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Volume 24, Number 1

International Journal of Vocational Education and Training

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Table of Contents

Improving Technical Drawing Skills of Vet Teachers: An Action Research Project

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Abstract

This study project titled Improving Technical Drawing Software Skills of Vocational Education Training (VET) Teachers (TED-VET) sought to organize trainings to introduce Adobe Illustrator as a Technical Drawing Software to technical VET teachers and determine the effect of these trainings on teacher effectiveness. Additional goals included developing the capacity of academic personnel at Akdeniz University to provide appropriate and high quality CPD (Continuing Professional Development) for VET teachers and trainers on Technical Drawing Skills with Information and Communication Technologies or ICT, institute practitioner networks among technical Vet teachers who give technical drawing courses; and to support this CPD with partnerships between Provincial Directorate of National Education, VET schools, industry and the University to contribute to CPD of VET teachers. As a result of this study, 15 teachers attended the training of trainers and directly benefited from CPD. These teachers have become trainers for VET teachers (T-VET) and will organize new trainings for other VET teachers in 61 VET schools in Antalya under the coordination of Education Directorate. The findings and outcomes of this study have important implications about how ICT in TVET schools can be used effectively.

Introduction

Drawing pictures with a perspective on nature, a person's view, and things based on the artist's imagination are expressed as "art pictures". If a drawing is based on some pre-determined rules, and if it is being produced by using specific methods, then it is considered a technical drawing. Technical drawing is a linear-based language which is used by technical staff to express shape, measure, and unit of the thing that will be produced. In technical drawing, complete information needed to produce a device or a tool can be found in the instructions. If a unit needs to be produced, exact measurements of that unit have to be drawn and scaled according to the technical drawing rules, and the features of that unit have to be shown with numbers or letters. That is why technical drawing is crucial for an efficient and accurate manufacturing process (MEB, 2011).

A drawing made in one country should be easily read in all countries. This is why technical drawing is considered a common language of engineers. Any language that provides communication should consist of some rules so it can mean the same thing to everyone. Similarly, if it will be used as a communication tool, drawing should have universal rules as well (Reddy, 2009). While emphasizing the importance of technical drawings, Uzodinma (2007) said that technical drawing is an important language that is used by technicians, engineers, artists and people working in industry. In summary, technical drawing is the transmission of information and ideas that need to be expressed with pictures and lines. In view of this general purpose, the goals of technical drawing can be stated as follows (NERDC, 2007):

- To understand theoretical and applied concepts in order to establish visual communication in manufacturing and construction industry,
- To introduce modern drawing applications,
- To set up the foundations of future works and technological improvements in construction and engineering fields,
- To improve and extend entrepreneurship skills in different drawing fields.

To understand this study in context, one must also understand how technical drawing is taught in Turkey.VET Schools in Turkey have technical drawing courses as major area courses in the 10th grade. These courses are given by major branch course teachers and the curriculum includes basics of technical drawing, such as drawing polygons; as well as more complex tasks such as understanding the perspective of 3D figures, and, based on these perspectives, producing 3D drawings. The courses in technical drawing laboratories with mechanical drawing tools are described by General Directorate of Lifelong Learning under the Ministry of National Education, as (HBOGM, 2016):

> "*In this course, the aim is to make the student qualified enough to do basic geometrical drawings and activities, do projection and configuration by introducing them to concepts related to technical drawings and vocational drawings in the field."*

When this description and the existing activities are examined, it can be assumed that computers, which are the essentials of this age, are not used in these courses. However, one can also assume that there are no obstacles to prevent the usage of computers in these courses.

With the globalization of the world, computers have become a very important part of our lives in many areas. In Turkey, computers were introduced to education in the beginning of the 1980's. In the 1990's, connections between several universities were established. In these years, Ministry of National Education started nationwide training of "trainer teachers" in order to teach computer courses at schools. Since the beginning of the 1990's, courses that involve information and communication technologies have been taught in teacher training courses. (Usun, 2003).

Use of technology, and especially use of Information and Communication Technologies (ICT), has brought changes to teaching and learning in Turkish classes. Students and the environment have become much more interactive and productive with the help of ICT activities (Rosen, 2009; Raileanu, 2010a; Bakar, Ayub, Tarmizi, 2010). Additionally, ICT activities have helped students gather the necessary information and share it for a better understanding of the field. Research also indicates that ICT helps students realistically visualize objects, as well as give students the opportunity to use existing information to understand a problem or the context of a problem (Raileanu, 2010b). In this way, abstract concepts are more easily understood.

(Pisciotta, Vello, Bordo, Morgavi, 2010). Therefore, ICT is used as a tool to improve the learning ability of students, especially in engineering fields (Viamonte, 2010).

In this century, computers are crucial in production and in engineering fields. In addition to the importance and definition mentioned above, computers also help technical drawing work to be completed much faster. Computer Aided Design (CAD) was first used in the 1950's by United States Air Force with light pens. It was followed by Professor Ivan Sutherland, working at Massachusetts Institute of Technology (MIT), who used light pens to enter data to computers. Now,, there are improvements in fields like designing, pre-studies, documentation process with the help of developments in computers (Goetsch, Chalk, Nelson, Rickman, 2005). CAD applications started professionally with 2D modeling of solids (machine parts, buildings, standard and non-standard elements, etc.). 2D projections are especially crucial for montage drawings (Nestorovic, 2008). 3D drawings followed 2D drawings with the gained experience.

In Turkey VET teachers and trainees are expected to make use of new pedagogies, teach new competences, work more closely with their colleagues and employers and make extensive use of new technologies. Especially in technical drawing courses given at technical VET schools, VET teachers and trainers are expected to use ICT. Technical staff who graduated from VET schools should be qualified in technical drawing which is the most suitable tool for transferring ideas in an engineer's, an architect's, or a designer's mind. Technical drawing can be performed by just freehand or by drawing tools as well as by the help of computer software. In technical VET schools in Turkey, technical drawing courses are taught by technical drawing expert teachers in technical drawing workshops. In these courses, students are introduced to basic concepts of technical drawing in their fields. In addition, the main objective of these courses is to make students gain the ability of drawing basic geometrical shapes, extracting the projections and the views of shapes, drawing diagrams and developing schemas for students' fields. Traditionally, these competencies are performed without the help of ICT. Developments in computer technologies and especially in two-dimensional and three-dimensional applications let designers perform drawings with almost no mistakes.. Therefore, the use of ICT should be applied in technical drawing courses. With recent improvement in computer technologies, most drawings are made by computers. In this way the error margin is almost zero, and it can be claimed that production expenses are lowered with the pre-cautions taken before the production process.

This action research was performed to raise awareness to technical drawing courses taught in VET schools in Turkey. The aim of this study was to update current curriculum to match the demands of the era, and to improve the accuracy of student technical drawings. This study also intended to improve vocational and technical education. Therefore, the action plan below was implemented.

Action Plan

This study was performed at Akdeniz University, under the title of "Improving Technical Drawing Skills of VET Teachers", and funded by European Training Foundation (ETF). This study consisted of two phases. In the first phase, 15 VET teachers, who would give technical drawing courses to other VET teachers, were trained for 40 hours to be a "trainer". This training was called "training of trainers". In second phase, these 15 trainers taught courses on the subjects they were trained in to 303 teachers who worked at VET schools in Antalya.

Phase1: Training of Trainers

- Preparation of training contents and approval from Antalya Provincial Directorate of National Education
- Selection of 15 teachers who would be "trainers" from Antalya Provincial Directorate of National Education
- Obtaining official permission and organizing the training location
- Administer a pre-test to 15 trainers before the "Training of Trainers" takes place
- Administer the 40-hour training to the trainees
- Applying post-test to 15 trainees following the 40 hour training
- Interviewing the 15 trainers after training and collecting data.
- Interpretation of content and functionality of training after the "Training of Trainers" by performing a content analysis of the interviews.

Phase 2: Training of 303 VET teachers

- Selecting of schools and teachers to would participate in training with Antalya Provincial Directorate of National Education
- Obtaining official permission and organizing training location
- Administering the pre-test to teachers who will participate in the study
- Administering the 40-hour training
- Administering the post-test to teacher participants in the study
- Analyzing Paired Samples t-test between pre and post-tests
- Interpreting the difference between opinions about integration of computers on technical drawings before and after the training

Methodology

Action research strategy which includes qualitative methods and quantitative methods were selected for this study. "Action research simultaneously assists in problem solving and expands scientific knowledge, as well as enhancing the competencies of the respective actors, being performed collaboratively in an immediate situation using data feedback in a cyclical process, aimed at an increased understanding of a given social situation, primarily applicable for the understanding of change processes in social systems and undertaken within a mutually acceptable framework." (Hult & Lennung, 1980, p. 241-250). Consequently, "the advantages of an action research can be summarized such as direct links between research and problem solving, Possible personal benefits for practitioner/professional self development, a continuous cycle of change and development - organizational benefits, practitioner participation, an accumulation of action research may lead to policy and practice changes" (Gunbayi & Akcan, 2015).

Selection of VET Teacher Participants

The study was conducted in two phases. Although the participant profile was the same, the number of the participants was different in two phases. In the first phase, it was important that the selected teachers had taken technical drawing courses had taught technical drawing courses in their schools. To secure the proper number of selected teachers, , VET schools teaching staffs were reviewed and 15 teachers from nine different VET schools were chosen on a volunteer basis who fit the requirements of the study. The demographic information of these

teachers is described in Table 2 below. The teaching areas of each participant are identified in Table 1.

Table 1
The Teaching Areas of Participants in the "Training of Trainers" Phase

Teaching Area	**Number of Participants**
Graphics and Photographs	3
Information Technologies	6
Metal Work	1
Machine Technologies	2
Machine Design	1
Construction Technologies	1
Art and Design	1

In the second phase of the study, 303 teachers working at VET schools in Antalya attended the trainings. The only criterion to select these teachers was working at a VET school in Antalya.

Data Collection and Analysis

Semi-structured individual interviews were used to acquire the opinions of the participants because this semi-structured approach provides an in-depth exploration of the topic. It would also allow the flexibility, to change the order of questions, simplify the questions, and to probe the interviewees (Cohen et al, 2007). Face-to-face interviews were employed and informants' experiences, thoughts and feelings pertaining to the training were recorded in an audio taped diary. Additionally, pre and post-test were applied to participants before and after the trainings to analyze the differences between their opinions before and after the trainings. Interviewers attempted to gather information about the effectiveness of the trainings and necessity of the integration of new technologies into technical drawing courses.

Data were organized categorically and chronologically, reviewed repeatedly and continually coded. Interview transcripts were regularly reviewed by the researchers. In addition, the data analysis process was aided by the use of the qualitative data analysis software NVIVO 10. NVIVO 10 does not perform the analysis but only supports the researcher doing the analysis by organizing data and recodes, nodes etc. (Kelle, 1995; Cohen, Mannion, Morrison, 2007).

To determine the effectiveness of the training and the necessity of the integration of new technologies into technical drawing courses, pre and post-tests were administered to participants. The analyses of the pre and post test data were performed with SPSS and paired sample t-Test was performed on the data. Paired Sample t-Test was conducted to determine if a significant difference existed between two independent variables by using correlation analysis between variables. The pre and post-test scores of participants were compared and analyzed.

Ethical Considerations

Participants were briefed about the objectives of the research, kept informed at all stages of the study and offered anonymity during the process. A consent form was signed between researcher and each participant about the use of the data in terms of how its analysis would be reported and disseminated.

Findings

Trainers who participated in the first phase of the research were questioned on the knowledge they gained from this training along with their perceptions on the usage of the training in future teaching opportunities. At the beginning and at the end of the initial phase pre and post tests were administered to 15 teachers. In the second phase of the research, pre-test and post-tests were also administered to 303 teachers who attended second training. The purpose of this pre and post-test was to measure the sufficiency and necessity of the training. Paired Samples t-Test was used to analyze the results. First, participant opinions about the training will be presented along with an analysis of the paired sample t-test.

Opinions of Participants after Training of Trainers

At the conclusion of the Training of Trainers program, semi-structured interviews were completed with participants. Interview items included:

1. Demographic information
2. Training Expectations
3. Training Preparation
4. Assessment of Training Impact on Professional Development
5. Overall Impression of the Training

The demographic information of the participants who attended trainings of trainers is shown in Table 2:

Table 2
Participant Demographic Information

Code	Branch	Work Year	Age	Sex
A	Information Technologies	12	34	M
B	Metal Work	34	55	M
C	Graphics and Photographs	24	47	W
D	Information Technologies	17	38	W
E	Information Technologies	7	30	W
F	Information Technologies	12	34	W
G	Information Technologies	12	36	W
H	Machine Technologies	17	40	M
I	Machine Design	23	45	M
J	Machine Technologies	17	40	M
K	Machine Technologies	15	40	W
L	Construction Technologies	6	31	W
M	Information Technologies	5	29	M
N	Graphics and Photographs	12	36	M
O	Art and Design	15	38	M

Participant responses were recorded on audio and transcribed by the researchers. The content analysis was performed, data were grouped and main and sub themes were determined. .The three emergent themes from the content analysis were:

- Fulfilling expectations
- Pre-training preparation
- Contribution to the Professional development

Emergent Theme #1. Fulfilling Expectations

The expectations of participants were categorized under the theme of fulfilling expectations.

Table 3
Fulfilling Expectations

Fulfilling Expectations	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	n	%
Lack of field knowledge	√					√		√	√	√		√	√	√		8	53.3
No expectation				√	√		√								√	4	26.7
Up-to-date information			√								√					2	13.3
Out of field usage		√														1	6.67

Data from Table three indicated that four participants (26.67%) had no expectations from the training. Eight participants (53.33%) stated that the training increased their knowledge of the subject materials.

The opinions of participants are as follows:

- *"The TED-VET training course fulfilled my expectations. Before this, I have never had a graphical training or used a graphics program. Also, my basic knowledge was lacking too. With this course I believe I have learned how to use a program especially about technical drawing." (A1,1)*
- *"This training fulfilled my expectations because I graduated from university 12 years ago, and since then, I have not participated in a graphical-based drawing training from Ministry of National Education or from another institution. This technical drawing training met my needs." (F1,1)*
- *"I came to the course with curiosity because I was hoping to learn how to use a new program. I was satisfied with the training and it fulfilled my expectations. Since I am a Construction Technologies teacher, I recognize that drawing is important in our field. I participated because it is a new program, something I don't know and I said that I am glad I learned. I think that I didn't come in vain." (L1,1)*

Only one (6.67%) participant said that the training fulfilled his expectations, he was capable of technical drawing but he needed better technical drawing knowledge for some subjects which were out of his field. He said:

> *"As I am teaching metalworking, we have a close relationship with some drawing programs. This course fulfilled my expectations in this matter. It even changed my perspective a little bit because we needed to edit some periodicals with some of our students. I learned how to do them with a better format." (B1,4)*

2. Preparation before Training

There were three sub-themes under the theme of preparation before training:

Table 4

Preparation before Training

Preparation Before Training	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**n**	**%**
No Preparation					√	√	√	√		√	√	√			√	8	53.3
Pre-Knowledge			√	√					√					√		4	26.7
Software Examination	√	√											√			3	20.0

When Table 4 is examined, it can be understood that 8 participants (53.33%) did no preparation, 4 participants (26.67%) already had knowledge, three participants (20%) examined the software. The opinions of participants are as follows:

- *"I haven't done any preparations before the course because I had no idea what the training would cover.(G2,1)*

- *"We haven't done any preparation before coming to the course because we didn't know the program's name" (J2,1)*
- *"Actually, I didn't have much information about course. We have used Adobe's different programs before in graphics courses. That's why I was prepared with knowledge about the program menus." (D2,2)*
- *"I didn't prepare much for the course. I use some drawing programs professionally because I am a machine drawing teacher. We prepared ourselves psychologically just because we were going to learn a drawing program." (I2,2)*
- *"We already have some vector based drawing programs that we used. I looked at their menus to see if there are any similarities. Because we had used them before, some things seemed similar to me. There are one or two differences but this program is more simple and nicer." (B2,3)*
- *"I did some research and preparation after hearing about the course and the program of course. Firstly, I downloaded the program and looked at the menus and how they work. Then I got some opinions about in which field they can be more beneficial." (M2,3)*

3. Contribution to Professional Development

There were five sub-themes under the theme of contribution to professional development.

Table 5

Contribution to Professional Development

Contribution to Professional Development	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	n	%
New Software	√			√	√				√	√	√	√				7	46.67
New Drawing Technique			√										√	√		3	20.00
Developing Material Outside of Course						√			√	√						3	20.00
New Teaching Material		√						√								2	13.33
No Contribution							√								√	2	13.33

Table five shows that two participants (13.33%) thought that the training had no impact on their professional development. On the contrary, seven participants (46.67%) stated that training helped them to learn new software, three participants (20%) stated that they learned a new drawing technique, three participants (20%) stated that they learned about material development outside of course and two participants (13.33%) indicated that they learned a new teaching material.

Participant opinions are included below::

"I think that the course impacted my professional development positively. Because I am a computer teacher, I think that being able to use a drawing program is and will be continue to be necessary, so I found it very useful. I believe I will use it in modeling and project studies. I think I will also use it in creating graphics on web sites. Again, because I graduated from computer and instructional technologies department, I believe it will help me to prepare materials in my field." (A3,1)

"I can say that its impact on my professional development is strong. I don't give technical drawing courses at my school, but next year I will want the technical drawing courses persistently." (D3,1)

"Drawing is so important in our field so it had a strong impact on my professional development." (L3,1)

"First, I learned scaling. I had not much scaling before the training. I knew functions like alignment but this is the first time I have learned how to choose the middle of a circle and finding the middle/center of a diameter. I didn't know these before actually." (C3,2)

"With the training I attended, I realized there were some points that I needed to learn about including vector based drawing. Next year, I am planning on giving animation courses. In order to do that, I need to be able to describe movements and animation with drawings. This course will help me make these drawings and describe the movements." (N3,2)

"This course strongly impacted my professional development. I would like to learn more about the details of this program because we may need invitation cards, banners, web site designs, and school logos while working at school." (F3,3)

"This course had a strong impact on my professional development. Even though I have prior drawing experience, some things need to be documented better in my work, some things need to be described better with vector based drawings, and I need to learn to draw better in order to encourage students." (F3,4)

"Will I use this program because I am an Information Technologies teacher? I don't think so. Yes, we have technical drawing courses, but we don't teach vocational drawings too much." (G3,5)

4. Metaphor

According to Sfard (1994), metaphor plays a strong role towards understanding an individual's experiences and cognitive styles. In other words, metaphor does not compare two objects or ideas, instead it makes abstract things concrete in our mind (Günbayı, 2011). With the help of metaphors, we can bring out the relation between objects which are related to each other (Martinez, Sauleda, Huber, 2011). Also metaphors are effective in explaining people's perceptions because they create these perceptions in details in a person's mind with through metaphorical expressions (Prawat,1999). In this study, metaphors were used to describe participants' deeper perceptions about training and participants were asked to connect the training to something that they knew about or was important to them. As a result, the metaphors were grouped according to their similarities and categorized in Table six.

Table 6

Metaphor Groups

Metaphor	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	n	%
Nature	√	√											√	√	√	5	33,33
Life			√	√		√	√			√						5	33,33
Other					√			√			√					3	20,00
Structure									√			√				2	13,33

The metaphors formulated by five participants (33.33%) were grouped under "Nature", five (33,33%) under "Life", three (20%) under "Other" and two (13.33%) two under "Structure". Participants produced metaphors related to the training and stated their reasons for creating the metaphors as follows:

> *"I can think it is like a rainbow because it is about graphics. Why do I think it is rainbow? Because I am a programmer, I haven't been involved with studies about graphics and I was using colorless, angled and sided objects while preparing other teaching materials. But with the help of the graphic program, I think I can visualize them more colorfully. That's why I see the training like a rainbow." (A4,1)*
>
> *"I see this training as a dam. A dam is effective when it is filled. As teachers, if we can be filled like a dam with these trainings and if we use technology actively we can be more successful. These trainings fill us like a dam." (I4,4)*
>
> *"A kid who knows walking learns how to run." (C4,2)*
>
> *"I can the training like an art school. I especially liked the pathfinder panel very much. It turned two geometric figures into a flower, a beetle, an emblem, a logo. That's why I saw it as an art school and I thought myself as an artist too." (K4,3)*
>
> *"If I see the professional development as a building, I think this training is one of the floors of this building and the next floors represent more in-depth training." (L4,4)*

Comparison of Pre-Test and Post-Test

Participants (15 Trainers, 303 Trainees, a total of 318) were asked to respond to the pre-test and post-test questions both of which consisted of four sections and 25 questions per section. The sections addressed participants' demographic information, vocational knowledge before and after the training, knowledge about adult training before and after training, and requesting information on the participant's thoughts about the training organization before and after the trainings.

The mean pre-test and post-test responses were calculated and these means were analyzed with a paired samples t-test. Results of the analysis are in in Table 7 and 8.

Table 7

Paired Samples t-test Results for the Pre-Test and Post-Test

Measurement	N	X	SS	Sd	t	p
Pre - Test	318	2.17	0.15	302	216.59	.000
Post - Test	318	4.52	0.12			

There was a significant difference between pre-test and post-test scores as it can be seen in table seven. When scores were analyzed, participants' post-test results (X=4.52) about vocational training knowledge, adult training knowledge and post training organizations were much higher than pre-test results (X=2.17). Also, as seen in Table 8, correlation analysis result was very low at 0.019, which meant there was no meaningful relation between these two variables, and it supported the results in Table 2.

Table 8

Correlation of Pre-Test and Post-Test Points

	N	Correlation
Pre-Test Score & Post-Test Score	318	.019

According to the results in Table seven and Table eight, participants improved their perceptions of their vocational knowledge, learned new information about training of adults, and had positive beliefs about organization of the training. Both results also supported the findings in the qualitative research which was conducted in the first phase of the research.

Discussion, Suggestions and Conclusions

The purpose of the study was to determine the level of improvement in VET technical drawing teachers who participated in multiple training opportunities. In the study, 318 participants received the training with 15 participants being trained to be trainers of the remaining VET teachers. The remaining 303 teachers were taught a 40-hour technical drawing training class for five days. The purpose of these trainings was to teach participants how to integrate computers in technical drawing and make technical drawings with minimal mistakes. Also, another purpose was to determine which technical drawing skills participants needed improvement on the most. Conclusions and interpretations about pre-test and post-test results are discussed.

In the interviews following the training, teachers expressed their expectations from training, preparation before training and the training's effect on their professional development and knowledge. In the "Fulfilling the Expectations" theme, most of teachers stated that they participated because they wanted to improve their vocational knowledge. The research indicated that teachers did not see themselves qualified enough about technical drawing and how to perform technical drawing tasks with computers. Some teachers stated that they did not expect anything before the training because they did not get enough information about the training content. Accordingly, whichever training it was, information given to the participants about the training affected their expectation from training and motivated them positively. Overall, the participating teachers believed the training was useful.

In the "Preparation before Training" theme, more than half of the participants did no preparation before the training. The respondents indicated that they had no knowledge of the software which was used in technical drawing courses or they had no access to any written material for the software. When interviews were analyzed, it was determined that participants (especially those working in information technologies) were more able to take advantage of the training due to their prior knowledge.. Information technologies teachers in the training were familiar with a variety of software because of their professional level of knowledge and they did

not have any difficulty in preparing for trainings. Although they had limited knowledge about the software used during the training, advanced knowledge about at least one version of graphic software was helpful. With the knowledge gained in the training, teachers will be much more successful in disseminating these training throughout the country.

In the "Contribution to Professional Development" theme, all participants (with the exception of two teachers) indicated this training helped them to improve their vocational knowledge of computerized drawing in various ways. Nearly half of the teachers said that they learned new software to improve their vocational knowledge. Participants also stated that they learned new drawing techniques. Some participants stated that they could now produce better materials in and outside of the course. Participants believe that computers will increase the efficiency in technical drawing courses. Teachers should also learn effective ways to better use the software outside the courses and in the technical education laboratories. The use of computers in technical drawing courses affected teachers in a positive manner.

To better understand the teachers' perceptions of the training, participants were asked if they could connect the training to a metaphor that might describe their thoughts on the training experience. When their answers were analyzed, all participants except one said that this training was a positive step in their professional development. It was also remarkable that teachers expressed metaphors that connected their training experience to other experiences outside of the training. According to metaphors of nature, life or building, it can be said that teachers were able to create meaning for themselves through the training.

A paired samples t-Test analysis was conducted utilizing the mean scores of the pre and post-tests. According to the analysis, there was a significant statistical difference between these pre-test and post-test scores. This significant difference meant that trainings were done successfully because the post-test scores were more positive. Participants' technical drawing skills level before and after the training was not the same. After the training, participants believed their knowledge was greater and they also thought that computers should be used in technical drawing because of how well the software created new pathways to their learning and how to utilize their knowledge in teaching.

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