to remove misconceptions of the student teachers. They mentioned that they spent a lot of time to prepare educative, interesting and attractive handbooks. They summarized what they learned by using less word, but more visual elements such as illustrations or pictures, etc. This process may have forced them to keep mentally active (*A1*).

Student teachers' comments indicated that the handbook preparation process increased their level of enjoyment and deep learning. The endocrine topic is a difficult and threatening subject for the student, but student teachers indicated that they took pleasure in learning this subject, and this may have been lead to higher motivation and higher achievement.

Their searches from different sources such as books, journals and the Internet may have been helped them to be aware of their incorrect ideas and to fill the gaps in their knowledge (*A2*).

Being involved in such a teaching/learning strategy changed perceptions of the student teachers about the traditional teaching methods (*A4*). They also said that they felt more confident to teach this subject because of the active involvement in

their learning (*A3*). It can be said that this material preparation process has some advantages such as activating mentally, directing to researching, motivating learning, providing social communication and promoting creativity.

These results suggest that handbook preparation may be used effectively as a SDL tool; however, it may not be a case for all students. A minority of the student teachers commented that they did not learn effectively because of their learning habits, which supports the findings of Bhat et al. (2007). As they stated, the students are not familiar with homework or projects or researching because of the teacher-oriented teaching. If a learner comprehends the handbook preparation as homework, and does not derive enjoyment from the activity or search for meaning in the information, the results will be surface process activities (URL-2, 2009). It seems that handbook preparation could be a direct copy of the information from the related resources directly without internalizing it. The student teachers' handbooks were not evaluated with a grade, and this situation might be encouraged the student teachers to act this way. This is a disadvantage for the student for continuation of existing misunderstandings. This undesirable situation may be prevented by the aid of feedback or control of the teacher.

In summary, the results of the study totally represent the effectiveness of the handbook. Teacher-centered teaching is dominant in our education system and the students rely on memorization; hence the students in any levels may have a bias against the new teaching methods. To overcome this bias is an achievement of the study, moreover, this activity promoted changes in beliefs and the learning of the student teachers.

Conclusions and Implications

Promoting self-directed learning and learning to learn has become an important goal of education. This goal requires activating and process-oriented teaching rather then traditional transmission of knowledge. This means that the roles of teacher and student have been changing. In this study, student teachers' knowledge of the endocrine system was examined and the handbook preparation method was used to increase their knowledge level and their willingness to learn. Results of the study revealed that the student teachers had inadequate knowledge and misconceptions related to endocrine glands, their functions and its main concepts such as feedback and hormone. In conclusion:

- The handbook preparation method caused a statistically better acquisition of understanding of the endocrine concepts.
- The handbook preparation method is effective in promoting mental activation, meta-cognition and creativity of the students.
- Students are passive listeners in traditional classes, but the handbook preparation process facilitated students to take primary responsibility for their own learning.
- The handbook preparation process supported social interactions of the student teachers with their classmates and this stimulated their motivation.
    - There is a relationship between the student teachers' willingness to learn and the handbook preparation method.

Teachers, who will use this method, should take some precautions to decrease its disadvantages.

1. S/he should outline the subject that will be learned, such as "organs of circulatory system," rather than saying just "circulatory system."

2. The student, developing the handbook, should be awarded with a grade or something else to improve the student's willingness and motivation. Rewarding students' learning outcomes is also a kind of feedback from the teacher.

3. Teachers should emphasize that the less word, more reminding information is the critical point of the development of handbooks. The information in the material must reflect the students' personal interpretation of learned information and their creativity. Creation is one of the important points in this process, because it forces the learner to think "what is the best way to teach this content to others."

4. The teacher who will use this method in his/her class should control the information in the handbooks of the students very carefully, because the sources used by the students may also have misconceptions or incorrect knowledge.

5. Assessment of what students have learnt, and whether it is relevant and deep enough, is the most important point when students take responsibility for their learning (Sile´n, 2001). Concept maps, puzzles, other alternative

techniques and the games in the handbooks of the students can be used to detect what students have learnt.

Many topics include classification; systems and the environment in biology are very suitable for this method. Students can prepare different and interesting handbooks about vertebrates, viruses, bacteria and vascular and nonvascular plants. Further studies are necessary to develop the application of the handbook preparation method in the science education.

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