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MECHANICAL ENGINEERING STUDENTS' LEARNING STYLES AND THEIR PERCEPTION OF PROFESSION

Cemil Yigit[1], Elif Atabek-Yigit[2i]
[1]Sakarya University, Engineering Faculty,
Mechanical Engineering Department, Sakarya, Turkey
[2]Sakarya University, Education Faculty,
Science Education Department, Sakarya, Turkey

Abstract:
In this study, it was aimed to explore learning styles of third year mechanical engineering students and also their perception of profession. Ninety-nine third year students studying mechanical engineering at a university located southwest of Turkey were the participants of this study. Data were collected through Kolb Learning Styles Inventory (KLSI) and a Word Association Test with the keyword "engineer" (WAT). Data obtained from KLSI were used in order to identify the participants' learning styles and data gathered by WAT were used to obtain information about their perception of their future profession. Four groups, namely assimilators, accommodators, divergers, and convergers were formed according to analysis of KLSI and WAT's of each group have examined separately. Conceptualizing of their future profession for each learning group was visualized by concept maps. It was found that majority of participants have assimilating and converging learning styles and learning styles have an effect on their perception of profession.

Keywords: learning styles, Kolb Learning Style Inventory, profession perception, mechanical engineering students

Introduction

Everyone learns in a different way and the best way one can learn is known as learning style. Individuals' cognitive, affective, and physiological structure which effect to perception, relations with others, and behavior in learning environment, determines

[i] Correspondence: email eatabek@sakarya.edu.tr

their learning style. There are tests and inventories to determine individuals learning styles and Kolb Learning Style Inventory (KLSI) is one of them. The Kolb Learning Style Inventory differs from other tests of learning style and personality used in education by being based on a comprehensive theory of learning and development, namely Experiential Learning Theory (McLeod 2013). According to this theory, learning is in a shape of spiral and this spiral has four learning modes namely Concrete Experience (CE), Abstract Conceptualization (AC), Reflective Observation (RO), and Active Experimentation (AE). These modes are the ends that are polar opposite of two dimensions i.e., first dimensions' ends are concrete experiencing and abstract conceptualization and the second one's are active experimentation and reflective observation (Kolb 1981). An individual's learning style is not only one of these learning modes but a combination of them (Askar and Akkoyunlu 1993, Kolb 1981). There are four learning styles resulting from these combinations and they are assimilators, accommodators, divergers, and convergers.

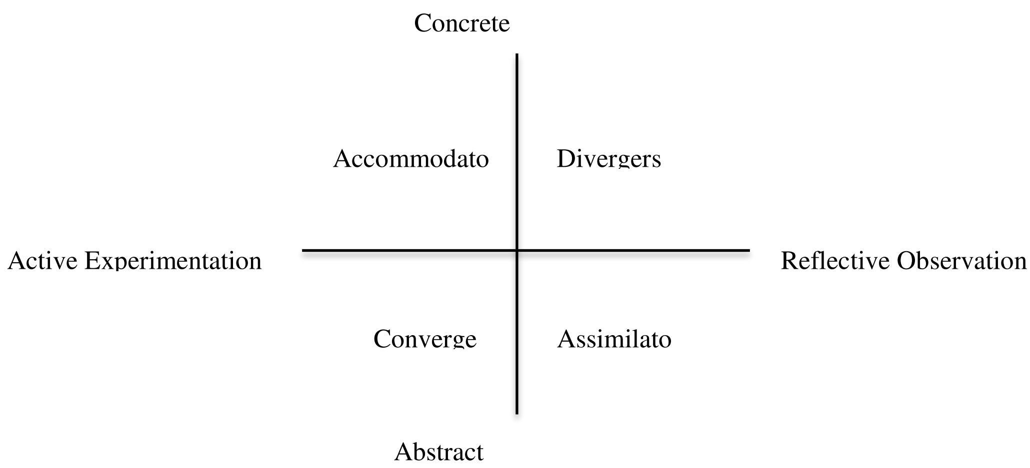


Figure I: Kolb's learning style categorization

Assimilators' learning modes are abstract conceptualization and reflective observation. They are good at planning and determination of problems but are ineffective in systematic applications. They have ability to create theoretical models and inductive reasoning. They tend to learn by reflecting and thinking and are less interested in people and more concerned about abstract concepts. Individuals with this learning style are successful in basic sciences and mathematics but have problems in application. In working environment, people in research and development departments are usually assimilators (Askar and Akkoyunlu 1993, Evin-Gencel 2007, Jonassen and Grabowski 1993, Kolb 1984).

Individuals with opposite strengths to assimilators are accommodators. Their learning modes are concrete experience and active experience. Therefore, they learn best while using their experiences they had before. They have abilities in leadership, initiative, and flexibility but are not good at technical solutions. They are risk-takers, tend to excel in situations that call for adaptation to specific immediate circumstances. Accommodators have good interpersonal relations and they tend to learn from people rather than gathering from technical information. They are successful in fields like business, education, and communication. Marketing and sales departments of factories generally have people with accommodator learning style (Askar and Akkoyunlu 1993, Evin-Gencel 2007, Kolb 1984).

Third type of learning style is divergers. They are best at concrete experimentation and reflective observation. Individuals with this learning style are generally patient, objective, and tend to observe rather than to go into action. They are good at organizing relations between situations and have imaginative ability. They can view concrete situations from many perspectives. Divergers generally specialize in arts and have backgrounds in humanities and liberal arts. Counselors, personnel managers, and organization development consultants have generally this type of learning style (Askar and Akkoyunlu 1993, Evin-Gencel 2007, Kolb 1984).

Convergers are the fourth type of learning style. Their learning modes are abstract conceptualization and active experimentation. They have opposite strengths from those of divergers. Individuals with this learning style are good at practical applications of ideas and have hypothetical-deductive reasoning. They can learn best by experimentation and focus on specific problems. Convergers are unemotional and tend to be interested in things rather than people. They specialize in physical sciences and many engineers have this type of learning style (Askar and Akkoyunlu 1993, Evin-Gencel 2007, Kolb 1984).

Figure I illustrates categorization of learning styles according to Kolb. There are studies in literature that aimed to explore individuals' learning styles using KLSI (Cavanagh, Hogan and Ramgopal 1995, D'Amore, James and Mitchell 2012) as well as studies using Kolb learning cycle to improve student learning (Stice 1987) and exploring students' learning styles in different classes (Diaz 1999). In a study by Larkin-Hein and Budny (2001) authors investigated the learning styles of students in physics and engineering classrooms and it was reported that Kolb learning style model was employed successfully with freshmen engineering students. Felder et al (2000) have also said that Kolb learning cycle was an effective way of teaching for engineering students. The studies (Carrizosa and Sheppard 2000, Felder & Silverman 1988) that aimed to explore learning styles of engineering students reported that the majority of engineering students are predominantly visual, sensing, inductive, and active learners.

A few studies in literature aimed to explore "engineer" perception of individuals. For instance Knight and Cunningham (2004) have studied about the development of a "Draw an Engineer Test", and students from different grades (from grade 3 to 12, a total of 384 students) were asked "what does an engineer do?" and "draw an engineer in workplace". Most of the students replied as the activities an engineer does as builds (30%) and fixes (28%), meaning that they have a perception of an engineer as a person who builds buildings (such as construction workers) or fixes cars (such as auto mechanics). Not many students responded to that question as an engineer designs (12%), improves (4%), and invents (3%). Data from the drawings for the engineer at workplace showed that many students (23%) have included tools (e.g. hammer, wrench), some of them (19%) drew cars, and a few of them (6%) drew a desk (with pen or pencils). From those results the researchers concluded that many of the students' perceptions about engineers is the person who builds or fixes things and they relate their perceptions about the working place for engineers with tools and cars, therefore they have misunderstanding about engineers and engineering profession though they do not thing engineering as a career. In a report by Marshall, McClymont and Joyce (2007) top of mind' associations with the term 'engineer' showed the profession to be more closely associated with fixing things rather than creativity, practical solutions or design.

Studies about perception generally use scales (Dabbagh and Menasce 2006, Ismail 2013, Misran and Sahuri 2013), interview (Marshall, McClymont and Joyce 2007) or open-ended questionnaire (Mishkin et al 2016) as data collecting tools. In this study, different from the literature, perceptions of engineering students about their professions were collected via Word association Test (WAT). WAT is a technique that aims to explore cognitive structure as well as perceptions of individuals. In this technique individuals are asked to respond with a word that comes into their mind first to any given stimulus word and it is assumed that response words can give a clue about one's cognitive structures or opinions since response words are in a relation with the stimulus word in mind (Bahar, Johnstone and Sutcliffe 1999). WAT was used in literature widely to investigate students' cognitive structures (Atabek-Yigit 2016, Atabek-Yigit, Yilmazlar and Cetin 2016, Bahar, Johnstone and Sutcliffe 1999, Bahar and Ozatli 2003, Kostova and Radoynovska 2008) as well as to determine misconceptions (Ozata-Yucel and Ozkan 2015) and to get information about perception (Ben-zvi-Assarf and Orion 2005). Once data were obtained with WAT frequency tables can be prepared and concept maps that visualize individuals' cognitive structures or perceptions can be drawn. Cut-off point technique as offered by Bahar, Johnstone and Sutcliffe (1999) is generally used when drawing the maps. According to cut-off point technique a number that is 3-5 less than the most frequent response word is determined as first cut-off point and responses bigger than this number are drawn in the map. Cut-off point is then lowered step by step and the full map is then constructed (Bahar, Johnstone and Sutcliffe 1999).

In this study, learning styles of engineering students were identified by Kolb Learning Style Inventory and four groups, i.e., assimilators, accommodators, divergers, and convergers, were formed. Students' perceptions about their future profession were determined through a Word Association Test with "engineer" as stimulus word. Each group's perceptions were investigated and findings were compared accordingly.

2. Method

2.1. Participants

Participants of this study were 99 third year students studying mechanical engineering at a university located at northwest of Turkey. 6% of the participants were female and 94% of them were male. Average age of the participants was 20. They were informed about the study and participated voluntarily.

2.2. Data Collection Tools

Data in this study were collected through Kolb Learning Styles Inventory (KLSI) and a Word Association Test (WAT).

a) *Kolb Learning Style Inventory (KLSI):* KLSI that was originally developed by David Kolb in 1976, modified in 1985 and translated to Turkish by Askar and Akkoyunlu (1993) was used to gather participants' learning styles. In the inventory there are 12 items with four statements which represents a different learning mode, namely first statement is for concrete experimentation (CE), second one is for reflective observation (RO), third one is for abstract conceptualization (AC), and the last one is for active experimentation (AE). An example item was given as below:

The best way I can learn is;
( ) when I trust my foresights and feelings
( ) when I listen and watch carefully
( ) when I trust my logical thinking
( ) when I work hard to finish the work

Cronbach-alpha reliability coefficients of the four dimensions (learning modes) of translated form of KLSI are in between 0.58-0.71.

b) *Word Association Test (WAT):* A WAT was used to gather participants' perceptions about their professions. It was formed by the researchers using the word "engineer" as stimulus word. Stimulus word was written on a page ten times down and blanks were left to get the response words. The reason for the stimulus word was written ten times down is to avoid the chain effect in which a response word can be seen as stimulus word. For instance, if a participant's responses to a stimulus word "jungle" were "trees-picnic-barbeque-meatball" then it could be said that this data would include chain effect since meatball is related to barbeque (previous response) rather than jungle (stimulus word). Data with chain effect cannot be evaluated. Participants were told to write also a "related sentence" at the end of the page and blank was left for that sentence.

2.3. Data Collection Procedure

Data were collected from participants at the end of 2015-2016 spring semester i.e., their third year at the university. After informing participants about the objectives and design of the study, data collection tools were explained. Firstly, Kolb Learning Styles Inventory (KLSI) was given to the participants and they were told to put four statements for each item in an order in a way that describes their preferences best. The inventory has 12 items and 10 min was given to the participants to complete the inventory. After completing the inventory, participants' papers were collected and then they were informed about word association technique and the procedure. They were told to response to the stimulus word with the first word that comes into their minds and do this ten times for the stimulus word. They were also told to write a sentence related to that stimulus word at the end of the page. The researcher performed an example with the stimulus word "flower" on the whiteboard. Chain effect was explained and participants were warned about it. Then an example Word Association Test (WAT) was performed with stimulus word "light" in order the participants to better understand the technique and to obtain more accurate data when administrating the actual WAT. Participants were told to have 1 min to complete the test. Actual administration of WAT with the stimulus word "engineer" was then accomplished. All participants' responses were collected and they were thanked for their contribution.

2.4. Data Analysis

Following procedure was performed in order to analyze the data gathered:

a) *For the analysis of Kolb Learning Styles Inventory,*

Each participant's ordering for each item was entered into an Excel sheet and then for each participant each learning style scores (total CE, RO, AC, and AE scores, that ranges between 12 to 48) was found. After that, the following calculation was done and two combined scores for each participant were calculated.

Score 1: AC-CE

Score 2: AE-RO

Score 1 and 2 ranges between -36 to +36. A positive score in Score 1 shows abstract learning whereas a negative score shows concrete learning. A positive score in Score 2 means active learning and a negative score means reflective learning (Kolb 1984). Then by using Kolb's learning styles diagram (Figure II) learning styles of the participants were determined.

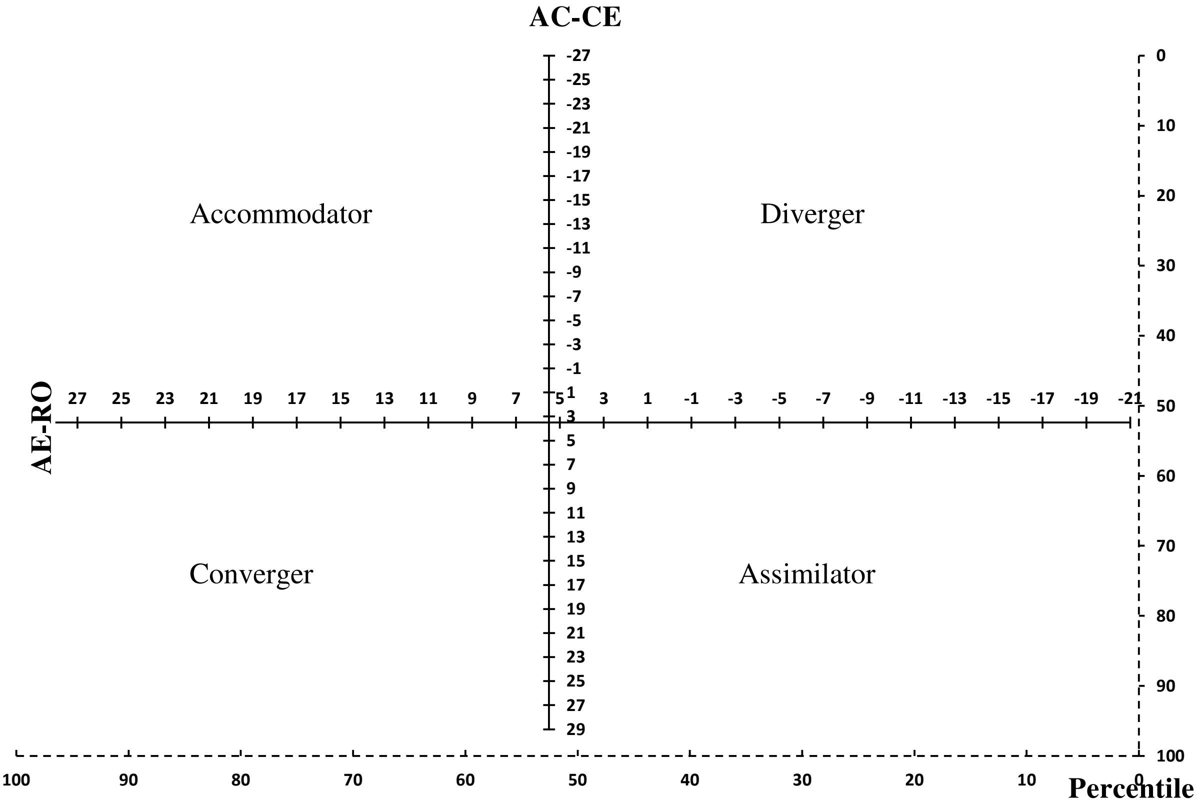


Figure II: Learning styles coordinates

b) *For the analysis of Word Association Test,*

Participants were grouped according to their learning styles and four groups i.e. accommodators, divergers, convergers, and assimilators were formed. For each group, each participant's responses to the stimulus word were examined and a list of different response words with repetition numbers was formed. Hence, frequency tables were prepared. Then concept maps in order to visualize participants' perceptions about their future profession, i.e." engineer", were drawn by using cut-off point technique that was suggested by Bahar, Johnstone and Sutcliffe (1999). According to this technique, a number that is 3-5 lower than the most frequent response to the stimulus word is determined as cut-off point and the map is drawn by using the response words that have bigger frequencies than the determined cut-off point. Then cut-off point is lowered stepwise and hence the map is formed. "Related sentences" were analyzed semantically. Two researchers accomplished the analysis separately and their codings were compared afterwards. An inter-coder agreement of 88%, which shows acceptable reliability of calculations i.e., higher than 70% according to Miles and Hubermans' criterion (Miles, Huberman & Saldana 2014), was calculated. Related sentences were categorized into eight groups. A frequency table for each learning style group was then formed.

3. Results and Discussion

After analysis, participants' learning styles were determined according to KLSI and given in Table I.

Table I: Learning styles of participants

Learning style	Number of participants	Percentage of participants
Assimilators	40	40.4
Accommodators	7	7.1
Divergers	17	17.2
Convergers	35	35.3

According to Table I, it can be said that most of the participants were assimilators (40.4%) that have Abstract Conceptualization (AC) and Reflective Observation (RO) as dominant learning abilities, and convergers (35.3%) that have Abstract Conceptualization (AC) and Active Experimentation (AE) as dominant learning abilities. Participants' response words to the stimulus word were examined and a frequency tables for each learning style group were prepared. Based on these tables number of different response words to the stimulus word by different groups were given in Table II.

Table II: Participants' number of different response words for each learning group

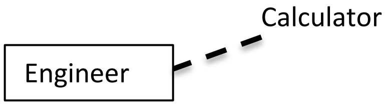
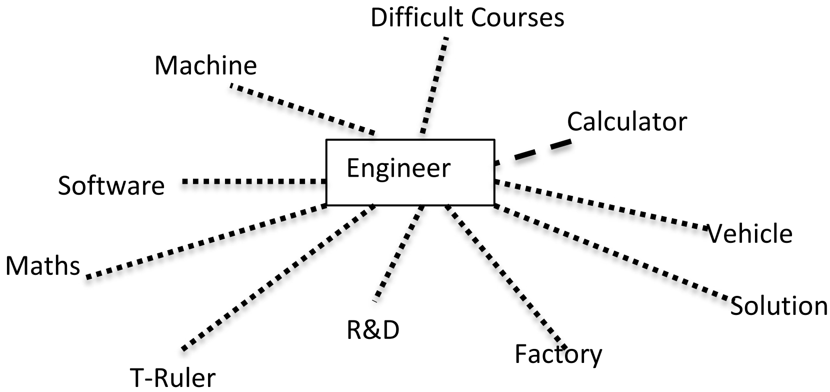
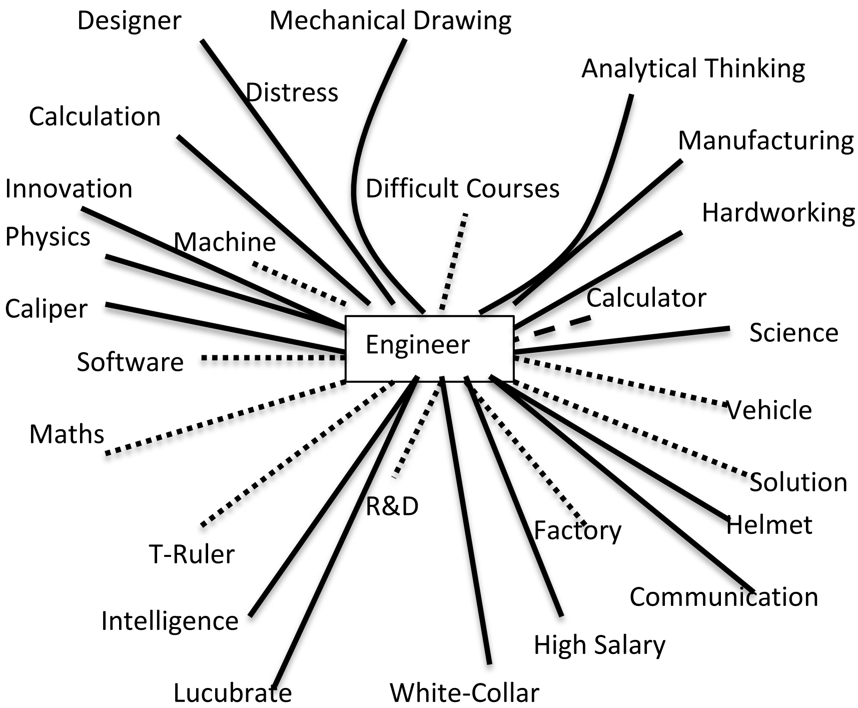
Group	Number of different response words
Assimilators	101 (2.53)
Accommodators	41 (5.86)
Divergers	84 (4.94)
Convergers	135 (3.86)

**Numbers in brackets show the number of different response words per participant*

Number of different response words to a given stimulus word can be a clue about one's conceptualization. If this number increases, it can be said that individual relates the stimulus word with many response words i.e. conceptualized better (Bahar, Johnstone and Sutcliffe 1999). In Table II number of different response words were given as well as the number of different response words per participant in brackets. Since number of participants in each group was different, it would be better to examine the numbers per participant. According to this, accommodators have the best conceptualization for engineer and assimilators have weak conceptualization.

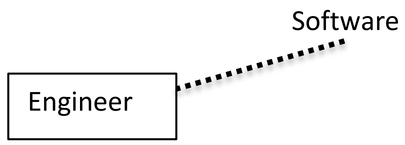
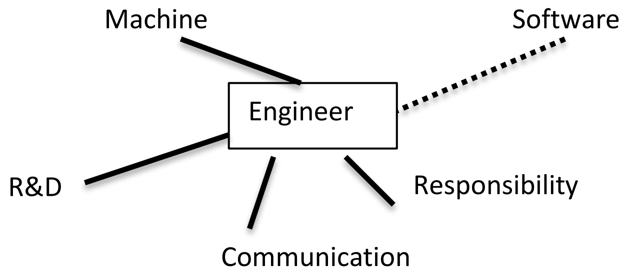
Concept maps for the stimulus word "engineer" were drawn for each learning style group by using cut-off point technique and were given in Table III for assimilators, in Table IV for accommodators, in Table V for divergers, and in Table VI for convergers.

Table III: Concept map of "assimilators"

Cut-off point	**Graph**
20≥CP≥15	
15≥CP≥10	
10≥CP≥5	

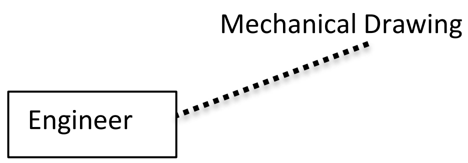
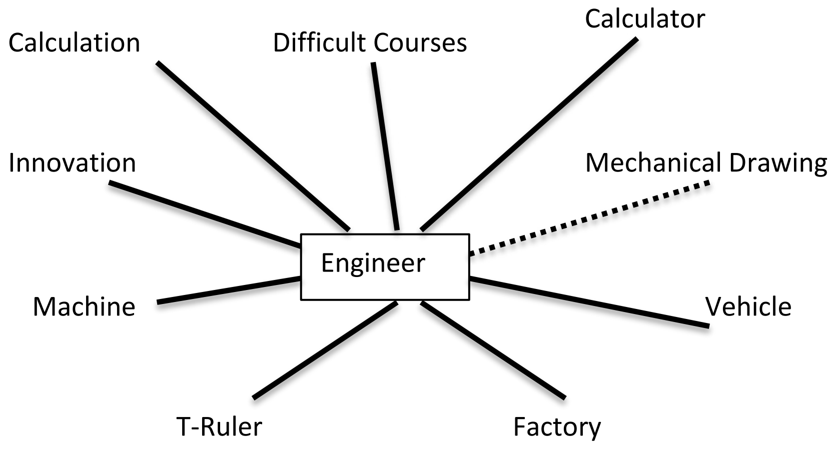
According to Table III, participants in assimilators group related "engineer" with "calculator" most (20≥CP≥15). When cut-off point was lowered to 15≥CP≥10 level many responds words such as "difficult courses", "R&D", "maths" were added to the map. Further relaxation of cut-off point to 10≥ CP≥5 level caused many response words like "analytical thinking", "innovation" to appear.

Table IV: Concept map for "accommodators"

<table>
<tr><th>Cut-off point</th><th>Graph</th></tr>
<tr><td>20≥CP≥15</td><td></td></tr>
<tr><td>15≥CP≥10</td><td>
</td></tr>
<tr><td>10≥CP≥5</td><td>
</td></tr>
</table>

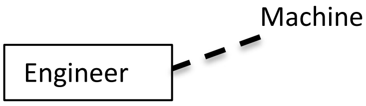
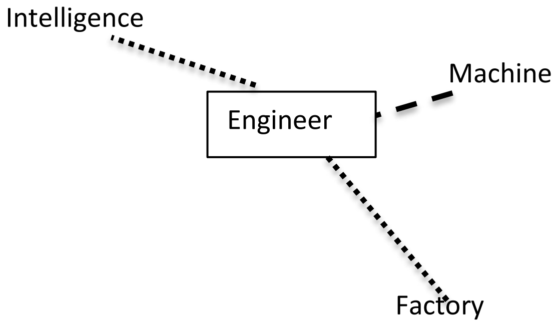
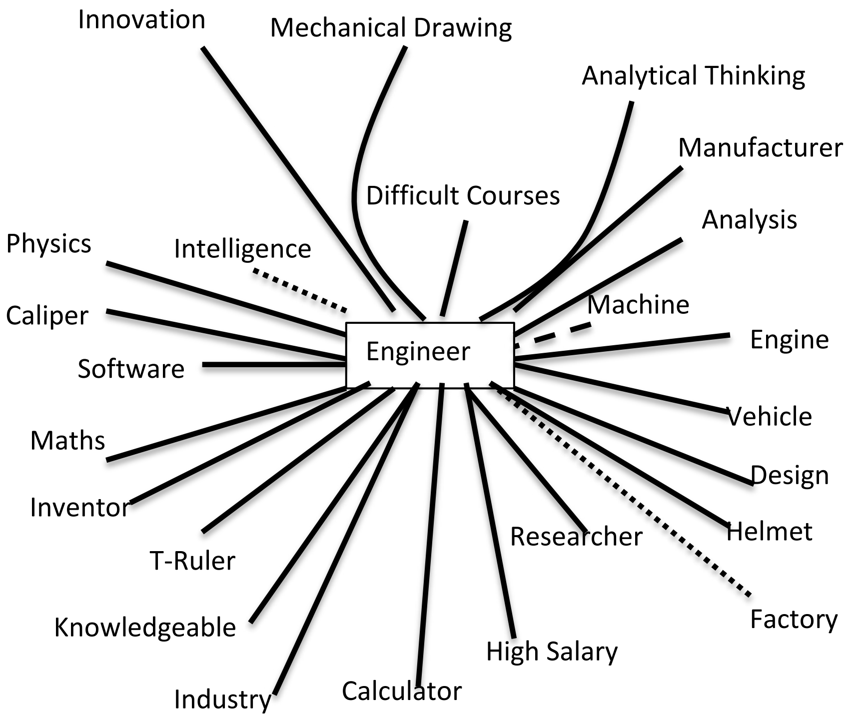
Participants with accommodator learning style related "engineer" with "software" most (Table IV, 15≥CP≥10). When cut-off point relaxed to 10≥CP≥5 level, "machine" and "R&D" were also added to the map.

Table V: Concept map for "divergers"

<table>
<tr><th>Cut-off point</th><th>Graph</th></tr>
<tr><td>20≥CP≥15</td><td></td></tr>
<tr><td>15≥CP≥10</td><td>
</td></tr>
<tr><td>10≥CP≥5</td><td>
</td></tr>
</table>

Participants in divergers group have a conceptualizing for "engineer" with "mechanical drawing" most (Table V, 15≥CP≥10). "Innovation", "factory", and a few more response words showed up at 10≥CP≥5 level.

Table VI: Concept map for "convergers"

Cut-off point	**Graph**
20≥CP≥15	
15≥CP≥10	
10≥CP≥5	

According to Table VI participants with converger learning style related "engineer" with "machine" most (20≥CP≥15). Relaxation of cut-off point to 15≥CP≥10 level lead "intelligence" and "factory" to appear in the map. When cut-off point was lowered to 10≥CP≥5 level many response words such as "analytical thinking", "analysis", "engine", innovation" added to the map.

Participants' related sentences were examined semantically and the findings were given in Table VII.

Table VII: Findings from participants' "related sentences" analysis

	Assimilators	Accommodators	Divergers	Convergers
Sentences that describes engineering	14 (35)	1 (14.3)	13 (37.1)	3 (17.6)
Sentences that give technical information	1 (2.5)	-	1 (2.9)	6 (35.3)
Sentences that stresses abilities to be an engineer	3 (7.5)	-	5 (14.3)	1 (5.9)
Sentences related to workplace	1 (2.5)	3 (42.8)	2 (5.7)	-
Sentences that involves feelings	5 (12.5)	1 (14.3)	6 (17.1)	-
Sentences that relates personal characteristics	9 (22.5)	-	1 (2.9)	2 (11.8)
Sentence about engineering education	2 (5)	-	2 (5.7)	3 (17.6)
Meaningless sentences	5 (12.5)	2 (28.6)	5 (14.3)	2 (11.8)
Total	40 (100)	7 (100)	35 (100)	17 (100)

** Numbers in brackets show percentages.*

It can be said that participants in assimilators (35%) and divergers (37.1%) groups mostly wrote sentences that describe engineering (e.g., "an engineer is a person who thinks analytically, is creative and finds solutions to problems") while participants in accommodators (42.8%) group mostly wrote sentences related to workplace (e.g., engineers may work in dirty places). Majority of participants in convergers group (35.3%) had sentences that give technical information (e.g., engineering means technical drawing, complex calculations, and various software).

4. Conclusion

An individuals' learning style describes the best way that individual attribute a meaning to information. It is unique for each person since someone's genetic background, life experiences, and the demands different from another one (Kolb 1984). Since it is how someone process information it affects how we perceive facts. The process by which a person selects, organizes, and interprets information, and create a meaning is known as perception and it plays an important role on how well someone is doing on something. In this study, learning styles of engineering students was determined and their perception of profession was explored according to their learning styles.

Majority of participants of this study were assimilators (40.4%) and convergers (35.3). According to Kolb (1984), educational specialization is one of the factors that shape individuals' learning styles. There is an increasing specialization in high school and individuals that were educated in similar high schools tend to have similar learning styles. Professional career choice, which exposes someone into a specialized learning environment as well as involving a commitment to a generic professional problem, is another factor that effect someone's learning style. According to studies by using Kolb learning theory, people that have assimilating learning style tend to have professions in sciences and information or research. Convergers tend to have professions in technical fields like medicine and engineering. Hence, this can be the explanation of learning style distribution of participants in this study.

It was found in this study that participants with assimilating learning styles related "calculator" with "engineer" most (20≥CP≥15). They have also responses like "solution", "hardworking", "lucubrate", and "science" which are different from other responses in other learning style groups. As for their related sentences, assimilators wrote mostly sentences that define engineering. These responses and sentences are meaningful since assimilators' greatest strength lies in the ability to create theoretical models (Kolb 1981). Participants in accommodators group who have the opposite strengths from those of the assimilators tend to solve problems in an initiative trial-error method and relying on other people for information rather than their own analytical stability, (Kolb 1981) conceptualized "engineer" with "software" most (15≥CP≥10). There were some responses in their concept map that were different from other groups such as "responsibility", and "communication" and these responses would be expected. Also, their related sentences were mostly about workplaces. As for the participants in divergers group "mechanical drawing" was the most related response for the stimulus word "engineer" (15≥CP≥10). These participants also wrote sentences that define engineering most. Participants in convergers group related "engineer" with "machine" most ((20≥CP≥15). Their different responses from other groups include "vehicle", "engine", "researcher", "industry", and "knowledgeable". From the point that convergers are good at practical application of ideas (Kolb 1981) those responses were definitely meaningful.

Overall it can be concluded that participants with different learning styles have different profession perceptions i.e., learning styles have an effect on perception.

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