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Pre-service teachers' attitudes toward use of Vee diagrams in general physics laboratory

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Abstract

The purpose of this study is to determine pre-service teachers' attitudes toward use of Vee diagrams in general physics laboratory. The sample of the study consists of 29 (16 girls and 13 boys) freshmen students enrolling to elementary school science education program at one of the universities in Turkey. To gather the data of the study "Attitude Test toward the Use of Vee Diagram" consisting of 18 Likert type questions and "Open-Ended Questionnaire about the Use of Vee Diagram" including 8 open-ended questions are administered after laboratory applications with Vee diagrams. The data from both the quantitative and qualitative part of the study revealed that pre-service teachers have positive attitudes toward the use of vee diagrams in physics laboratory.

Keywords: *Pre-service teachers, Vee Diagrams, general physics laboratory*

Introduction

The Chinese saying "*I hear and I forget, I see and I remember, I do and I understand*" (Confucius) has often been misunderstood by educators. Educators have so much faith in laboratory work that they think that because the learners have done and seen something, they have therefore gone through meaningful learning and they will understand what is required to perform a given task. However it is very often that learners done practical work and yet not understood what they were doing or why they did

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what they did. Learners often find laboratory work frustrating as there is hardly any interplay between what they are thinking and what they are doing. Most often, it would be a case of hands-on but minds off affair.

Establishing relations between theoretical information and the daily life experiences, changing abstract information to concrete, and therefore learning by doing is only possible by using laboratories effectively in science courses. In traditional laboratories, students are directed by laboratory manuals including all the stepwise description of the experiments they are going to make. In this process, students repeat the steps, remembering theoretical knowledge, which has been learned in the course. In inquiry-based science laboratories, students are able to use and improve scientific process skills. Related to the hypothesis, that they established or were already given; they provide the materials, design the experiments, make observations and measurements, record data, bring up and interpret findings, and determine whether the hypothesis is valid or not. Finally they confirm or refute the hypothesis or they change and test it again. Than they add a new factual hypothesis or generalization to the knowledge related to the subject (Aydoğdu, 1993; Çilenti, 1985; Okan, 1993). Vee diagramming is one of the ways to make the laboratories inquiry based learning environments (Tatar, Korkmaz & Ören, 2007).

Vee diagramming

The Vee heuristic was originally designed by D. Bob Gowin in 1977 (Novak, 1989). Vee diagramming as an instructional tool is underpinned by Ausubel's (1968) theory of meaningful learning. Vee map has been used to guide students in their laboratory experience, to facilitate reflective thinking and learning, as they plan and conduct their own investigations (Novak & Gowin, 1984). To learn meaningfully, individuals must choose to relate new knowledge to relevant concepts and propositions they already know. The Vee diagram aids students in this linking process by acting as a metacognitive tool that requires students to make explicit connections between previously learned and newly acquired information (Alvarez & Risko, 2007).

Vee diagrams are less structured than conventional teaching methods. A Vee diagram consists of a V-shape separating theoretical/conceptual (thinking) from the methodological (doing) elements of inquiry. Both sides actively interact with each other through the use of the focus question(s) that directly relates to events and/or objects (Alvarez & Risko, 2007). The structure of the Vee diagram with its various labels and guiding questions provide a systematic guide for students to reason from the problem context (event/object) and given information (records) in identifying relevant principles, theorems, formal definitions and major rules (principles and concepts) which can guide the development of appropriate methods and procedures (transformations) to find an answer (knowledge claim) to the focus question. The arrow indicates that there is a continuous interplay

between the two sides as students reason through the various sections of the Vee (Afamasaga-Fuata'i, 2004).

Benefits of Vee diagramming

A review of the literature (Novak & Gowin, 1984; Wandersee, 1990) reveals that Vee diagramming has been found to be beneficial to the teaching-learning process in the following ways:

- Concepts are mapped thereby organizing meaning in a more coherent and comprehensive way,
- Existing knowledge structure is tapped into, misconceptions are picked up and gaps in knowledge are identified,
- It is believed that through Vee mapping learners will be more confident of themselves as they go through the learning process and they will feel good about themselves because what they are doing is more meaningful to them, and as such these learners are able to organize their thinking in a coherent way,
- Once learners are able to draw their own Vee maps, they are in a better position to reorganize new information using what they already know. This process is creative and idiosyncratic and requires that the understanding be expressed through a variety of ways of thinking and doing,
- A study conducted by Novak & Gowin (1984) showed that Vee diagramming helped learners do better in tests requiring problem solving skills and their performance increases with time as they get more experienced in using the Vee map (Novak & Gowin, 1984; Wandersee, 1990).
- Vee diagrams increase the communication skills of the students giving them opportunity of studying together (Luft, Tollefson & Roehrig, 2001).
- Since laboratory courses require preparation, it drives the students to research and it also provides a standard as an experiment report (Nakiboğlu & Meriç, 2000).

A review of literature revealed that while learning physics subjects, in cooperative learning environments, use of Vee diagrams caused students to participate in effective group work and interrogated what are their aims and what they should learn in experiment (Roth & Roychoudhury, 1993). Also previous studies showed that students' find Vee diagrams as instructive and a way of making conceptual learning and this application changed their attitudes toward science and their point of view to electricity concepts (Ramahlape, 2004). In her study "Use of Vee Maps in a College Science Laboratory", Lebowitz (1998) explained that 75% of students told they comprehend in a better way with Vee diagramming approach, while most of them did not prefer to use this approach. They stated that they did not like

design their own experiments but they like to reveal the findings and most of them would try Vee diagrams again and this would get easier with more study.

Present study

When the previous studies are examined it is observed that Vee diagrams, removes the problems students face during laboratory work (Nakiboğlu & Meriç, 2000; Roth & Browen, 1993), makes laboratory work more productive (Gurley-Dilger 1992; Nakiboğlu & Meriç, 2000), and contributes to forming meaningful learning environments in laboratories (Nakiboğlu, Benlikaya & Karakoç, 2001; Novak, 1990; Novak, 1998; Passmore, 1998). In respect of literature reviews, it is understood that Vee diagrams as a teaching strategy is widely used in science, especially chemistry and biology courses (Atılboz & Yakışan, 2003; Lebowitz, 1998; Nakiboğlu & Arık, 2005; Nakiboğlu, Benlikaya & Karakoç, 2001; Nakleh, 1994; Sarıkaya et al., 2004), while this strategy is not used often in physics courses (Ramahlape, 2004; Roth & Roychoudhury, 1993). From this point of view we hope this research will contribute to the literature.

With this respect the purpose of this study is to determine the pre-service teachers' attitudes towards the use of Vee diagrams in general physics laboratory courses and to take their views on these applications.

Methodology

Participants

Data of the study were obtained from 29 freshmen students (16 girls and 13 boys) enrolling to the elementary school science education program of one of the universities in Turkey. The participants of the study took General Physics Laboratory-I course for non-science majors in 2008–2009 fall semester.

Instruments

Attitude test toward the use of vee diagram (ATUVD). To determine students' attitudes toward the use of Vee diagram in laboratory an 18-item questionnaire developed by Demirtaş (2006) administered to the students at the end of the semester. The reliability of the questionnaire is calculated as .73. ATUVD includes 18 Likert type questions. For statements representing positive attitudes toward the Vee diagram, 5 points were assigned to "strongly agree", 4 to "agree", 3 to "undecided", 2 to "disagree", 1 to "strongly disagree". As for the statements representing a negative attitude, the score was reversed. For the interpretation of the data "strongly agree" and "agree" responses and "strongly disagree" and "disagree" responses were combined together.

Open-ended questionnaire about the use of vee diagram (QUVD). Besides the ATUVD, an open-ended questionnaire including 8 questions related with the use of Vee diagram was developed. Open-ended questions were prepared

in advance by considering the relevant literature (Ramahlape, 2004; Demirtaş, 2006). In a 30 minute period participants were asked to answer to the following questions:

- What are the differences between the laboratory studies done with Vee diagramming and the other laboratory studies?

  In terms of planning, practice, learning, evaluating.
- What are your duties and responsibilities in the laboratory studies, which are performed using Vee diagramming?
- What are the properties that you liked at most while preparing Vee diagrams?
- What are the properties that you did not like while preparing Vee diagrams?
- What do you think about benefits of Vee diagrams?
- Would you like to use Vee diagrams in the schools, which you will be appointed? Why?
- Did you observed any skills, which you or your mates developed while preparing Vee diagrams?

  From the point of view of learning, thinking skills (critical thinking, creative thinking, problem solving…), social aspects (participation, interaction, taking over responsibility, co-operation).
- What do you think about the contribution of Vee diagrams to science education?

Procedure

This research was performed with freshman pre-service teachers enrolling to elementary school science education. The participants attended General Physics Laboratory Course, for 9 weeks, totally 18 lessons. In this course, seven experiments named as analysis of an experiment, motion, acceleration (speeding up/slowing up), circular motion, Newton's laws of motion, motion on inclined plane, law of conservation of momentum were made. Experiments were conducted by using air tables.

In the first week, participants were divided in groups including three members- one of the groups was consisted of two pre-service teachers. The pre-service teachers were informed with presentations related to Vee diagrams prepared by researcher. After the presentations, groups were provided theoretical knowledge, materials, data gathered and results of an experiment named as "Analysis of an Experiment" and asked to prepare an example Vee diagram containing information about the experiment.

In the second week, pre-service teachers presented the Vee diagrams they prepared to their mates. Groups stated the deficiencies in the studies of each other. After presentations, groups were shown ideal Vee diagramming

of the experiment, which was prepared by researcher and asked to compare it with their diagrams and get rid of the deficiencies.

Beginning from the third week of research, pre-service teachers were asked to design the experiments, which were performed by group work in physics laboratory course, by using Vee diagrams. In the study, the Vee diagram format, which was modified by Afamasaga-Fuata'i (1998), was used.

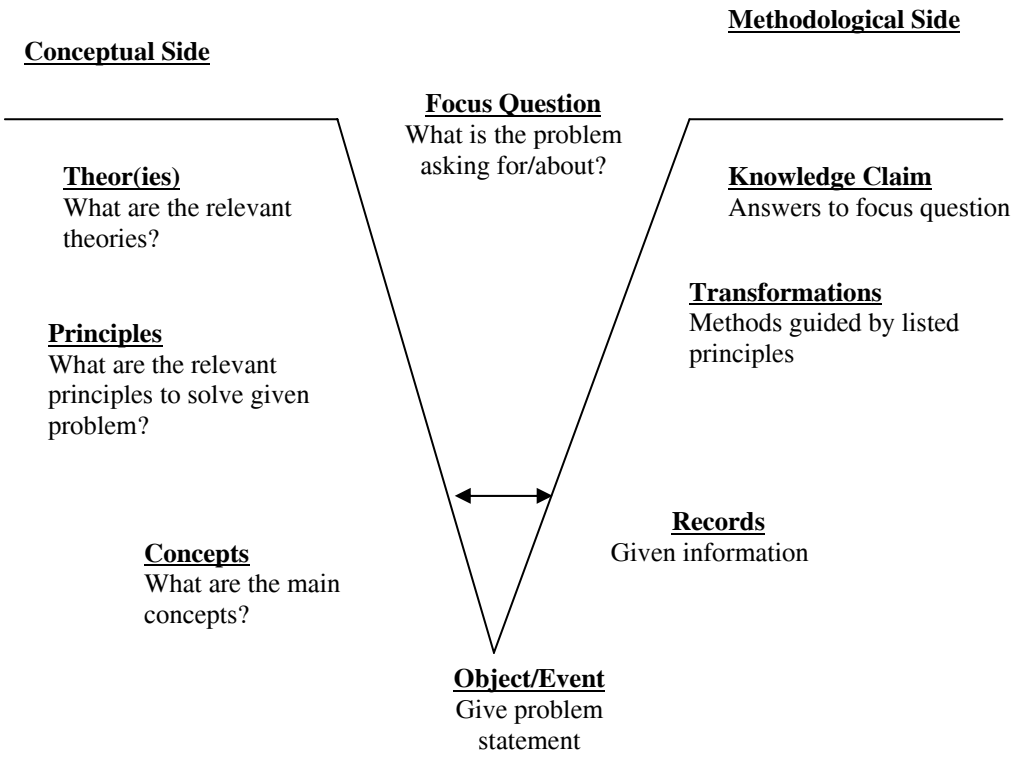


Figure 1 Afamasaga-Fuata'i (2004) modified from Novak & Gowin, 1984).

Every week pre-service teachers were informed about the subject they are going to study in the laboratory. They were asked to complete the conceptual side of Vee diagram before coming to laboratory. To complete the conceptual side they first determined a focus question. They then created a concept list that includes vocabulary relevant to the question under investigation. In the objects/events section, participants designed a procedure to examine the focus question. After determining the focus question, concepts and objects/events, pre-service teachers completed theories and principles part by conducting research. By this way, before coming to the laboratory pre-service teachers gained an extensive knowledge about the topic they are going to study. In the laboratory, participants conducted the experiments with their mates. They planned the experiments by themselves. The researchers acted as a guide throughout the course. After completing the experiment, pre-service teachers recorded

the data in the record section and included appropriate charts, graphs, and tables in the transformations section. Participants completed the Vee diagram by reporting conclusions and answering yhe focus questin in the knowledge claim section.

In the last week, ATUVD was applied in order to determine the attitudes of pre-service science teachers towards using Vee diagrams in general physics laboratory and QUVD was applied to take their views about Vee diagramming in laboratories.

Analysis

Statistical analysis included tabulation of frequency distribution of students' responses to the ATUVD. Scores were analyzed using the SPSS for Windows software. Also a simple categorization of the answers was made based on extracted key ideas from the QUVD. While analyzing qualitative data, content analysis method was used. Content analysis is defined as a systematic, iterable technique, with which the words of a text were summarized with smaller content categories (Büyüköztürk et al., 2008). Categories were determined coding raw data obtained from the replies of open-ended questions. To do this each response was read and the concepts within it were added to a summary sheet to build up a list of all concepts in all the responses. Categories for coding the concepts were then generated from this list. The analytical process then involved examining each response and using the categories to code the concepts present. Note that once a given category had made an appearance in a response, further occurrences of the same category in the response were not coded. In other words, the responses were coded for the *categories* present— each category could only occur once (even though its presence may have been supported by several elements). Since one response usually contained several categories, the number coded was far greater than the sample size.

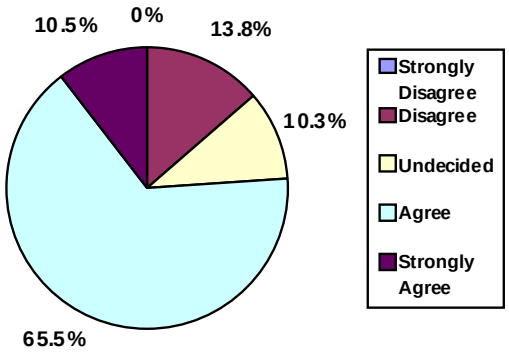
Results

Results of quantitative data

Considering the points will be obtained from ATUVD, if the highest total point is 90, this is the most positive attitudes' indicator; and if it is 18, that is the most negative attitudes' indicator. If all "undecided" replies are marked, 54 points can be obtained and this indicates neutral situation. In other word, over 54 points represents positive attitudes and the other ones represent negative attitudes. Therefore 21 pre-service teachers (72.4%), who have more than 54 points, show positive attitude, while 8 pre-service teachers (24.6%), who have less than 54 points, show negative attitude to using Vee diagrams.

Pre-service science teachers participating in the study reported the following perceptions about the use of Vee diagram in the lab:

Using Vee diagrams in the lab helps us to learn the subject meaningfully.



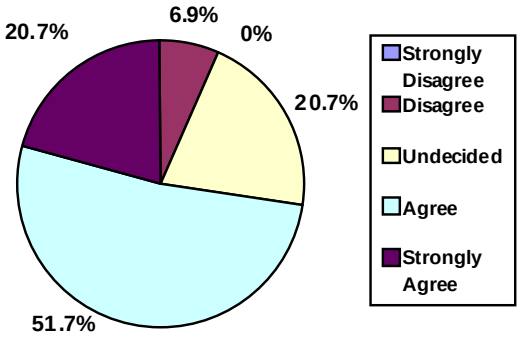
76% of the pre-service science teachers stated that Vee diagrams are helpful in learning the subject meaningfully. Besides, only 13.8% of them did not found Vee diagrams helpful in meaningful learning of the subject.

The replies of pre-service teachers, who participated in the study, to open-ended questions show similarity with the qualitative data. Some views of pre-service teachers are given below.

- "Vee diagrams help us to understand the subjects more easily."
- "Content is grouped under appropriate titles in Vee diagrams, it facilitates learning."
- "We gained skills that make able to save the knowledge in our minds in a better way, thanks to applications."
- "Vee diagrams ensured learning to be more effective and lasting. We learned concepts clearly with these diagrams."
- "Vee diagrams make the knowledge concrete and facilitate learning."
- "Thanks to Vee diagrams we can save knowledge in our minds in a systematic way."
- "Thanks to Vee diagrams we can connect the concepts to each other."

Using Vee diagrams in lab helps us to make a meaningful relationship between theoretical knowledge and experimental processes.

Although 6.9% of the sample disagree and 20.7% of them undecided, 72.4% of pre-service science teachers think that by using Vee diagram they can make a meaningful relationship between theoretical knowledge and experimental processes.



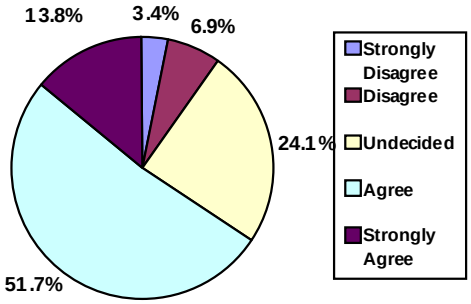
The replies of pre-service teachers to open-ended questions support the replies to the surveys. Some of them are:

- "Thanks to that theoretical knowledge and results of experiment was separated, I learned more."

- "I could make contact between the experiment and theoretical knowledge thanks to Vee diagram."

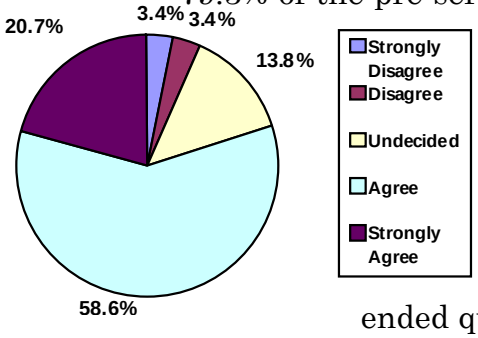
Using Vee diagrams in lab helps us to realize our misunderstandings and to reorganize our knowledge.

75.8% of pre-service science teachers enrolling in the study stated that Vee diagrams helped them to realize their misunderstandings and reorganize their knowledge. Only, 10.3% of them disagree with this statement.



Using Vee diagrams is a way to get rid of rote learning

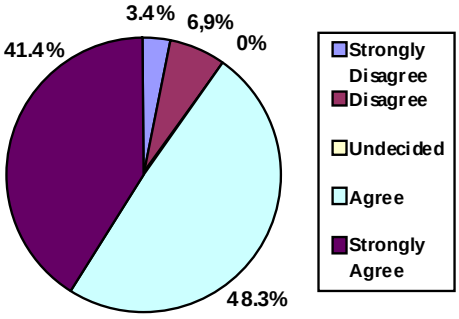
79.3% of the pre-service science teachers in the study stated that they believe that Vee diagrams is a way to get rid of rote learning. Only 6.8% of them disagreed with this statement.



In open-ended questions pre-service teachers frequently mentioned that Vee diagrams impede memorizing. Some of the replies of pre-service teachers to open-ended questions are:

- "It ensured me to inform about the subject and not to forget it with learning-based application instead of memorizing."
- "Science cannot be done with memorization. I think these diagrams can impede memorization in a certain degree."
- "Vee diagramming is a method that requires research. This property impedes memorization and ensures the things learned to be lastful."

Vee diagram lab applications enforced me to conduct a research.

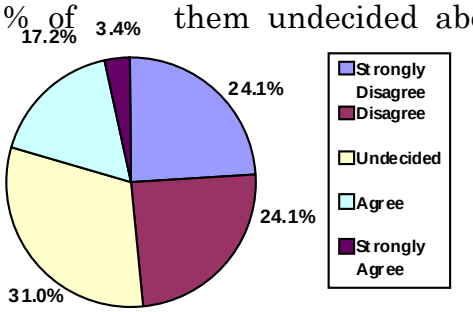


More than 80% of pre-service science teachers found Vee diagram applications enforcing to conduct a research. Only 10.3% of them did not agree with this statement.

The percent of the replies to this statement in ATUVD, which is related to that Vee diagrams directs to search, was encountered also in open-ended questions. Nearly all of the pre-service teachers stated that Vee diagrams directed them to research and they developed searching skills while preparing Vee diagrams.

Vee diagrams can be a very useful instructional strategy for physics laboratory.

48.2% of the sample disagreed and 31% of them undecided about using a Vee diagram is a useful instructional strategy for physics laboratory. 20.6% of pre-service science teachers agreed with this statement.



While replying open-ended questions, the pre-service teachers, who participated in the research, told that using, Vee diagram would not be a very good strategy considering the difficultness of preparing Vee diagrams. The pre-service teachers generally asserted that preparing Vee diagrams is difficult, requires time and labour.

Results of qualitative data

The explanations, which reveals the diversity of Vee diagram descriptions of pre-service teacher that participated in the research was turned into a table (Table 1). Table 1 includes description categories formed by researchers for each open-ended questions and sample examples of pre-service teachers descriptions. For example in the first question, the participants were asked the differencies between laboratory studies done with vee diagramming and other laboratory experiments in terms of planning. From the answers of the participants the researchers formed four categories; "organized", "planned", "in different form", "amusing". It can be concluded that pre-service teachers found vee diagrams more organized, planned, amusing than other laboratory experiments. It also can be concluded that pre-service teachers think that vee diagramming is in different form than the other laboratory experiments. For the first question sample answers from the participants are:

- "Vee diagram is an instructive study because it is organized any generally contains important parts of the subject."
- "It has a different plan and form apart from the other experiment reports."
- "We can see all stages of the experiment on a single sheet."

Table 1 Examples of pre-service teachers' answers to the questions in QUVD and categories formed (continued)

Question	Description Category	Examples of Pre- Service Teachers Descriptions
1	*In terms of planning;*	"Vee diagram is an instructive study because it is organized any generally contains important parts of the subject."
	Organized	
	Planned	"It has a different plan and form apart from the other experiment reports."
	In different form	
	Amusing	"We can see all stages of the experiment on a single sheet."
	In terms of practice;	"A little compelling method. It requires thinking and searching."
	Interesting	
	Useful	"Very difficult, boring and exhausting in practice"
	It requires labor	
	Difficult	"At first it was a little difficult but last practices was easy."
	Exhausting	"Study was difficult because it required labor."
	Ensures organized study	"It was positive because it ensures organized study."
	In terms of learning;	"I learn in a better way in comparison to other laboratory methods."
	Effective	
	Lastful	"Vee diagram ensured learning that was more lasting."
	Conveniable with visual intelligence	"We learned in a better way thanks to that we registered theoretical knowledge before the experiment and we registered the knowledge obtained after the experiment."
	Directs to searching	
		"Formally, it is a study that does not push student but attract them."
		"It requires more research."
	In terms of evaluation;	"Although our grades are low, we learned more."
	Fair	"Evaluation is fair."
	Grading was low	"Interpretation part is more complex than theoretical. Therefore our points are low if we cannot interpret our knowledge."
	Difficult	
2	To research	"....my principal duty and responsibility is searching."
	To take down data	
	To be active participant in experiment	"At first, to participate in experiment, to register data, interpret obtained data logically, to work with mates together to prepare Vee diagram."
	To complete theoretical part before experiment and to complete methodical after the	"Before the experiment completing the

	experiment To take responsibility To state our interpretations and views	theoretical part by conducting a research, then completing the methodological part after the experiment."
3	To draw V form of the diagram To present knowledge obtained in an organized form To think focus question To write our interpretations To prepare methodological part	"While preparing Vee diagrams, the stage that I liked at most is writing my interpretations. The works that I liked at most are evaluating the experiment, revealing my views." "I like V shape of the diagram" "the property that I like at most is taking down the information regularly." "…after finishing I can read it easily because it is in a certain order." "While preparing Vee diagram, my favorite property is thinking the focus question." "I like to prepare the methodological part of Vee diagrams, because in this part, I write the stage that I learned and applied in experiment. This helps me to learn more."
4	To interpret To write conceptual part It requires very much attention It takes time It is exhausting	"It takes a lot of time." "Because it is a study that requires attention, it is boring." "While preparing Vee diagram, the property that I dislike is interpretation." "It was difficult for me that titles were detailed in diagram and these were separated with slight lines." "To find focus question and knowledge assertions..."
5	To look at events with a wide perspective To be organized and planned Development of interpreting, researching, and resulting skills To strengthen communication skills	"It increased our thinking skills and directed us to search." "It taught me planned study, doing everything in time, doing research." "It taught us to present knowledge in an organized way." "It ensured to establish closer dialog with mates." "It helped me not to forget the lesson because it isnot based on memorization but based on learning." "It is very important that it presents more concrete, visual knowledge to us."

6	*Yes;* Amusing Effective It teaches thinking more. It teaches searching. It increases creativity and conceptual understanding.	*No;* Difficult Preparing students of Primary School Students to examinations is more important than this technique. Techniques that are more effective can be preferred.	"I will use. Because it is an amusing work, connects student to lesson and helps learning." "I think it is an effective learning technique." "Yes I would like to use it because it is not memorizer but directs to search. Thus it makes learning effective." "I would like to use it. Because Vee diagram increases creativeness, thinking, and design power." "Yes because I want students to develop their thinking skills."	"No, because I work as a primary school teacher, and that children cannot prepare these diagrams." "No because preparing Vee diagram is really a difficult and exhausting technique." "No because I am going to become primary school teacher. They should prepare to exams. They shouldnot occupy with this."
7	*In terms of learning;* To facilitate learning Comprehension subjects Active and lasting learning		"It increases learning." "Because it is towards to research, we were learning easily." "I learned actively and permanently."	
	In terms of thinking skills; Creative thinking Problem solving Interpretation Criticism		"With Vee diagrams, our interpretation skills developed. We found our errors and their reasons. Thus our problem solving skills developed." "It helps human to think in a better way and to look with various perspectives." "Some parts in Vee diagrams as knowledge assertions, interpretation, developed our thinking and critical thinking skills."	
	In terms of social aspects; Interaction in group Responsibility Co-operation Supporting friendship Supporting group work		"We became closer with our group mates, while nobody was talking each other at first." "We work with our group mates thanks to co-operation. We and our friends become closer."	

8	Understanding the lesson in a better way It changes rote learning to meaningful learning. Developing searching, thinking, and creative skills It facilitates learning.	"There cannot be memorization in science, and in my opinion, these diagrams can compel it." "Science education is towards to research, thinking, and creativeness. Vee diagram is towards to research. Therefore it contributes to science education's development." "In my opinion Vee diagram can be used in every sub-unit of science education. Increasing the permanency in mind, it facilitates learning. It contributes development in terms of social aspects and thinking skills." "In terms of thinking in a better way, increasing creative thinking, and establish relation-ship with classmates of thinking, it contributes."

Discussion and Conclusion

This study is conducted to determine pre-service science teachers' attitudes toward the use of Vee diagram in general physics laboratory. The study specifically contributed to the literature of the Vee diagramming as being an example of an application for the physics subjects. The findings gathered from both ATUVD and QUVD revealed that most of the pre-service teachers show positive attitudes and only few show negative attitudes toward the use of Vee diagramming. Participants showing negative attitudes found Vee diagramming as difficult to prepare, exhausting and time taking. For the pre-service science teachers enrolled in the study, this was the first time they have experienced the use of Vee diagram. The reasons for negative attitudes toward some aspects of using Vee diagram in the laboratory may be due to this situation. Pre-service teachers also stated that their Vee diagrams improved over time. It can be concluded that it took some time for pre-service teachers to get comfortable with this approach.

One of the most important finding of the study is; most of the pre-service teachers find Vee diagrams is a way for meaningful and effective learning. Pre-service teachers also found Vee diagramming more effective than traditional laboratory. This result shows consistency with the findings of the previous studies. Ramahlape (2004) stated that learners find Vee diagram informative, useful and facilitative to their conceptual understanding. Besides, Nakiboğlu & Meriç (2000) also reported that Vee diagram is helpful for conceptual understanding.

Findings of the present study also revealed that use of Vee diagrams in physics laboratory enforced pre-service teachers to conduct a research. Almost all participants, more than %80, stated that they had to conduct a detailed research to complete the Vee diagram. A wide variety of studies

reported that Vee diagrams caused students to conduct a research before the laboratory work (Atılboz & Yakışan, 2003; Nakiboğlu & Meriç, 2000; Roth & Browen, 1993).

Another result supported by both the quantitative and qualitative part of the study is; pre-service teachers found Vee diagramming useful because it helps to organize the knowledge in a structured manner because of its shape. Roth & Browen (1993) reported similar results in their study. They found that Vee diagramming helps organization of the knowledge since it draws main lines for both theoretical and practical knowledge.

The qualitative results of the present study supported that use of Vee diagramming improved pre-service teachers communication skills and social relationships with their group-mates. In the literature it is reported that in cooperative learning environments by use of Vee diagrams students participate in effective group work, by this way they found opportunity to improve their communication skills (Luft, Tollefson & Roehrig, 2001; Roth & Roychoudhury, 1993).

Based on the findings of the present study it can be stated that use of Vee diagrams in laboratories will provide several benefits to students such as, learning the content meaningfully and effectively, getting rid of rote learning, organizing their knowledge in a systematic way, developing their communication and research skills. For this reason use of Vee diagrams in science laboratories especially in physics laboratories strongly suggested to science educators in the education faculties of the universities and elementary and high school science teachers.

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Biographic Statements

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