

# Determination of Turkish First Robotics Competition (FRC) participants' perceptions towards FRC via metaphors and construction of a novel mind map

Enes Arda ÖZGÜR<sup>1</sup>, Handan ÜREK<sup>2,\*</sup>, Fikrican ÖZGÜR<sup>3</sup>

<sup>1</sup>Robert College, Istanbul, Turkey

<sup>2</sup>Balikesir University, Necatibey Education Faculty, Balikesir, Turkey

<sup>3</sup>Aalborg University, Esbjerg, Denmark

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## Abstract

*In this study, it is aimed to investigate Turkish First Robotics Competition (FRC) participants' perceptions towards the concept of FRC with the help of metaphors and to construct a novel mind map. The study is expected to contribute to FRC research and development studies by presenting local information from the point of Turkey. Also, the study will allow the researchers to compare the findings obtained from Turkey with FRC core values. For this reason, a qualitative study in the design of phenomenology was conducted with 282 Turkish FRC participants in fall, 2018. Data were collected with the help of a questionnaire consisting of two questions. The findings showed that participants mostly perceived FRC as family, school of life and addictive matter. Also, most of the participants mentioned robot and teamwork among their initial responses when they heard the word, FRC. As a result, the study indicated the excitement of Turkish participants towards FRC by relating their perceptions to the FRC core values and philosophy. So, it is thought that establishing cooperation with universities might be beneficial for future studies in Turkey.*

**Keywords:** First Robotics Competition (FRC), Turkish participants, perceptions.

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Enes Arda ÖZGÜR, ozgene.20@robcol.k12.tr, <https://orcid.org/0000-0003-1061-106X>

\* Handan ÜREK, handanurek@balikesir.edu.tr, <https://orcid.org/0000-0002-3593-8547>

Fikrican ÖZGÜR, ozgurfikrican@gmail.com, <https://orcid.org/0000-0003-1323-8539>

# First Robotik Yarışması (FRC) Türkiye katılımcılarının FRC algılarının metaforlar yardımıyla incelenmesi ve özgün bir zihin haritası oluşturulması

## Öz

*Bu çalışmada, First Robotik Yarışması (FRC) Türkiye katılımcılarının FRC kavramıyla ilgili algılarının metaforlar yardımıyla araştırılması ve zihinsel yapılarının özgün bir zihin haritası yardımıyla ortaya çıkarılması amaçlanmıştır. Çalışma ile Türkiye'den elde edilen verilerin literatüre kazandırılması ve FRC araştırma-geliştirme çalışmalarına katkıda bulunulması beklenmektedir. Ayrıca, çalışma sonucunda elde edilen bulguların FRC çekirdek değerleri ile karşılaştırılabilmesi mümkün olacaktır. Bu kapsamda, 282 FRC Türkiye katılımcısı ile 2018 güz döneminde nitel araştırma desenlerinden fenomenoloji deseninde bir araştırma gerçekleştirilmiştir. Çalışmanın verileri, iki sorudan oluşan bir anket ile toplanmıştır. Elde edilen bulgulara göre katılımcıların çoğu FRC'yi aile, hayat okulu ve bağımlılık yapan bir madde şeklinde algılamaktadır. Ayrıca, FRC denildiğinde katılımcıların zihinlerinde beliren ilk kavramlar arasında, robot ve takım çalışması yer almaktadır. Sonuç olarak çalışmadan elde edilen bulgular, katılımcıların FRC'ye karşı ilgisini göstermekte olup ortaya çıkan algıların FRC çekirdek değerleri ve felsefesi ile ilişkili olduğunu göstermektedir. Bu kapsamda, üniversiteler ile yapılacak işbirliklerinin gelecekte ülkemizde yapılacak FRC çalışmaları kapsamında fayda sağlayacağı düşünülmektedir.*

**Anahtar kelimeler:** First Robotik Yarışması (FRC), Türkiye katılımcıları, algılar.

## 1. Introduction

There are interdisciplinary studies which combine science, technology, engineering and mathematics (STEM) outside of the school environments. Those studies carry significance in the education area at pre-university level as there is a growing need for talented young individuals at this respect. Among those studies, For Inspiration and Recognition of Science and Technology (*FIRST*) has started a new trend for young learners. *FIRST* is an international program [1] which was founded in the USA in 1989 and aims to inspire young people's interest and participation in science and technology [2]. The targets of the program include motivating young people to be science and technology leaders by engaging them in exciting mentor-based programs that build science, engineering and technology skills, inspiring innovation and fostering well-rounded life capabilities such as self-confidence, communication and leadership [3].

The program introduces *FIRST* philosophies of *Gracious Professionalism* and *Coopertition* through the *FIRST* Core Values to accomplish the abovementioned targets [1]. Those core values are (i) discovery, (ii) innovation, (iii) impact, (iv) inclusion, (v) teamwork and (vi) fun. *FIRST* combines the excitement of sport with science and technology with its

competitions, FIRST Robotics Competition (FRC) which is one of four different robotics programs for children ranging in age from 6 to 18. FRC is referred as the ultimate Sport for the Mind by *FIRST* [4]. In FRC, teams of students and their mentors work in order to solve a common problem in a six-week period using a standard ‘kit of parts’ and a common set of rules [5]. Teams composed of 12 to 20 students working with a high school teacher and mentors from local universities, professional organizations and/or businesses to build a robot that they use to compete against other teams from the United States [6].

### ***1.1. FRC studies in Turkey***

The reports of FIRST indicate that more than 94,750 participants from 3,790 teams from all over the world participated in FRC in 2018-2019 [7]. When the situation in Turkey is considered, it is seen that the first FRC team, Sultans of Türkiye #2905 was established in 2008-2009, and it led to an increasing number of teams in the following years [8]. Afterwards, Fikret Yüksel Foundation brought the first FRC off-season event to Turkey in December, 2015 and continued to organize it in Istanbul, Turkey every year until 2018-2019. Also, Istanbul held the first official FRC regional tournament for Europe and Turkey in 2017-2018 and held two more official tournaments in 2018-2019. With those supports and organizations, Turkey became the country which has the largest number of teams (80 teams) after the USA and Canada [9]. It might be concluded that FRC is a relatively new concept, but it has an expanding potential in Turkey.

### ***1.2. Related literature***

There are relatively new studies about FRC in the literature. In his study, Oppliger [10] explains how high school students interact with Michigan Technical University engineering students through FRC. The study presents information about FRC and adoption of it into the university’s curriculum as a part of Engineering Enterprise Program. Similarly, in their paper, Wilczynski and Flowers [11] present the current situation related to participation in FRC until 2005. The researchers also discuss a four-step model for engineering educators to follow while implementing FRC related instructions in their institutions. Davis [12] reports experiences of a first-time mentor in FRC. The study gives details about FRC Oklahoma City Regional and intends to make a more detailed analysis about FRC with an ongoing study.

The abovementioned studies deal with FRC from the perspective of students, universities or mentors in a theoretical manner. In another study, Melchior et al. [5] make an evaluation of FRC on account of an agreement between FIRST and Brandeis University. The study provides a detailed evaluation of the effects of FIRST on participants’ academic and career trajectories, on implementation of FIRST in schools as well as on participants’ impact on their schools and partnering organizations with a retrospective approach. The results show that FRC has a positive impact on its participants.

The number of studies related to FRC research is seen to be restricted when compared to the theoretical ones. Griffith [13] investigates potential relationships between high school students’ attitudes and interests in science, technology, engineering and mathematics, and their participation in FRC via pre and post survey questionnaires. According to the study results, significant differences were determined for pre and post attitudes of the students who participated in FIRST robotics programs. Welch and Huffman [14] examine the effect

of FRC on high school students' attitudes towards science in the USA. For this purpose, they make a comparison of high school students' attitudes who participated and who did not participate in FRC. In their study, they investigate scientific attitudes in seven categories. As a result, the students who participated in FRC had more positive attitudes in the dimensions of *Social Implications of Science*, *Normality of Scientists*, *Attitude toward Scientific Inquiry*, and *Adoption of Scientific Attitudes* than the students who did not participate in FRC. On the other hand, no statistical significance was found in the categories of *Enjoyment of Science Lesson*, *Leisure Interest in Science*, and *Career Interest in Science*.

There is also research in the literature which addresses robotics other than FRC. Barker and Ansorge [15] explore the impact of an after-school program, the 4-H robotics, on 9-11 year old students' achievements in science, engineering and technology in the USA. Barak and Zadok [16] investigate the effect of LEGO robotics projects on learning and problem solving processes of the seventh and eighth grade students in Israel within the framework of a robotics course offered to junior high school students. Nugent et al. [17] examine the effect of robotics (LEGO Mindstorms NXT robotics) and geospatial technologies summer camp on middle school students' learning of science, technology, engineering, and mathematics as well as their attitudes towards them in the USA. Whitehead [18] scrutinizes the impact of robotics (Lego NXT Mindstorm Educational Robotic Kit) on high school students' science, technology, engineering and mathematics thoughts, interests and classroom inquiry levels in the USA. In another study, Jaipal-Jamani and Charoula Angeli [19] deal with robotics education from the perspective of elementary preservice teachers in Canada and examine their self-efficacy, understanding of science concepts, and computational thinking as they engaged with LEGO WeDo robotics kits in a science methods course.

It might be stated that research which deals with FRC is limited in the literature. This might be acceptable because FRC is a relatively new and specific concept in the science and technology education field. However, there is a strong need to conduct various research considering different aspects of FRC, such as perceptions of the participants, applications and comparisons among the countries.

### ***1.3. Students' perceptions and science education***

In educational studies, a certain part of the research deals with the perceptions of students related to various concepts. Metaphors are one of the tools that are utilized to investigate students' perceptions. Bezuidenhout [20] explains that, in common view, metaphors are cases in which the speaker literally says one thing but means something else instead. Metaphors reflect personal beliefs, attitudes or feelings about a subject or situation [21]. For instance, several studies deal with the perceptions of teachers or teacher candidates related to technology via metaphors [22-24]. Also, technology was found to be perceived as children and fashion since it had a developing and changing entity [23]. In another study, the metaphorical expressions of science and technology in the press and popular scientific magazines in Greece were investigated, and a number of active, creative metaphors were identified in the articles related to all fields of scientific and technological knowledge [25].

In addition to the determination of the perceptions related to a definite concept, it is required to present collected information in a meaningful way. Graphic organizers assist presentation of information with several techniques. Mind mapping is one of such techniques encountered in constructivist approaches in science education [26]. The researchers state that mind maps represent knowledge by organizing it as a network or other non-linear diagram incorporating verbal and symbolic elements. Budd [27] defines a mind map as “an outline in which the major categories radiate from a central image and lesser categories are portrayed as branches of larger branches”. Usually, the mind maps are prepared by mentioning keywords in same-size shapes, such as in circles, with equal distances to the key concept.

#### ***1.4. Rationale of the Study***

It is necessary to imply that FRC studies bring a new aspect to STEM education all over the world. However, the conducted studies about FRC are seen to deal with the participants in the USA. There is a gap in the research considering the local status of FRC in other participant countries. The fact that there is a lack of FRC related research based studies outside the USA provided significance for the research. For that matter, it is demanded to determine the current situation in Turkey in terms of participants’ perceptions towards FRC. Thus, this paper intends to investigate Turkish FRC participants’ perceptions towards FRC via metaphors. Also, the preceding conceptions of the participants related to FRC are expected to illustrate in the form of a novel mind map by introducing a new conceptual evaluation tool. In this way, the study will allow the researchers to present the mental structures of the participants and interpret it.

The study is expected to make contributions to the literature in two aspects. Firstly, it is expected to provide local information to FRC research and development studies from the point of Turkey. Thus, it will also be possible to compare the study findings with FRC core values, analyze the status of Turkish FRC participants’ perspectives among those values and consider what might be done in order to develop the current status in Turkey. Secondly, the study is believed to carry significance by introducing a new conceptual evaluation tool to the literature. With this tool, it will be feasible to find out the mental structures of the students related to a concept in a relatively easy and quick way for all teachers both in science education and in other branches.

## **2. Method**

### ***2.1. Study model***

In this study, phenomenology from qualitative research designs was utilized. Phenomenology focuses on various phenomena around us about which we do not have a deep understanding although we are aware of them [28]. Phenomenology aims to research those phenomena by collecting data from the individuals who experience and reflect on them.

### ***2.2. Study group***

A total of 282 Turkish FRC participants were involved in the study voluntarily. The participants consisted of 23 FRC Mentors, 25 FRC graduates, 17 FRC volunteers, and 217

active FRC participants.

### **2.3. Data gathering instrument**

Data were collected with the help of a questionnaire consisting of two questions between September and December, 2018. The first question asked FRC participants to build metaphors on FRC. For this question, a blank space was left for the participants to build their metaphors as in the following statement: “I think FRC is like ..... because .....”. By using the word *like*, it was aimed to make an association between the source and the target of the metaphor. By using the word *because*, they were asked to provide *a reason* (or *a logical support*) for their metaphor [29].

The second question asked the participants to write down the first ten words that come to their minds when they hear the word, FRC. The second question was designed in the form of a table with ten blank rows for the participants to write down their answers.

Data gathering instrument was shared on Google Forms on the web to reach as many Turkish FRC participants as possible. Also, the first author of this paper collected data at 2018 Turkish off-season FRC event in İstanbul. The responses given by Turkish FRC participants formed the basis for data source of the study.

### **2.4. Data analysis**

#### **2.4.1. Analysis of the first question (metaphors)**

Responses of the Turkish FRC participants to the first question of the questionnaire were examined with the help of content analysis. The main purpose of conducting content analysis is to reach the concepts and relationships that explain the collected data. The basic process conducted in the content analysis is to gather similar data under definite concepts and themes and to interpret them by organizing in a manner which can be comprehended by the readers [28]. The analyses of the metaphors built by the participants were conducted by considering the following five steps as defined by Saban [30]:

1. Naming: This step included the examination of the questionnaires in order to determine the metaphors attributed to FRC by Turkish FRC participants. The metaphors produced were arranged alphabetically in two separate temporary lists. The reason of the formation of two lists was to control whether the metaphors, collected with the help of the questionnaires, were mentioned by the participants clearly.

2. Elimination and Clarification: In this step, the metaphors given by the participants were clarified by reviewing each of them and divided into temporary groups in terms of the similar and common properties with other metaphors. The target, the source and the relationship between the target and the source of the metaphor were considered while grouping them. As a result of the analysis, it was seen that several participants did not build valid metaphors related to the concept FRC. At this respect, the followings are stated to be *ill structured metaphors* in the literature [31]: (i) Responses which only give definitions, (ii) Responses which do not involve the source of the metaphor, (iii) Responses which mention a definite metaphor without providing the reason (logical support), (iv) Responses which involve characteristics related to several categories, and (v) Illogical metaphors or metaphors which have no contribution to the better comprehension of the

concept of FRC. Such ill-structured metaphor responses (obtained from 27 participants) were omitted from the data set. Therefore, data for metaphors consisted of 255 participants' responses in this study.

3. **Compilation and Categorization:** In this step, valid metaphors built by the participants were again arranged in an alphabetical order. Thus, a list of metaphors was produced. According to this process, 59 valid metaphors were determined to be built by Turkish FRC participants on FRC. Afterwards, those metaphors were divided into categories by considering the relationship between the target and the source of the metaphor. Accordingly, a total of 9 different conceptual categories were constructed about FRC.

4. **Ensuring Validity and Reliability:** In this process, quotations from the responses of Turkish FRC participants to the first question were provided. Metaphors and category lists were discussed with two university teaching staffs in order to prove the accuracy of the steps applied in the analyses and to identify the accuracy of the metaphors and their categories. Accordingly, the teaching staffs were asked to match given metaphors with the categories. Based on the opinions of those area experts, discussions were held on mismatched metaphors (10%) and a final arrangement was reached on the metaphors and their categories.

5. **Transfer of Data to the Computer:** In the final step of the analysis, data were transferred to the computer. The frequencies (f) and percentages (%) of the categories were calculated.

As a result of those steps, collected data for the first question was transformed to indicate 9 main categories and 59 metaphors about the concept of FRC. Those categories were as follows: (i) book, (ii) family, (iii) food, (iv) hobby, (v) independence, (vi) lifestyle, (vii) addictive matter, (viii) love, and (ix) school of life.

While building the main categories, the emphasis on the relation between the target and source made by the participants was taken into consideration. For example, several participants were determined to state that FRC was like honey, cake or skimmings and highlight eating, sating, and tasting in their responses. Hence, the main category for their metaphors was built as *food*. In another category, the students were found to mention the concepts of baby, child or wire for FRC and give the reasons, such as connection, concern, protection and solidarity. Those responses were collected under the main category, *family*. A similar approach was also followed for the construction of other metaphors.

The results of the analysis of metaphors for the concept of FRC are presented in the findings in detail.

#### **2.4.2. Analysis of the second question (the preceding FRC conceptions: construction of the novel mind map)**

The participants' conceptions related to FRC were analyzed with the help of a conceptual evaluation tool introduced by the researchers to present students' perceptions on a novel mind map. In this approach, the participants' responses were displayed in different distances to the central concept on the mind map based on the *priority* of the corresponding response (in which place the response was given). Being closer to the key concept

indicated being mentioned earlier. In addition, circles with different areas were used to demonstrate the *superiority* of the response. A larger circle area signified that more participants had given the corresponding answer. This presentation was based on the calculations made with the help of the codes written by one of the researchers performed with Processing 3.3.7 Software. The codes are given in the Appendix. The following eight steps were considered in the analysis of the second question:

1. An alphabetical order was made for the participants' responses (concepts).
2. The responses ( $f = 19$ ) which were meaningless or not related to FRC were omitted from the analysis.
3. The similar responses were grouped and named with a more comprehensive term considering content analysis [28]. After making groups, 17 main key concepts were determined.
4. The validity and reliability of the mind map was ensured with the following rule set by the researchers: In order for a key concept to be placed in the mind map, it should have been mentioned at least 17 times (1%) among the whole concepts ( $f=1730$ , 100%). So, five different key words were omitted from the study due to the scarcity of their frequencies.
5. The total frequency of the concepts ( $f = 1730$ ) was determined. This value was used in the formation of the area of central circle, FRC TURKEY in the mind map.
6. The frequencies of each of 17 key concepts were determined. The concepts were demonstrated with circles in the mind map. The areas of all circles were calculated considering their ratio with the other circles and the circle of FRC Turkey. The suggested tool allowed making proportions by considering the frequency of the key concept and total frequency ( $f=1730$ ). For example, the frequency of *Robot* was 333 and the frequency of *Safety* was 24. As can be understood, the circle of *Robot* is larger than the circle of *Safety*. In addition, the sum of all the areas of the key concepts' circles is equal to the area of the FRC TURKEY circle.
7. Next, a scoring was made for the order of responses written by the participants beginning from 0 to 9. For example, if the responses were in the order of *robot*, *labor*, *family*, *teamwork*..., they were scored with '0' for robot; '1' for labor; '2' for family, '3' for teamwork.
8. The score obtained for each key concept in the previous step was divided by the frequency of the key concept. This finding determined the distance of the response to the central concept, FRC TURKEY.

After the abovementioned steps, the categories and numerical data were processed with Processing 3.3.7 packet program by writing special codes. As a result of this analysis, a novel mind map was constructed. The key concepts with larger circles meant that they were considered by so many participants. The key concepts closer to the circle of central concept meant that they were the most preceding key concepts among the responses.



The steps mentioned above were designed by the researchers considering the target of the second question. The conceptual evaluation tool introduced in this study is expected to make it possible to investigate students' mental structures easily for other concepts by changing the name and frequency of the responses with the use of the codes given in the Appendix by the teachers all around the world.

### 3. Findings

The findings obtained from the study are presented in two sections below.

#### 3.1. Findings related to the metaphors about FRC

The participants' metaphors about the concept, FRC and their reasons for building those metaphors are presented in Table 1.

Table 1. Participants' metaphors about FRC.

<i>Metaphor (FRC is like ...)</i>	Reason (because ...)	f (%)
<i>BOOK: light, ocean, summer breese</i>	Triggers enthusiasm, brightens dreams, allows you to make discoveries, gives happiness, it is warm	10 (3.92%)
<i>FAMILY: baby, garden, child, dance, robot, chain, wiring harness, wire</i>	Solidarity, cooperation, protection, accord, strong connection, strong as the root of a tree, concerned, well-kept, asks for assistance, endless problems	71 (27.84%)
<i>FOOD: pomegranate, cake, honey, skimmings</i>	You are never sated with it, gives pleasure, it is tasty	27 (10.59%)
<i>HOBBY: game, gazelle, Gemini, lemon, computer game</i>	Makes you happy, makes you feel all the emotions, it is joyful, gives you the opportunity to do your favorite work	22 (8.63%)
<i>INDEPENDENCE: democracy, cloud, water</i>	Allows you to live independently, clean, limpid, fair	6 (2.35%)
<i>LIFESTYLE: life, universe, way of thinking, future</i>	Shapes life, reality, interaction, dream, knows its desires	12 (4.71%)
<i>ADDICTIVE MATTER: Chewing gum, cigarette, drug, sex, pill, raki</i>	Makes addiction, attracts, you want more of it as it attracts, you cannot give it up, delightful, passionate	33 (12.94%)

Table 1. (Continued).

<i>LOVE: rollercoaster, enthusiasm, passion</i>	Unrequited emotions, being out of expectation, unstable, unable to give it up, bringing together, makes you gain sensitivity	16 (6.27%)
<i>SCHOOL OF LIFE: life, fair, stock market, business life, surprise, party, scene, show, fairground area, contest</i>	Multidimensional, prepares for life, team spirit, full of surprises, requires creativity, entertaining, represents opportunity, teaches, teaches new information, teaches while entertaining, colorful, full of competition, develops strategy, involves a range of experience	58 (22.75%)
<i>Total</i>		255 (100.00%)

According to Table 1, the participants were found to build 9 main metaphors about FRC. In Table 1, main metaphors are demonstrated in the left column with capital letters. The other words written next to those metaphors are other metaphors related to the main category. In the table, the second column gives the reasons of the students for the corresponding metaphor. Several examples from participants' responses were presented to support the metaphor determined in the left column. Finally, the third column gives the frequency and percentage of the main metaphor. For instance, 58 participants that corresponds to 22.75% of the participants stated "FRC is like school of life because it prepares for life or it is full of surprises or it involves a range of experience...". In the study, 9 main metaphors built by the students in the order of descending frequency are as follows: *family, school of life, addictive matter, food, hobby, love, lifestyle, book and independence*.

### 3.2. Findings related to the preceding FRC conceptions

Descriptive statistics results related to the preceding conceptions of the participants about FRC are shown in Table 2. According to Table 2, participants provided 1730 words when they heard the word, FRC.

Table 2. Descriptive statistics of the participants' preceding FRC conceptions.

<i>Participants (f, %)</i>	<i>Words entered (f)</i>
52 (18.44%)	10
48 (17.02%)	9
30 (10.64%)	8
32 (11.35%)	7
9 (3.19%)	6
14 (4.96%)	5

Table 2. (Continued).

16 (5.67%)	4
23 (8.16%)	3
18 (6.38%)	2
21 (7.45 %)	1
19 (6.74%)	0
282 (100.0%)	1730

As can be seen in Table 2, 52 participants (18.44%) wrote down the first 10 words that came to their minds when they heard the word FRC as requested. On the other hand, 19 participants (6.74%) did not provide any data for the study.

When the preceding FRC conceptions of the participants were analyzed with content analysis, they were summarized with 17 key words, as shown in Table 3. Table 3 also introduces the numerical values obtained from Processing 3.3.7 packet program; providing the circle area and the distance of the participants' concepts to the central concept, FRC TURKEY.

Table 3. The preceding FRC conceptions of the participants.

<i>Key Words</i>	Frequency (Circle Area)	Ranking Score (Distance)
1. <i>Award, Success</i>	44	4.06
2. <i>Competition</i>	93	3.40
3. <i>Community Service</i>	18	2.60
4. <i>Effort</i>	78	2.58
5. <i>Experience</i>	31	5.14
6. <i>Family</i>	57	2.21
7. <i>Friendship</i>	147	3.43
8. <i>Future</i>	47	4.28
9. <i>Fun</i>	202	3.18
10. <i>Gracious Professionalism</i>	195	3.12
11. <i>Innovation</i>	78	4.35

Table 3. (Continued).

12. Programming	69	2.86
13. Robot	333	2.56
14. Safety	24	4.38
15. Sponsorship	27	4.40
16. STEM	117	3.32
17. Teamwork	170	2.78

The responses which were summarized in Table 3 with their relative frequency and distance calculations gave rise to the construction of a novel mind map as demonstrated in Figure 1 with the utilization of the suggested conceptual evaluation tool.

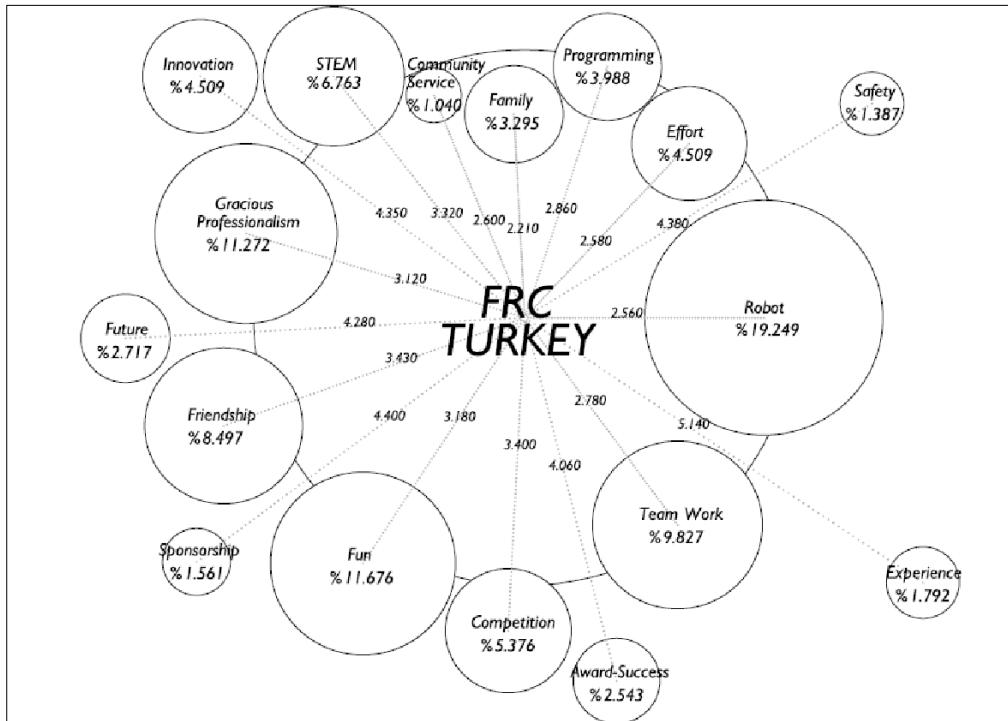


Figure 1. The novel mind map showing participants’ preceding FRC conceptions.

According to Figure 1, there are circles with different areas and different distances to the central circle, FRC TURKEY on the mind map. The area of FRC TURKEY circle is the sum of all circle areas on the mind map. In this way, a visual representation of the weight of each key concept among the others is obtained. Circle areas are directly proportional to their frequency. Additionally, the distance between the center of the circle, FRC TURKEY and the center of each key concept’s circle indicate the priority of the corresponding key concept among the responses of the participants.

To make it more clear, *experience* was given by a relatively less number of participants in the lower rankings (its area constitutes 1.79% of the central circle; the distance was calculated to be 5.14) whereas *robot* was mentioned by more participants in higher rankings (its area constitutes 19.25% of the main circle; its distance was calculated to be 2.56).

In Figure 1, the order of the concepts from the closest to the most distant one to the central concept can be listed as follows: *Family, robot, effort, community service, teamwork, programming, gracious professionalism, fun, stem, competition, friendship, award/success, future, innovation, safety, sponsorship and experience*. The order of the concepts from the most frequent to the least frequent one is as follows: *Robot, fun, gracious professionalism, teamwork, friendship, stem, competition, effort, innovation, programming, family, future, award/success, experience, sponsorship, safety and community service*.

#### 4. Discussion and conclusion

The present study depicts the perceptions of Turkish FRC participants related to the concept of FRC with the use of metaphors and a novel mind map. At this respect, the study also introduces a different approach related to the evaluation of FRC studies present in the literature [5]. Besides, the study is expected to contribute to the evaluation of FIRST in terms of a local perspective outside the USA [13-14].

When the metaphors built by the participants are investigated, the most frequent metaphor in the study indicates that the participants consider FRC as their *family*. The family metaphor shows parallelism with what has been reported by Melchior et al. [5], indicating that most of the participants mentioned the sense of belonging to their team. The present study also shows that the participants refer to FRC as *school of life*. That metaphor supports the findings stating that pupils are likely to benefit from informal instructions on the concepts in science and technology received through project-based programs such as Lego Mindstorm environment [16] and 4-H robotics [15]. The other metaphors (*addictive matter, hobby, love, food, book*) indicate that they like FRC and enjoy it very much. This result is also consistent with the literature which indicates the excitement and interest of the participants in robotics studies other than FRC [17-19]. The metaphor, *lifestyle*, means that the participants adapt FRC to their lives and they esteem it very much. The last metaphor, *independence*, might show that FRC meets self-actualization needs of the participants which they cannot fulfill in the regular school environments as pointed out by Maslow [32].

Similar to the metaphors, the preceding FRC conceptions of the participants allow the researchers to comprehend participants' point of view towards FRC. However, they have a different function in the study considering the most frequently stated concepts (superiority of the concepts) and the preceding concepts (priority of the concepts). Those outcomes are important for future FRC studies in Turkey.

Among the preceding concepts of the participants, *family* is also encountered within the metaphors. Thus, it might be asserted that the participants feel confident during their FRC activities as they feel a sense of belonging. Also, the concepts of participants like *friendship, teamwork, family and fun* show similarity with the finding of Welch and

Huffman's [14] study which determine a significant difference in FRC participating students' attitudes in terms of social implications of science. This finding also shows consistency with the positive social results of Melchior et al.'s [5] report.

Among the preceding concepts of Turkish FRC participants, the concepts of *innovation*, *fun* and *teamwork* directly match with the core values of FIRST [1]. In addition, the concepts, *competition* and *Gracious Professionalism* indicate that participants have gained the philosophy of FIRST. Besides, the concepts of *programming*, *robot* and *STEM* might be related to the core value, *discovery*. The concept of *future* might be related to the core value, *impact* as technological inventions signify a better life for future and *safety* might be related to *inclusion* as teamwork requires collaborative work in a peaceful and friendly environment.

In the novel mind map, several concepts are seen to be relatively small and away from the central concept, FRC TURKEY. Those concepts can be listed as *future*, *experience*, *sponsorship*, *safety* and *innovation*. Participants were found to mention these concepts less and among their final responses. The reason of this situation might stem from the fact that FRC is relatively new in Turkey. To begin, *innovation* is a relatively new concept for Turkish society. Besides, there are insufficiencies in Turkish research and development studies. Additionally, the less frequency of the concept of *experience* might indicate that the participants consider FRC as a significant step in their lives instead of an ordinary experience. For the concept of *sponsorship*, it might be asserted that technological studies are not given sufficient value in Turkey for FRC which might be associated with the cultural background. Another concept, *safety* is unfortunately observed to be ignored in Turkish society. The severity of the concept of *future* might be related to fewer amounts of people who have been aware of FIRST. However, it is gladsome that young learners show a growing interest and participation in FRC studies as the reports highlight Turkey's place in the worldwide [9].

When the findings obtained from both parts of the study are evaluated together, the participants' perceptions are seen to support each other in their metaphors and preceding concepts. For instance, the most frequent metaphor for the concept of FRC is *family*. Also, *family* is the concept considered by the students in the first place when they heard FRC. Those perceptions totally match with each other. The second most frequent metaphor built by the participants for FRC is *school of life*. The participants were also found to indicate *fun* in the second place among their preceding concepts for FRC. Those findings might show that the participants perceive this program like a different kind of school and they enjoy it very much. On the other hand, while the concept of *community service* was stated among the initial places, it was considered by few participants. In another words, it is the least frequently mentioned concept for FRC. In parallel, no metaphor was detected related to this concept among the participants' responses. It might be asserted that such concepts should be addressed in the future research and development studies in detail.

In sum, it could be stated that Turkish FRC participants possess positive perceptions towards FRC. This result might be concluded to be parallel with Welch's [6] and Griffith's [13] studies. Also, the present study indicates that participants' concepts seem to match with the core values and philosophy of FIRST [1]. Thus, it might be concluded that FRC

has positive effects on Turkish participants. On the other hand, it is realized that several aspects (the concepts of *future*, *experience*, *sponsorship*, *safety* and *innovation*) are required to be supported more in order to supply a steady improvement towards a true absorption of FIRST values via FRC. Therefore, it can be concluded that Turkish young learners should continue to be supported for FRC related activities in a global manner as presence of many obstacles to success at FRC are mentioned by Oppliger [10].

As a recommendation, it is thought that establishing cooperation with universities might be beneficial for considering the forthcoming studies in Turkey as they constitute an important part [11]. Also, it is suggested to conduct various research related to the impact of FRC activities on Turkish participants' academic achievements and scientific attitudes in the future. Finally, the conceptual evaluation tool introduced in the present study is thought to be utilized for the investigation of other concepts or comparison of the same concept among different samples.

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#### Appendix. Processing Program for Visualizing a Novel Mind Map

```
1. import processing.pdf.*;
2. float LengthScale = 9.78;
3. float AreaScale = 160;
4. int number = 17;
5. float TotalWeight = 0;
6. float[] radius = { 2.56, 4.38, 2.58, 2.86, 2.21, 2.6, 3.32, 4.35, 3.12, 4.28, 3.43,
7. 4.4, 3.18, 3.4, 4.06, 2.78, 5.14};
8. float[] weight = { 333, 24, 78, 69, 57, 18, 117, 78, 195, 47, 147, 27, 202, 93, 44,
9. 170, 31};
10. String[] keyword = { "Robot", "Safety", "Effort", "Programming", "Family", "Community
Service", "STEM", "Innovation", "Gracious Professionalism", "Future", "Friendship",
11. "Sponsorship", "Fun", "Competition", "Award-Success", "Team Work", "Experience"};
12. float[] percentage = new float[number];
13. float degree = 360/number;
14.
15. void setup()
16. {
17. beginRecord(PDF, "FRCMindMap.pdf");
18. fullScreen();
19. background(255);
20. PFont normalItalic = createFont("GillSans-Italic", 100);
21. textFont(normalItalic);
22. translate(width/2, height/2-52);
23. float totalWeight = 0;
24. for (int i = 0; i < number; i = i+1)
25. {
26. totalWeight += weight[i];
27. }
28. fill(255);
29. ellipse(0, 0, 2*sqrt(AreaScale*totalWeight/PI), 2*sqrt(AreaScale*totalWeight/PI));
30. float [] nextDegree2 = { 0, 32, 47, 72, 93, 112, 128, 143, 163, 183, 200, 217, 237,
31. 267, 284, 306, 326};
32. float nextDegree = 0;
33. for (int i = 0; i < number; i = i+1)
34. {
```

```

35.  bubble(radius[i], nextDegree2[i], weight[i], keyword[i], i, percentage[i]);
36.  nextDegree += degree;
37.  percentage[i] = ( weight[i] / totalWeight ) * 100;
38.  }
39.  printAll();
40.  endRecord();
41.  }
42.
43. void bubble(float radius, float degree, float weight, String keyword, int i, float percentage){
44.  float r = 1000*radius;
45.  float theta = -PI*degree/180;
46.  float area = weight;
47.  float x = (r) * cos(theta);
48.  float y = (r) * sin(theta);
49.  fill(255);
50.  ellipse( x/LengthScale, y/LengthScale, 2*sqrt(AreaScale*area/PI), 2*sqrt(AreaScale*area/PI));
51.  textSize(20);
52.  fill(155);
53.  fill(0);
54.  stroke(180);
55.  for(i = 0; i < 80; i = i+1)
56.  {
57.  ellipse((x/LengthScale)*(i+1)/80,(y/LengthScale)*(i+1)/80,1,1);
58.  }
59.  textSize(16);
60.  fill(0);
61.  text(radius, (x/LengthScale)*2.1/5-20, (y/LengthScale)*2.1/5);
62.  stroke(0);
63.  }
64. void printAll()
65. {
66.  textSize(52);
67.  fill(0);
68.  text("FRC", -50, 0);
69.  text("TURKEY", -95, 42);
70.
71.  textSize(20);
72.  fill(0);
73.
74.  text("Robot", 240, -25,160,200);
75.  text("%", 230, 20);
76.  text(percentage[0], 240, 20);
77.
78.  text("Safety", 360, -265,160,200);
79.  text("%", 350, -220);
80.  text(percentage[1], 360, -220);
81.
82.  text("Effort", 155, -220,160,200);
83.  text("%", 145, -175);
84.  text(percentage[2], 155, -175);
85.
86.  text("Programming", 42, -305,160,200);
87.  text("%", 55, -260);
88.  text(percentage[3],65, -260);
89.
90.  text("Family", -40, -255,160,200);

```

```
91. text("%", -45, -210);
92. text(percentage[4], -35, -210);
93.
94. text("Community ", -130, -295,170,200);
95. text("Service", -130, -275,170,200);
96. text("%", -130, -230);
97. text(percentage[5], -120, -230);
98.
99. text("STEM", -230, -295,170,200);
100.text("%", -240, -255);
101.text(percentage[6], -230, -255);
102.
103. text("Innovation", -397, -295,170,200);
104. text("%", -390, -250);
105. text(percentage[7], -380, -250);
106.
107. text("Gracious", -340, -140,170,200);
108. text("Professionalism", -360, -120,170,200);
109. text("%", -350, -75);
110. text(percentage[8], -340, -75);
111.
112. text("Future", -460, 0,170,200);
113. text("%", -470, 45);
114. text(percentage[9], -460, 45);
115.
116. text("Friendship", -370, 95,170,200);
117. text("%", -370, 140);
118. text(percentage[10], -360, 140);
119.
120. text("Sponsorship", -402, 245,170,200);
121. text("%", -390, 290);
122. text(percentage[11], -380, 290);
123.
124. text("Fun", -195, 250,170,200);
125. text("%", -215, 295);
126. text(percentage[12], -205, 295);
127.
128. text("Competition", -60, 325,170,200);
129. text("%", -50, 370);
130. text(percentage[13], -40, 370);
131.
132. text("Award-Success", 50, 380,170,200);
133. text("%", 70, 425);
134. text(percentage[14], 80, 425);
135.
136. text("Team Work", 125, 205,170,200);
137. text("%", 135, 250);
138. text(percentage[15], 145, 250);
139.
140. text("Experience", 395, 270,170,200);
141. text("%", 405, 315);
142. text(percentage[16], 415, 315);
143. }
144.
```