Determination of Elementary Prospective Teachers' Perceptions of Some Basic Physics Concepts by Word Association Test

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Abstract
The purpose of this study is to determine perceptions of elementary prospective teachers about the basic concepts of physics including force, motion, speed, velocity, acceleration and displacement. This research, as a qualitative study, had a study group that constitutes of 35 elementary prospective teachers who successfully completed general physics courses. A word association test was used as the data collection tool. In the word association test, elementary prospective teachers were asked to write down the first five words/concepts they thought of regarding the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" in the first stage, in the second stage they have been asked to write the sentences regarding these concepts. A frequency table was formed with the words/concepts that the prospective teachers associated with the key concepts, cutoff points were determined based on these data, and conceptual networks that reflected their perceptions were drawn. Prospective teachers' sentences for key concepts were analyzed by using content analysis method. The findings showed that the participants associated the key concepts mostly with the concepts of distance, time, velocity, force, energy, motion, friction, power, car, physics, displacement, acceleration and speed. Additionally, it was observed that a significant part of the sentences formed by the participants was scientifically acceptable, while the participants also formed similar sentences that contained emotional and unscientific expressions.
Keywords: Basic physics concepts, elementary prospective teacher, word association test.

INTRODUCTION

Several studies showed that students have various alternative concepts for concepts of physics that are abstract, and they even had difficulty in learning (Aydoğan, Güneş & Gülçiçek, 2003; Clement, 1982; Çepni, 1998; Eryılmaz, 2002; Gilbert, Watts & Osborne, 1982; Trumper & Gorsky, 1996). Additionally, considering the position of basic physics concepts in different disciplines and their role in real life, the significance of teaching activities about these concepts may be seen very clearly. Students encounter basic physics concepts such as force, motion, speed, velocity, acceleration and displacement in certain periods of time in all education levels from primary school to university. This is why it is important that these concepts are understood correctly.

It is seen that several studies have been conducted on how these concepts are perceived, and such studies aimed to determine participants' levels of understanding these concepts and related concepts and reveal and eliminate the alternative concepts participants may have (Bayraktar, 2009; Borghi, DeAmbrosis & Massara, 1993; Demir, Uzoğlu & Büyükkasap, 2012;

Eryılmaz & Tatlı, 2000; Eryılmaz, 2002; Kuru & Güneş, 2005; Maloney, 1984; Nuhoğlu, 2008; Öztuna-Kaplan, Yılmazlar & Çorapçıgil, 2014; Rosenquist & McDermott, 1987; Rosenblatt & Heckler, 2011; Rosenblatt, Sayre & Heckler, 2008; Trumper & Gorsky, 1996; Yıldız & Büyükkasap, 2006; Yıldız, Büyükkasap, Erkol & Dikel, 2007; Yıldız, Büyükkasap & Günel, 2011; Yıldız, 2017). It was reported that participants on different educational levels usually had alternative concepts for mechanics' terms and subjects. Clement (1982) determined that students formed the relationship among velocity, motion and force as that a motion that is going on at constant velocity may be facilitated by a force in the direction of the motion, and that force can increase velocity. The students associated displacement and velocity as "*if two objects have the same displacement, they have the same velocity,*" they associated velocity and acceleration as "*if two objects have the same velocity, they have the same acceleration*," and the associated force and velocity as "*there is a linear relationship*" (Rosenquist & McDermott, 1987; Bayraktar, 2009). Dall'Alba, Walsh, Bowden, Martin, Masters, Ramsden and Stephanou (1993) investigated students' understanding of the concept of acceleration, and found that students who explained the concept utilized the concepts of velocity and force in these explanations. Eryılmaz and Tatlı (2000) found that university students thought there is force where there is motion, and force is directly proportional to velocity instead of acceleration. Kuru and Güneş (2005) determined that, in their responses to questions, high school students tried to make associations between acceleration and motion (*e.g., the direction of an object's acceleration is always in the direction of its motion*), force and motion (*e.g., if an object is moving, there are forces that act on it in the direction of its motion*), force and velocity (*e.g., the total force that acts on an object becomes zero, the velocity of the object decreases*) and force and displacement (*e.g., the amount of motion is in direct proportion to the amount of force*) and these associations usually contained alternative concepts. Yıldız and Büyükkasap (2006) revealed undergraduate students of physics and physics teacher students had thoughts such as that only living objects can apply force and inanimate objects (like a table) cannot. Yıldız and et al. (2007) stated that prospective science teachers found it difficult to associate velocity and speed and understand the difference between displacement and distance, and made explanations that contained alternative concepts such as "*velocity is the unit of speed*." Rosenblatt, Sayre and Heckler (2008) revealed that students made associations among the concepts of force, velocity and acceleration as "*velocity affects force more than force affects velocity*" and "*force affects velocity more than acceleration does*." Rosenblatt and Heckler (2011) found that the students who answered the questions that were related to the relationship between force and velocity, also provided wrong answers for the questions related to the relationship between velocity and acceleration. Öztuna-Kaplan, Yılmazlar and Çorapçıgil (2014) determined that undergraduate physics students confused the concepts of velocity and speed, stated there may be speed if there is force, had alternative concepts for the concepts in question and they made the association between acceleration and velocity. Considering the findings and results of these studies, it may be seen that the relationship/relationships among the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" was/were not studied sufficiently.

Learning is a product of the interaction between the concepts present in the individual's mind and those that are introduced newly (Çepni et al., 2005). Kurt and Ekici (2013b) stated that students form conceptual construct towards concepts that they thought to be meaningful in their own cognitive structures but are actually not really related to scientific knowledge. It was also stated that, just as students, teachers and prospective teachers also had opinions that were different from scientifically accepted facts (Demirçalı, 2006; Kerr, Beggs & Murphy, 2006; Soner, 2006; Zeybek, 2007; cited in Yıldız, 2008). Based on studies, it is known that it is difficult to eliminate alternative concepts that individuals may have, existence of alternative concepts obstructs meaningful learning, and even leads to formation of new alternative concepts

(Clement, 1982; McDermot, 2001; Yağbasan & Gülçiçek, 2003; Yıldız et al., 2007). It was reported that concepts or pieces of information that are not learned correctly affect the future academic lives of individuals, and may lead them to face much greater problems in understanding and comprehension in their daily and professional life (Schulte, 2001; cited in Töman & Odabaşı-Çimer, 2011; Töman, Karataş & Odabaşı-Çimer, 2013). Likewise, Kaya (2010) also stated that concepts that are not learned correctly, those that are misunderstood or those that are incomplete will make it difficult for prospective teachers to lead their professional life in the future as they will make it difficult to understand some subjects in their field, they may lead to misunderstandings in their students, and therefore, they may affect the academic success of students in sciences and their interest in such courses will decrease. Bradley and Mosimege (1998) stated that misunderstandings of prospective teachers may lead to misunderstandings in their students through their daily in-class interactions in teaching processes. Hence, it is highly important to determine how prospective teachers perceive the basic physics concepts that are encountered in daily life and faced by students from primary school to university such as force, motion, speed, velocity, acceleration and displacement, and reveal their perceptions towards the concepts in their minds.

The purpose of this study was to determine perceptions of elementary prospective teachers on the physics concepts force, motion, speed, velocity, acceleration and displacement using a word association test. This way, it will be possible to reveal how the prospective teachers constructed the basic physics concepts in their minds.

METHOD

In this qualitative study, case study method was used. Case study is a method of research that studies a current phenomenon in its real-life framework which is used when the borders among the researcher, phenomenon and context are not clearly set and there are more than one source of evidence or data (Yin, 1994). Creswell (2009) described case studies as a type of inquiry where a researcher conducts an in-depth investigation of an activity, event, process, one or more persons. According to Gökçek (2009), case studies are a way of looking at what happens in the actual setting, systematically collecting and analyzing data and revealing results, while their product is the clarified understanding of why the case is so and what should be focused on in more detail for future research. Case studies focus on a phenomenon, even, situation, individual or group and aim to investigate these in detail (Ekiz, 2009; Yıldırım & Şimşek, 2011; Yin, 1994).

Participants

The participants consisted of 35 elementary prospective teachers who successfully completed general physics course at a state university in the Eastern Black Sea Region in Turkey.

Data Collection

A word association test was used to determine the participants' perceptions towards the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement". Word association test is one of the techniques used to assess conceptual constructs in addition to determining psychological and sociological beliefs and attitudes (Hovardas & Korfiatis, 2006). Word association test is alternative techniques of measurement and assessment that allow revelation of the cognitive structure by facilitating assessment of the networks of knowledge in the minds of individuals, the structure of the connections among concepts that form the networks, and whether these connections and meaningful or not, in the framework of a key concept or concepts (Bahar, Johnstone & Sutcliffe, 1999; Bahar & Özatlı, 2003; Ercan, Taşdere

& Ercan, 2010; Kaya & Taşdere, 2016). This technique is based on the assumption of responding independently in association with the stimulant word without limiting the ideas that come to mind (Bahar et al., 1999; Sato & James, 1999). Using the word association test, students' cognitive structures can be determined and their alternative concepts can be found.

It is seen in the literature that word association test was often used to reveal cognitive structures of participants, determine their alternative concepts, find their conceptual changes and reveal their perceptions (Ercan, Taşdere & Ercan, 2010; Kaya & Taşdere, 2016; Kurt & Ekici, 2013a, 2013b; Özata-Yücel & Özkan, 2014, 2015, 2016; Paliç-Şadoğlu, 2016).

In the word association test, each of the concepts of "force", "motion", "velocity", "speed", "acceleration" and "displacement" was given separately as one stimulant word as seen below.

Force-1:……	*Motion -1:……*	*Velocity-1:….*	*Speed-1:……*	*Acceleration-1:…*	*Displacement-1:…..*
Force-2:……	*Motion -2:……*	*Velocity-2:….*	*Speed-2:……*	*Acceleration-2:…*	*Displacement-2:…..*
Force-3:……	*Motion -3:……*	*Velocity-3:….*	*Speed-3:……*	*Acceleration-3:…*	*Displacement-3:…..*
Force-4:……	*Motion -4:……*	*Velocity-4:….*	*Speed-4:……*	*Acceleration-4:…*	*Displacement-4:…..*
Force-5:……	*Motion -5:……*	*Velocity-5:….*	*Speed-5:……*	*Acceleration-5:…*	*Displacement-5:…..*
Word 1:……..	*Word 1:……..*	*Word 1:……..*	*Word 1:……..*	*Word 1:……..*	*Word 1:……..*
Word 2:……..	*Word 2:……..*	*Word 2:……..*	*Word 2:……..*	*Word 2:……..*	*Word 2:……..*
Word 3:……..	*Word 3:……..*	*Word 3:……..*	*Word 3:……..*	*Word 3:……..*	*Word 3:……..*

As word association tests require the participants to write down the concepts that are brought to mind by the stimulant world in a certain time interval (Gussarsky & Gorodetsky, 1990), this study asked the prospective teachers to write down the first five words that came to their mind about each of the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" in 30 seconds. In the second state, they were asked to write down at least 3 sentences related to the concepts that they wrote down about each of the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement".

Analysis of the Data

A frequency table was formed based on the words and concepts that the participants associated with the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" in the first stage of the word association test. Cutoff points were determined based on these data, and conceptual networks that revealed the perceptions of the participants were drawn. In order to reveal the relationships among the concepts clearly, the study used the cutoff point technique developed by Bahar et al. (1999) to create the conceptual network. In this technique, for any key concept involved in the word association test, the answer given most often is used as a cut-off point. The answers above this frequency are written in the first part of the conceptual network. The cutoff point is then pulled down at regular intervals and the process continues until all the keywords appear in the conceptual network. This means the concepts that appear in each cutoff point interval are repeated as many as the number of students in that interval.

The sentences written down by the prospective teachers in relation to the concepts they associated with the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" were organized for analysis by utilizing the categories developed by Özata-Yücel and Özkan (2015).

- The category "information containing scientific expressions" included the scientifically accurate sentences the participants formed. Example: *"force provides an object with motion or we move objects by applying force on them."*

- The category "information containing emotional expressions" contained sentences that reflected the emotions and opinions of the participants which involved meanings of previous experience or tradition. Example: "*The child was moving so much that he brought down the museum.*"
- The category "information containing superficial expressions or daily examples of daily life" contained sentences that are used in daily life and language which did not have a scientific meaning. Example: "*Objects may be moving or stationary*".
- The category "information containing non-scientific or alternative concepts" contained sentences where the participants tried to assign scientific meanings to the key concept but responded by associating this concept by concepts that have different meanings or are unrelated. Example: *"Force is the power that acts on an object, gives it motion, changes the position or shape of the object."*

In the scope of reliability studies during the data analysis process, a researcher determined the cutoff points by considering the words and concepts that the participants associated with the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement", and conceptual networks that revealed the perceptions of the participants were drawn. The analysis that followed was checked and repeated by the other researcher, and necessary adjustments were made. Similarly, in the second stage of analysis, categorization of the sentences regarding the concepts of "force", "motion", "speed", "velocity", "acceleration" and "displacement" by the method developed by Özata-Yücel and Özkan (2015) and adapted by the researchers was carried out separately by both the researchers. In order to determine the level of agreement in data analysis, the study used the agreement percentage formula developed by Miles and Huberman (1994) [agreement percentage= agreement / (agreement + disagreement)]. The agreement percentages were 88% for "force", 89% for "motion", 81% for "speed", 81% for "velocity", 85% for "acceleration" and 86% for "displacement". Additionally, in order to achieve validity of the results reached in the study, attention was paid to provide as much raw data as possible in the findings section.

FINDINGS

Table 1 shows the frequencies of the words/concepts that elementary prospective teachers express for basic physics concepts.

Table 1. *The words that elementary prospective teachers express towards key concepts*

Key concepts													
Answers	F	M	S	V	A	D	Answers	F	M	S	V	A	D
a (symbol)	-	-	-	-	10	-	Move from point A to B	-	2	1	-	-	1
Acceleration	6	5	5	3	-	4	Muscle	2	-	-	-	-	-
Accelerator pedal	-	-	1	-	-	-	Newton	12	1	-	-	-	-
Accelerometer	-	-	-	-	3	-	Noncontact	1	-	-	-	-	-
Action	8	1	-	-	-	-	Obstacle	-	-	-	-	1	-
Airplane	-	-	-	1	-	-	Opposite direction (positive and negative)	-	-	-	-	3	-
Average velocity	-	-	3	1	-	-	Orbit	-	1	-	-	-	-
Bouncing ball	-	-	-	-	8	-	Physics	4	2	5	10	9	2
Buoyant force	4	-	-	-	-	-	Plane	-	1	-	-	-	-
Car	-	1	15	11	3	-	Position	-	6	-	1	1	10
Cargo	-	-	3	-	-	-	Potential energy	-	-	-	-	-	1
Change	1	-	-	-	-	1	Power	14	4	-	-	-	13
Change in velocity	-	-	3	1	5	2	Race	1	-	6	7	-	-
Change of shape	2	-	-	-	-	-	Radar	-	-	2	-	-	-
Circular motion	-	2	-	-	-	-	Reaction	4	-	-	-	-	-
Contact	1	-	-	-	-	-	Rectilinear	-	6	-	-	-	-

Dance	-	2	-	-	-	-	Resultant force	1	-	-	-	-	-
Direction	1	6	4	2	-	2	Road accident	-	-	1	2	-	-
Displacement	2	17	5	10	5	1	Run	-	2	2	1	1	1
Distance	3	13	25	17	8	19	Scalar	-	-	3	-	-	1
Dynamometer	3	-	-	-	-	-	Simple machines	3	-	-	-	-	-
Ending point	-	1	-	-	-	8	Skeletal system	-	4	-	-	-	-
Energy	5	9	1	1	-	4	Slow	-	-	1	1	-	-
F (symbol)	12	-	-	-	-	-	Speed	1	5	-	12	3	2
Fall into place	-	-	-	-	2	1	Sport	1	4	1	-	-	-
Fixed point	-	1	-	-	2	-	Stable	-	2	-	-	-	-
Force	-	13	1	3	4	12	Stop	-	-	1	1	-	-
Friction	10	2	1	2	4	5	Strike	1	4	2	1	-	3
Galileo	-	-	-	-	1	-	Surface	1	-	-	-	2	-
Gauge for car	-	-	3	-	-	-	Tangential acceleration	-	-	-	-	2	-
Gravity	6	1	-	-	2	-	Technology	-	-	-	1	-	-
Height	-	-	-	-	3	-	The shortest distance	-	-	-	-	-	2
Horizontal or vertical motion	-	2	-	-	-	-	Thrust and attractive	13	2	-	-	-	1
Human	2	-	-	1	-	1	Time	3	7	23	21	16	6
Hyperactive	-	3	-	-	-	-	Travel	-	-	-	-	-	5
Inertia	-	1	-	-	-	-	Unlike velocity	-	-	2	-	-	-
Instantaneous velocity	-	-	-	2	-	-	Unstable/changeable	-	1	1	1	9	-
Intensity	-	-	-	-	3	-	V (symbol)	-	-	-	10	-	-
Kinetic energy	-	1	-	-	-	1	Vectoral	4	-	1	1	2	-
km/h (unit)	-	-	4	9	-	-	Velocity	1	16	22	-	19	11
Length	-	-	-	2	1	1	Velocity of light	-	-	-	2	-	-
Lightning	-	-	-	1	-	-	Voice	-	-	-	2	-	-
Magnetics	1	1	-	-	-	-	Walking back and forth	-	7	-	-	-	6
Magnitude	2	-	-	-	1	1	Weight	2	-	-	-	-	1
Mass	3	-	-	3	1	-	Wind	1	-	-	1	-	-
Mechanics	-	4	-	-	-	-	Work	1	4	-	-	-	2
Moon	-	-	-	-	2	-	World	-	-	-	-	1	-
Motion	6	1	5	4	6	17	X=V*t (formula)	-	2	1	9	-	-
Move away from the starting point	-	-	-	-	-	3							
Total of words/concepts: 97													

*** In Table 2, F: Force, M: Motion, S: Speed, V: Velocity, A: Acceleration and D: Displacement**

The prospective teachers provided a total of 97 words/concepts in association with the key concepts. Table 1 show that the prospective teachers associated the key concepts mostly with the concepts of distance, time, velocity, force, energy, motion, friction, power, car, physics, displacement, acceleration and speed. The cut-off points for the key concepts expressed by the prospective teachers and the conceptual networks constructed according to the key concepts are shown in Figures 1 to 4.

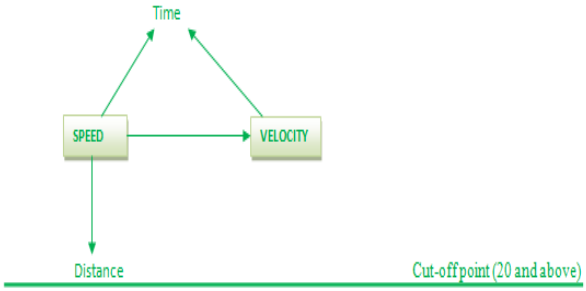

Figure 1. *Cut-off point (20 and above) and conceptual network for the concepts expressed by the participants*

For the cutoff point 20 and higher; In this interval, distance and time were associated with Speed, time was associated with Velocity, and the key concepts of Speed and Velocity were associated. It is seen that the concepts in this interval are somewhat related.

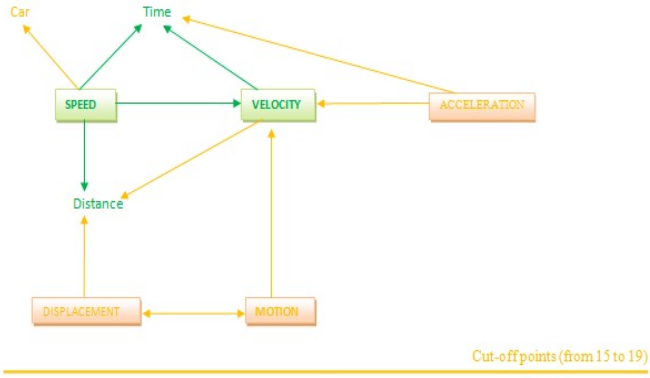

Figure 2. *Cut-off point (15-19) and conceptual network for the concepts expressed by the participants*

For the cutoff point 15-19; The key concepts Acceleration, Displacement and Motion appeared in this interval. Speed, Velocity and Acceleration were associated with time, Displacement, Speed and Velocity were associated with distance. It is seen that the number of key concepts and related words increased in this interval, but this was not a very significant increase.

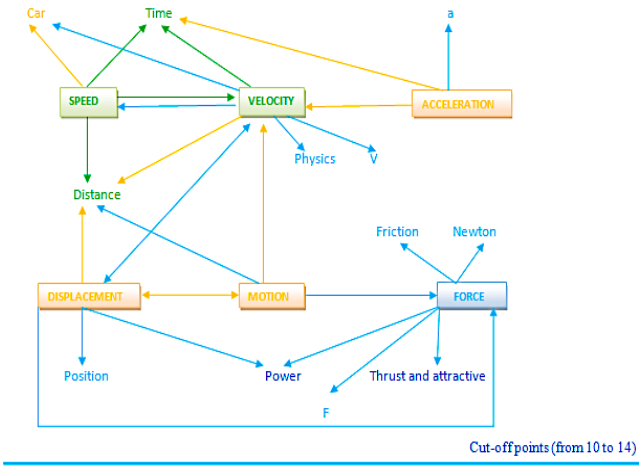

Figure 3. *Cut-off points (10-14) and concept network for the concepts expressed by the participants*

For the cutoff point 10-14; It is seen that the number of key concepts and related words increased in this interval. The increase in all key concepts, the relationships among the key concepts and the numbers of related words increased in this interval. Speed, Displacement, Velocity and Motion were associated with distance, Displacement and Force was associated with power, and Speed, Velocity and Acceleration were associated with time. It was also seen that the key concepts of Speed and Velocity were associated, so were Displacement and Motion.

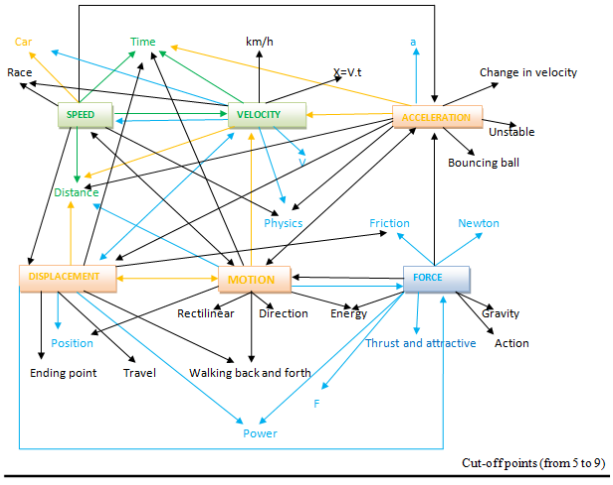

Figure 4. *The cut-off points (5-9) and the concept network for the concepts expressed by the participants*

Table 2. *Distribution of the sentences formed by the participants based on semantic categories*

Categories	Force		Motion		Speed		Velocity		Acceleration		Displacement		Total	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Scientific expressions	42	52.5	23	30.3	27	36.5	19	22.9	32	42.7	20	25.3	163	34.9
Emotional expressions	9	11.3	8	10.5	13	17.6	18	21.7	5	6.7	12	15.2	65	13.9
Superficial expressions or daily examples of daily life	13	16.2	25	32.9	16	21.6	18	21.7	29	38.6	28	35.4	129	27.6
Non-scientific or alternative concepts	16	20	20	26.3	18	24.3	28	33.7	9	12	19	24.1	110	23.6
Total	80	100	76	100	74	100	83	100	75	100	79	100	467	100

It was observed that a total of 467 sentences were formed regarding the key concepts, and almost the same number of sentences was provided for each concept by 78 on average. Considering the distribution of the sentences formed by the participants into semantic categories, a significant portion (34.9%) was in the scientific information category. Some of the remaining responses were distributed in the superficial or daily-life information (27.6%) and unscientific information or information containing alternative concepts (23.6%) categories. It is seen in Table 2 that the ratio of sentences in the emotional information category (13.7%) was very low.

When the categorical distribution of the responses was investigated based on the concepts, the ratio of the sentences formed by the participants that were considered to be scientific was the lowest in the concept of velocity (22.9%) and the highest in the concept of force (52.5%). It was seen that the number of the sentences that were superficial or contained daily-life examples formed by the participants regarding the concepts of motion, acceleration and displacement were close to each other hand higher than those in the cases of the other concepts. Additionally, the ratio of the sentences formed by the participants that were considered to be unscientific or contain alternative concepts was the highest in the concept of velocity (33.7%) and the lowest in the concept of acceleration (12%). In the emotional information category which contained the lowest number of sentences, the highest number of responses was about the concept of velocity (21.7%) and the lowest number of responses was about the concept of acceleration (6.7%).

Examples are provided in Table 3 regarding the responses of the participants summarized in Table 2.

Table 3: Examples of sentences provided by the participants regarding the key concepts based on the categories*

	Scientific expressions	Emotional expressions	Superficial expressions or daily life examples	Non-scientific or alternative concepts
Example Expressions	Force provides the object with motion/ we lead objects to move by applying force onto them (F-6)**	His breath has force (F-1)	It is Newton's second law (F-2)	
	We spend energy while applying force (F-5)	The cold wave of air coming from the Balkans seems to have force and will affect our country (F-1)	Force is applied on an object (F-2)	It is the force that acts on an object, provides it with motion, changes its shape or place (F-2)
	Force is a vectoral measure / quantity (F-4)	A healthy person has force (F-1)	It is connected to energy (F-1)	The more force is applied, the more time is saved (F-1)
	Pulling force or pushing force may be applied to an object (F-4)	A good force is needed to pull the branches while collecting hazelnuts (F-1)	A car moves from A to B (M-1)	The energy that affects an object is called force (F-1)
	Force is shown as F (F-4)	Where there is motion, there is abundance (M-1)	I apply force to move the table (M-1)	It is work based on time (F-1)
	A unit of force is Newton (F-3)	The child was moving so much, he brought the museum down (M-1)	It is a physics concept (M-1)	Force is mass multiplied by distance (F-1)
	If there is motion, there is a displacement (M-10)	To have motion, we should generally run and be active (M-1)	Objects may be moving or stationary (M-1)	Motion = distance / time (M-2)
	A force should be applied to the object for motion to happen(M-6)	We broke his arm because of improper motion (M-1)	I spend energy to move the table (M-1)	The formula of motion is X=V*t (M-1)
	If the object changed place, it has moved (M-3)	Too much speed leads to traffic accidents (S-2)	It moved towards the light (M-1)	Motion happens by focusing on a constant point (M-1)
	Motion requires energy (M-3)	C. Ronaldo/Gareth Bale has speed in football (S-2)	Speed and velocity are different (S-5)	It is the change in (M-1)
	A force is an effect that moves a stationary object and changes an object's direction and strike (M-2)	Bugatti Veyron/Lightening McQueen is the speediest automobile (S-2)	Speed is a physics concept (S-3)	It is distance (S-2)
	It is the value on the gauge of a car (S-5)	My sister had so much speed coming from Istanbul that she was caught by a radar (S-1)	Speed and velocity are confused (S-1)	Speed is motion over unit time (S-2)
	It is a scale quantity (S-4)	Speed is important in athletics competitions (S-1)	Cars can do high speeds in a straight line (S-1)	It is average velocity (S-2)
	Speed's formula is distance / time (S-4)	One who has velocity wins the race (V-3)	Cars a speedy (S-1)	It is shown as V_{avg} (S-2)
	Velocity provides speed/ as velocity increases, so does speed (S-3)	I couldn't understand the difference between velocity and speed (V-3)	Velocity is a physics concept (V-3)	Velocity and speed are the same (S-1)
	No strike or direction is shown (S-3)	Too much velocity is not good (V-1)	Velocity and speed are different things (V-2)	It is the velocity of an object in unit time (S-1)
	It is the displacement over unit time (S-2)	It is an important concept in physics (V-1)	Velocity and speed are concepts that are confused (V-1)	Speed is found by multiplying displacement and time (S-1)
	An object that get faster gains acceleration (S-2)	Most accidents happen because of velocity (V-1)	A rabbit has more velocity than a tortoise (V-1)	Velocity is equal to distance / time (V-7)
	It is shown as V (V-6)	Technology is progressing with velocity today (V-1)	Velocity decreases or increases by acceleration (V-1)	It is distance over time (V-6)
	Velocity is the displacement over time (V-3)	I confuse velocity with speed. I guess velocity also has direction (V-1)	Velocity is dependent on speed (V-1)	The formula of velocity is X/t (V-5)
	Velocity is vectoral quantity (V-2)	Acceleration was one of the subjects I didn't understand in physics (A-1)	Acceleration is a physics concept (A-5)	Velocity is the magnitude of movement for a moving object (V-2)
	Friction reduces velocity (V-2)	Porsche has large acceleration (A-1)	Acceleration is connected to velocity (A-4)	Velocity is the distance in unit time (V-1)
	It is shown as a (A-6)	Acceleration is important in penalty kicks (A-1)	Acceleration may decrease or increase (A-3)	It is the energy needed for displacement (V-1)
	It is the change in velocity over time (A-5)	A tenant has high displacement (D-1)	Motion is needed for acceleration (A-2)	Acceleration reduces velocity (V-1)
	If an object accelerates, its velocity increases (A-5)	We have displacement from somewhere to somewhere in travelling (D-1)	It is the change or the amount of change that happens in unit time (A-2)	Acceleration increases as altitude increases (A-3)
	Acceleration is the change in the velocity of an object over unit time (A-3)	That vase doesn't look good there, you must displace it (D-1)	It is increase or decrease in velocity over a certain time (A-2)	Acceleration changes based on surface (A-1)
	It is the change in the position of a moving object (D-5)		Displacement requires motion/Motion results in displacement (D-7)	Acceleration is found by the formula m.a (A-1)
	It is the difference between the starting point and the last position (D-3)		It is a physics concept (D-3)	It is the unit of velocity that an object gains over unit time (A-1)
	If something returns to the starting point, displacement is zero (D-3)		It is going from somewhere to somewhere else (D-3)	Objects cannot have acceleration as there is no gravity on the moon (A-1)
	Displacement may occur if force is applied (D-3)		Velocity of an object that is displaced may change (D-2)	The velocity of an object that is displaced changes (D-2)
			Displacement and distance are difference concepts (D-1)	The size of the object is effective in displacement (D-1)
			It requires energy (D-1)	Increase in velocity increases displacement (D-1)
			Displacement may be + or –(D-1)	Motion and velocity affect displacement (D-1)
				In displacement, the object moves towards a direction (D-1)
				It is the last position of the object (D-1)

*** In Table 3, F: Force, M: Motion, S: Speed, V: Velocity, A: Acceleration and D: Displacement**

**** The letter in parentheses shows the abbreviation of the related concept, and the number is the frequency of the related sentence. For example, F-1 shows that this sentence written down for the concept of force was used by one person.**

As seen among the example statements above, it may be seen that the prospective teachers written down similar sentences that may be considered scientific. Considering the scientific information category which contained the most responses, the statements that were frequently repeated by the participants included "*force provides the object with motion,*" "*we spend energy while applying force*," "*if there is motion, there is displacement*," "*force should be applied for motion to take place*," "*speed is the value shown on the gauge of a car*," "*velocity is shown as V*," "*acceleration is the change in velocity over time*," "*the velocity of an accelerating object increases*" and "*displacement is the change in the position of an object that moved".* While there were some similar responses in the examples in the other categories, they usually started to differ. While similar responses were seen in the unscientific information or information containing alternative category, the responses categorized as such were fewer than the superficial or daily-life examples category.

DISCUSSION AND CONCLUSION

This study used a word association test to determine the concepts that elementary prospective teachers associated with the physics concept force, motion, speed, velocity, acceleration and displacement and revealed their perceptions towards these concepts. This way, it was aimed to obtain results regarding how prospective teachers have constructed the basic physics concepts in their minds.

The prospective teachers stated 97 words/concepts regarding the 6 key concepts. The participants usually associated the concept of "force" with power, pulling-pushing, F, Newton, friction, action, gravity, motion and acceleration, the concept of "motion" with displacement, velocity, force, distance, energy, walking back-forth, linear, time, position and direction, the concept of "speed" with distance, time, car, velocity and racing, the concept of "velocity" with distance, car, physics, km/hour, speed, V, displacement, racing and time, the concept of "acceleration" with velocity, time, falling-jumping, a, distance, nonstationary, physics and motion, while they associated the concept of "displacement" with motion, distance, power, finishing point, velocity, force, position, walking back-forth and time. On the other hand, it is also seen that teacher candidates are associated with strike, unstable/changeable, velocity change, running, vectoral and racing response words in line with the given key concepts. It was found that the prospective teachers associated the given key concepts mostly with the concepts of distance, time, velocity, force, energy, motion, friction, power, car, physics, displacement, acceleration and speed, and their responses had very low variety. Additionally, the words distance and time were those that were the most frequently associated with the key concepts of "speed", "velocity", "motion", "displacement" and "acceleration".

This study asked prospective teachers to form sentences related to the concepts they associated with the six key concepts, and the sentences formed by the participants were divided into four categories. The participants formed a total of 467 sentences, and the number of sentences for each key concept was similar, by 78 on average. About one third of the sentences formed by the participants (34.9%) contained scientific information and they were usually similar in nature. This category was included the least in the key concept of "velocity" and the most in the key concept of "force". 27.6% of the sentences had superficial or daily-life examples, and this category included sentences towards the key concepts of "acceleration", "displacement" and "motion" the most. The sentences in this category were diverse. 23.6% of the sentences formed by the participants were in the unscientific information or information containing alternative concepts category, and 13.7% were in the emotional information category, while these sentences were similar in nature. The sentences in the emotional information category were mostly about the concept of velocity, and the sentences were diverse.

It was seen that some participants associated the key concept of force with the concepts of motion and power, and defined force as "*the power that provides an object with motion*" and

as "*the power that acts on a moving object*". Eryılmaz and Tatlı (2000) reported that university students thought where there is motion, there is force. Similarly, Kuru and Güneş's (2005) study with middle school students and Demir, Uzoğlu and Büyükkasap's (2012) study with prospective science teacher, alternative concepts were seen in responses like "*if an object is moving, there are forces that act on this object in the direction of its motion*". Turgut, Gürbüz and Turgut (2011) reported that high school students had alternative concepts as in "*the force applied on an object when it is thrown continues to act on the object throughout its motion,*" "*when a force that leads an object to move is applied once, the object keeps moving until it is stopped*" and "*if an object if moving, there are forces that act on this object in the direction of its motion*". Nuhoğlu (2008) found that primary education students though no motion can take place when there is no force.

It was observed that some of the participants associated the key concept of speed with the concept of velocity and the key concept of velocity with the concept of speed. It was determined that the participants who made this association thought "*speed is velocity*", "*speed is distance*" or "*speed is the motion over unit time*." Some participants related the key concept of velocity to distance. These participants were observed to state that "*velocity is the distance covered in unit time*" or "*velocity is the distance over time*". Additionally, there were participants who associated the key concept of displacement with the concept of velocity, and these participants had alternative concepts as in "*the velocity of a displaced object changes*" and "*displacement increases as an object accelerates*". Yıldız, Büyükkasap, Erkol and Dikel (2007) reported that prospective science teachers found it difficult to define velocity, relate velocity and speed to each other and understand the difference between distance and displacement, and they had alternative concepts as in "*velocity is distance over unit time*," "*velocity is speed*" and "*velocity is the unit of speed*". Öztuna-Kaplan, Yılmazlar and Çorapçıgil (2014) reported that undergraduate physics students confused velocity and speed with each other and they had alternative concepts such as "*speed is instantaneous velocity*". Yıldız (2014, 2017) found that although speed and velocity have completely different types of quantity, it is a widespread situation that they are used interchangeably in daily life conversation and textbooks. Yıldız, Büyükkasap and Günel (2011) observed that prospective teachers could not understand the concepts of speed and velocity, and they mostly used the word velocity to mean speed.

As a result of the findings of the study, some alternative concepts found in the responses of the participants to the key concepts and the sentences they formed accordingly. In this sense, as the key concepts are concepts that are encountered frequently in daily life, it is recommended to organize activities that help prospective teachers to associate the basic physics concepts mentioned above with situations in daily life. It is also recommended that the word association test used as a single step to determine the case in this study is applied in the form of pre-test / post-test in different study models with the purpose of investigating the conceptual change in prospective form teachers.

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