Multidimensional Perceptions of Physics

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Abstract

The current study was designed to determine how physics is perceived by students and members of the public. It was carried out in four phases, including an online survey, and offline survey, semi-structured interviews, and a focus group discussion. The online survey was conducted with 564 people from different ages and occupations to identify their perception of physics. The offline survey was conducted with 22 undergraduate physics students whose future professions will be in physics. The semi-structured interviews were conducted with four undergraduate science students, and a focus group discussion with six physics graduates was conducted to determine their perception of physics. A qualitative descriptive research approach was applied to collect and analyze the data. The results of the study showed that people perceived physics in different ways; however, their views were connected to the definition of science in general.

Introduction

Physics is one of the fundamental branches of science that deals with every moment of our lives. As stated in Physics.org (2016), *'It's applied in every sphere of human activity'*. Physics is defined by the Institute of Physics as, *'The study of matter, energy, and the interaction between them'*. It goes on to say that, *'Physics is about asking fundamental questions and trying to answer them by observing and experimenting'* (Physics.org, 2016). Moreover, Marx (1983) emphasized that physicists are interested in explaining world. These are broad definitions of what physics is and what physicists do, however, it is not clear exactly what physics means to different people (IOP 2008).

Several studies have been conducted on the perceptions people have regarding physics. However, these studies mostly demonstrate a relationship between course enrollment and students' perceptions of physics. In one study, Checkley (2010) worked with students, in grades 10 to 12, investigating whether their perceptions of physics affected their decision to take physics courses. The results of the study indicated that the students who found physics boring, difficult, and irrelevant tended to not to take physics courses during their secondary and post-secondary education. On the other hand, the students who found physics interesting, enjoyable, and relevant chose to take physics courses. Similarly, in a study conducted by Lavonen, Angell, Bymen, Henriksen, and Koponen (2007), the possible motives affecting students' decisions about whether to study physics was researched. The results of their study showed that the factors affecting students' reasons for taking physics courses were the classroom activities, teaching methods, and other external factors including gender and personality. In this same study, it was stated that many students perceive physics as being difficult, and that they take this into account when selecting subjects for specialization at upper secondary school.

Similarly, Osborne, Simon, and Collins (2003) concluded that students perceive the subject matter of physics to be very difficult. These studies yielded significant results that should be considered when observing and attempting to overcome students' preconceptions about physics. Lising and Elby (2005) stated that students often see physics as many unrelated topics and formulas and claimed that if one explores students' epistemology, there will be an opportunity to alter students' learning ability with respect to their already held epistemological beliefs. Exploring students' epistemology is important because students' epistemology may have an impact on their understanding of physics (Lising & Elby, 2005). Similarly, Wutchana and Emarat (2011) used Maryland Physics Expectations (MPEX) Survey (Redish, Saul, & Steinberg, 1998) which probes student attitudes, beliefs, and assumptions about physics. They found a significant correlation between students' physics expectations and their learning gains in introductory physics classes.

To gain more information regarding why students view physics as a difficult subject and how their epistemologies are affected by their perceptions of physics, we need to have more information on what they really know about physics, as well as the concepts and ideas underlying physics itself. In one such study the IOP (2008) investigated public perceptions of physics. They asked people what physics was about and supplied them with several concepts, before asking them to pick-out the concepts they thought were most relevant to physics. *"Science/scientific"* was the most popular answer, totaling 17% of all answers. Interestingly, 11% of the participants stated that physics is *"Something to do with body/health/exercise"*. *"Formulae/numbers/theories/laws"* was another popular answer(15%) as was *"school/education/curriculum"* (14%). Several similar studies have been conducted to identify students' views of science. The interchangeable use of the terms *science* and *technology* was noted by Zeman (2005) in his research with year 10 students, on the definition of science. In a clearer perspective, Squires (1980) quoted the definition of science by a ten-year-old as *"Science is to help you to find out about everything...."*. On the other hand, Karakas (2011) investigated how college science faculties defined science. Seventeen science instructors from five different institutions in the northeastern U.S. participated in his study. The results of his study revealed that most science faculties defined science as *an experimental way of exploring nature* while a few others defined science as *an understanding that explains the reality, an inquiry and asking the good questions, a way of knowing and understanding the world*.

In general, the IOP study was comprehensive and informative, and yielded reliable results with the help of multi-data collection techniques such as surveys and focus groups. However, it is also necessary to have a clear view of the science and physics students' perceptions to see the current picture. In this respect, the current study probed people's thinking about physics in four phases, including the perceptions of the public, physics undergraduates, science undergraduates, and physics graduates in Turkey. The results of this study provide an important background for creating a new physics epistemology and understanding future research.

Research question

The research question of this exploratory-descriptive study was: *What does physics mean?* There were two sub-questions that were investigated:

- How do people perceive physics?
- What are the differences among diverse people in their perceptions of physics?

Method

Design of the study

To answer the research question, this study employed a qualitative descriptive research method (Sandelowski 2000; Parse 2001). This method is commonly used in nursing research, however, it has been used in other areas such as in the Mendez-Shannon study (2010). The qualitative descriptive research method is also called a qualitative description. It should be noted that there are other qualitative research methods, descriptive in nature. However, here the researcher is after a rich, straight description rather than theory development, interpretative meaning, or a thick description that could be achieved by ethnography, grounded theory, and phenomenology respectively (Sandelowski 2000). In qualitative description, structured and/or semi-structured interviews can be used. In this research, both were used.

Data collection

The researcher preferred to use a variety of data collection techniques to ensure the credibility of the qualitative research. The data collection period took almost a year, starting in September 2011 and ending in December 2012. Four phases were involved during this period: (1) online survey with people from different ages and occupations to find out public perceptions of physics, (2) survey with undergraduate physics students to find out how those whose profession will be in physics interpret physics, (3) semi-structured interviews with undergraduate science students to find out how they perceived physics, and (4) a focus group discussion with physics graduates to find out how they perceived physics. Open-ended questions were used during all phases. All the discussions during the focus group and semi-structured interviews were audiotaped.

Measuring tool

In this study, the data were collected with interviews and surveys. The interview protocol and surveys had four structured questions:

1. What is physics?
2. Why do we learn physics?
3. What are some examples of physics in daily life?
4. What are your favorite topics in physics?

Participants

958 people participated in the online survey. IP addresses and date-stamps were collected to check duplicate entries, and the collected data was cleaned by omitting invalid entries such as duplicate entries, meaningless words, phrases, and dummies. If a response had any meaning, it was counted as valid. After the data cleaning process, data from 564 respondents remained. Table 1 summarizes the occupations of the online survey participants.

Table 1. Occupation of online survey participants

Occupation	Frequency	Percent
Student (from K-12 to graduate level)	327	58
Teacher	72	13
Unemployed	14	2.5
Engineer	12	2.1
Worker	37	6.6
Medical Doctor	14	2.5
Others	88	15.6

Among them, 58% of the participants (f=327) were students (from K-12 to graduate level), 13% of them (f=72) were teachers, 2.5% of them (f=14) were unemployed, 2.1% of them (f=12) were engineers, 6.6% of them were workers (f=37), and 2.5% of them (f=14) were medical doctors. The mean value of the participants' age was 24 (min 9 and max 72). With respect to gender, 49.5% of the participants (f=279) were female and 50.5% of the participants (f=285) were male.

In addition to the online survey, an offline survey was conducted with 22 undergraduate physics students: 13 of the students were female and nine were male. Semi-structured interviews were conducted with four undergraduate science students: two male and two female. A focus group was conducted with six people who had graduated with an undergraduate degree in physics.

Results

Online survey

The data collected with the online survey was cleaned leaving only valid data remaining. After the cleaning process, the researcher read the responses to identify possible codes. Initial coding resulted in a high number of the codes; therefore, the researcher revisited each code to combine the similar ones and construct the themes. Finally, 15 themes were identified. The frequency distribution of these themes can be seen in Table 2.

Table 2. How do people perceive physics?

Theme		Frequency	Percent
branch of science		131	23.2
	that can explain matter and energy with mathematics	*33*	*5.5*
	that deals with matter and energy.	*26*	*4.6*
	that investigates/explains nature and the universe.	*15*	*2.7*
	that investigates matter and interactions of matter	*18*	*3.2*
nature/life		88	15.6
physical appearance		60	10.6
course		51	9.0
everything		35	6.2
concepts		30	5.3
emotions		28	5
don't know		18	3.2
mystic		18	3.2
universe		16	2.8
formulas		14	2.5
laws		13	2.3
fundamental science		12	2.1
science		9	1.6
chemistry		5	0.9
philosophy		5	0.9
other		31	5.5
Total		564	100

The first emerging theme from the online survey data was that the people viewed physics as *a branch of science*. Of the total number of participants, 23.2% (f=131) defined physics as a branch of science and more specifically, 5.5% of all participants (f=33) defined physics as *a branch of science that can explain matter and energy with mathematics* and 4.6% of the participants (f=26) described physics as *a branch of science that deals with matter and energy*. These participants stated that every part of our life has matter and energy, which is why we need to learn physics. Similarly, 2.7% of the participants (f=15) perceived physics as *a branch of science that investigates/explains nature and the universe*. On the other hand, 3.2% of the participants (f=18) stated that physics is *a branch of science that investigates matter and interactions of matter*. However, only three of the participants described physics as *a branch of science that investigates matter, energy, and interactions between them*.

Moreover, the crosstabs were generated for this theme using age groups and occupation. It was seen that 37.5% of the participants between the ages of 45 and 50, viewed physics as a branch of science, and 19% of the participants between the ages of 21 and 26 viewed physics as a branch of science. 28.8% of the participants between the ages of 15 and 20 also perceived physics in a similar way. When we checked all other age groups, we saw that they were all around the overall percentage. When occupations were taken into account, it was found that 16.2% of the teachers viewed physics in this way, while 26.3% of the students thought in similar way. Moreover, 46.2% engineers viewed physics as a branch of science.

Another theme that emerged from the data was that of *nature/life*. It was found that one of the biggest proportions of the participants (15.6%, f=88) thought that *physics is life and/or nature and it aims to give clear explanations of life and/or nature*. Following are examples of their answers:

> *"....in short, physics is life itself from (-) infinite to (+) infinite"*
>
> *"For me, physics is life. It is all around us in every area of life."*
>
> *"Physics is the key to the questions of nature...."*
>
> *".... is investigating nature and defines the rules of events to understand them clearly."*

From the answers to the second question, asking people why they learn physics, it was found that the people who perceived physics as *nature/life*, thought that they learned physics because they *need to understand/learn nature and life and consequently make their life better*. For example, the following answer best illustrates this: *".... is to understand nature. The one who doesn't know nature cannot live in harmony."*

Again, the crosstabs were generated for this theme using age groups and occupations. It was seen that 26.7% of the participants between the ages of 21 and 26 viewed physics as nature/life. However only 4.9% of the participants between the ages of 9 and 14 perceived physics in a similar way. When we checked all other age groups, we saw that they were all around the overall percentage. When occupations taken into account, it was seen that 25.7% of the teachers viewed physics in this way, while 16.1% of the students thought in similar way.

One other theme that emerged from the data was *physical appearance* as one of the most frequent phrases used when people tried to define physics. It was found that 60 of the participants (10.6%) described physics as physical appearance. Moreover, 62% (f=37) of the people who described physics in this way were female whereas only 38% (f=23) of them were male. It is interesting that 8.7% of the students and 8.1% of the teachers also perceived physics

in same way. Moreover, 28.7% of the participants between the ages of 9 and 14 viewed physics as physical appearance. Some of the answers were as follows:

"Physics is concerned with the shape of our body."

"It is physical appearance."

"Physics is the body of human-beings."

"Physical properties of people, for example length of the hair."

When we looked at the second question, it was found that people who described physics as physical appearance said they learn physics *to know their body better* (f=22), but eight of them stated that they didn't know why they learn physics. The following are examples of their answers:

"I learn physics to know more about my body"

"… to being healthy"

"… to know my body better"

In the third question, participants were asked to give examples of physics from their daily lives. 34% of them (f=20) gave several physical characteristics including *weight and height* as daily life examples of physics. On the other hand, 10 participants gave several daily-life activities such as *walking, running, and swimming* as the examples of physics in daily life.

From the answers of 9% of the participants (f=51) it was seen that physics was perceived as *a course*. Some of them (f=8) labeled physics as the most difficult course available. Answers to question showed that these participants thought that physics is a necessary course because it is *compulsory* and is needed in several *exams*.

From the answers of 6.2% of the participants (f=35), another theme emerged; *everything*. It was seen that these people perceived physics as everything and/or an explanation for everything. The following answers are example of this:

"Physics is the explanation of everything. It is everything being done and the things that we are doing in our daily life..."

"Physics is everything. Even, now physics laws are applied when I am writing these sentences. Physics is the explanation for the reasons behind the events in life."

From the answers to the second question, it can be seen that the people who perceived physics as the explanation of everything, thought that one learned physics because of the need to understand the world and life.

"… in order to comprehend happenings in the world and nature and make life easier with the physics laws."

"… to comprehend events in our life in an experimental and theoretical way."

One of the other themes derived from the answers was *concepts* (5.3%, f=30). People perceive physics as just a concept. From this point of view, physics was defined as *"force"*, *"motion"*, *"gravity"*, *"matter and energy"*, etc.

The next theme that emerged was *emotions* (5%, f=28). This theme was named in this way because several of the participants defined physics as follows: *"Physics is ridiculous"*, *"It is boring"*, *"Physics is love"*, and *"Physics is meaningless"* etc. Half of these statements (f=14) were positive such as *"physics is love"*, whereas the other half was negative such as *"physics*

is boring". Furthermore, 10 of the females (out of 19) perceived physics in a positive way and 4 of the males (out of 9) perceived physics in the same way.

Another interesting theme that emerged was *mystic* (3.2%, f=18). It was seen that people perceived physics as a mystical concept. For example one of the participants defined physics as *"Unseen effects on matter"*. Another definition was *"The journey of exploring creation from part to whole and from whole to part"*.

2.8% of the participants (f=16) described physics as the study of the *universe*. These participants stated that they learned physics because it will enable them to better know their universe. They gave examples of several physical events in nature, such as friction between objects, buoyant force, and motion as examples of physics in daily life. The other themes that emerged were *formulas*, as defined by 2.5% of the participants as physics is a *set of formulas*. *Laws* were defined by 2.3% of the participants as physics being a *set of laws*, and physics as a *fundamental science* was defined by 2.1% of the participants as physics being a fundamental part of all the other branches of sciences. *Science* was defined by 1.6% of the participants as physics being just science, while 0.9% of the participants defined physics as *chemistry*, and 0.9% of the participants defined physics as *philosophy*.

As it might be of interest, the frequency distribution with respect to each gender can be seen in Table 3. It was seen that the frequencies of *branch of science*, *physical appearance*, *course*, and *emotions* themes were higher for the female participants than the male participants.

Table 3. Physics perceived by female participants

Theme	Female		Male	
	Frequency	Percent	Frequency	Percent
branch of science	70	25.1	61	21.4
nature/life	43	15.4	45	15.8
physical appearance	37	13.3	23	8.1
course	28	10	23	8.1
emotions	19	6.8	9	3.2
concepts	13	4.7	17	6
everything	13	4.7	22	7.7
don't know	8	2.9	10	3.5
laws	7	2.5	6	2.1
universe	7	2.5	9	3.2
formulas	6	2.2	8	2.8
mystic	5	1.8	13	4.6
science	5	1.8	4	1.4
fundamental science	3	1.1	9	3.2
chemistry	0	0	4	1.4
philosophy	0	0	4	1.4
other	15	5.4	18	6.3
Total	279	100	285	100

The results of the analysis of the second question yielded 11 themes of why people learn physics, described as follows: *I like it* (they learn physics because they like it), *it is a course* (they have to learn physics because it is a course part of their education), *it is important* (they

learn physics because they think physics is an important subject), *curiosity* (they learn physics because they are curious about several facts and/or phenomena and they think physics explains those), *it is needed in daily life* (they learn physics because physics is needed at their daily life practices), *personal improvement* (they learn physics because they want to be better person), *it is needed to pass exams* (they learn physics because they want to pass future exams such as university entrance exam), *it is needed to learn concepts* (they learn physics because they need it to learn several physics concepts), *understand life better* (they learn physics because physics help them to understand their life), *understand nature* (they learn physics because it helps/will help them to understand natural events and phenomena), *and understand universe better* (they learn physics because it helps/will help them to understand universe). The frequency distribution of these themes according to each gender can be seen in Table 4. It can be seen that 15.9% of all participants (f=88) don't have any idea of why they learn physics, and they clearly admit this. This was followed by *needed in daily life*. 15% of all participants (15.1% of males and 14.9% of females) state that they learn physics because they (will) need it in daily life. 12.8% of all (14.4% of males and 11.3% of females) seem to learn physics because it may help them to better understand life.

Table 4. Why do people learn physics?

Why do you learn physics?	Female		Male		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
because I like it	7	2.5	16	5.8	23	4.2
because it is a course	21	7.6	23	8.3	44	8.0
because it is important	13	4.7	8	2.9	21	3.8
curiosity	6	2.2	10	3.6	16	2.9
don’t have any idea	46	16.7	42	15.1	88	15.9
needed in daily life	41	14.9	42	15.1	83	15.0
other	9	3.3	6	2.2	15	2.7
personal improvement	23	8.4	20	7.2	43	7.8
to learn concepts	14	5.1	15	5.4	29	5.2
to pass exams	17	6.2	9	3.2	26	4.7
understand life better	31	11.3	40	14.4	71	12.8
understand nature	33	12.0	27	9.7	60	10.8
understand universe better	14	5.1	20	7.2	34	6.1
Total	275	100	278	100	553	100

Table 5 summarizes daily life examples given by participants. 19.6% of all participants gave direct examples from their own experiences (personal examples). 15.8% of all participants did not provide any examples. 9.1% of all participants stated that everything includes physics, and they didn't specify any specific example from daily life. Males (f=30) were significantly different from females (f=20) in this respect. On the other hand, females (f=26) provided broader examples as a whole field, far more so than males (f=13). Other themes were similar for each gender.

Table 5. Examples of physics in daily life

Examples of physics in daily life	Female		Male		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
abstract examples such us change in gravity	2	0.7	3	1.1	5	0.9
broad examples as whole field such as electricity, optics etc	26	9.6	13	4.7	39	7.1
devices and tools	27	10	23	8.2	50	9.1
direct fragmented concepts	15	5.5	23	8.2	38	6.9
don't have any examples	44	16.2	43	15.4	87	15.8
everything includes physics	20	7.4	30	10.8	50	9.1
gravity	17	6.3	13	4.7	30	5.5
observations from nature	30	11.1	30	10.8	60	10.9
observations of artifacts	23	8.5	25	9	48	8.7
personal examples	50	18.5	58	20.8	108	19.6
physical appearance	17	6.3	18	6.5	35	6.4
Total	271	199	279	100	550	100

Table 6 summarizes participants' favorite physics topics. They were asked to provide their favorite topics, and each of these topics was recoded as units, and these were recorded as themes. Mechanics was the most popular theme for both males and females (32.6% of all). This was followed by modern physics for males, and electromagnetism for females. It was also found that number of invalid entries and those who did not provide any examples were significantly higher for females.

Table 6. Favorite topics in physics

Favorite topics	Female		Male		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
astrophysics	2	0.7	5	1.8	7	1.3
electromagnetism	35	13.1	39	14.2	74	13.6
every topics	12	4.5	6	2.2	18	3.3
invalid	49	18.3	34	12.4	83	15.3
mechanics	82	30.6	95	34.5	177	32.6
modern physics	34	12.7	47	17.1	81	14.9
nature of physics	4	1.5	0	0	4	0.7
nothing	28	10.4	21	7.6	49	9.0
optics	14	5.2	14	5.1	28	5.2
thermodynamics	8	3.0	14	5.1	22	4.1
Total	268	100	275	100	543	100

In addition to those, frequency distribution of how people perceive physics, and why they learn physics (see Table 7), frequency distribution of how people perceive physics, and daily life examples from them (see Table 8), and frequency distribution of how people perceive physics and their favorite topics in physics (see Table 9) were constructed.

Table 7. Reasons to learn physics and physics perceptions

	Why do you learn physics?													
physics	like	course	imp	curiosity	No idea	need	other	per	con	exam	life	nature	univ	Total
boring/meaningless	2	6	1	0	6	4	0	2	0	4	1	0	1	27
branch of science	3	6	10	0	7	23	0	8	15	3	22	19	11	127
chemistry	1	0	0	0	1	1	0	1	1	0	0	0	0	5
concepts	0	3	1	0	4	9	0	1	2	0	5	3	1	29
course	4	12	1	0	6	5	0	0	6	9	2	2	0	47
don’t know	0	3	0	0	12	0	0	0	0	2	1	0	0	18
everything	4	3	1	2	2	2	0	5	0	2	6	7	1	35
formulas	0	2	0	0	3	2	0	0	0	1	1	2	3	14
fundamental science	0	0	0	1	1	1	0	0	0	0	5	2	2	12
holly	0	0	0	3	2	8	0	1	0	0	0	1	3	18
laws	0	0	0	2	3	1	0	1	0	0	1	3	2	13
nature/life	3	3	3	3	3	13	0	10	3	5	23	13	6	88
philosophy	1	0	0	0	1	2	0	1	0	0	0	0	0	5
physical appearance	2	2	2	1	26	2	15	4	1	0	2	3	0	60
science	1	1	0	0	4	1	0	0	1	0	0	0	0	8
universe	0	1	0	3	1	2	0	3	0	0	1	2	3	16
other	2	2	2	1	6	7	0	6	0	0	1	3	1	31
Total	23	44	21	16	88	83	15	43	29	26	71	60	34	553

Abbreviations: Like: because I like, course: because it is course, imp: because it is important, no idea: don’t have any idea, need: needed in daily life, per: personal improvement, con: to learn concepts, exam: to pass exams, life: understand life better, nature: understand nature, univ: understand universe better

Table 8. Daily life examples and physics perceptions

	Themes of daily life examples											
physics	abs	broad	devices	frag	No example	evr	gra	obs	art	personal	pa	Total
boring/meaningless	0	2	5	1	8	2	1	3	1	5	0	28
branch of science	2	9	11	12	15	7	10	21	10	27	1	125
chemistry	0	0	2	0	2	0	0	0	0	0	1	5
concepts	0	1	1	2	2	4	3	4	2	10	1	30
course	0	7	5	2	11	2	3	2	11	2	2	47
don’t know	0	1	1	0	13	1	0	0	0	1	1	18
everything	1	1	5	1	0	7	2	4	4	10	0	35
formulas	0	1	1	1	2	0	1	2	1	4	1	14
fundamental science	0	1	2	0	0	2	2	2	1	2	0	12
holly	0	0	0	1	2	2	2	2	5	4	0	18
laws	0	0	0	2	2	1	1	2	2	3	0	13
nature/life	1	5	14	5	3	17	4	12	6	20	1	88
philosophy	1	0	1	0	1	0	0	0	0	2	0	5
physical appearance	0	6	0	3	11	1	0	1	2	10	25	59
science	0	2	1	1	2	0	1	0	0	0	0	7
universe	0	0	1	4	1	1	0	4	2	3	0	16
other	0	3	0	3	12	3	0	1	1	5	2	30
Total	5	39	50	38	87	50	30	60	48	108	35	550

Abbreviations: abs: abstract examples, broad: broad examples as whole field such as electricity, optics etc, frag: direct fragmented concepts, evr: everything, gra: gravity, obs: observations from nature, art: observations of artifacts, personal: personas examples, pa: physical appearance

Table 9. Favorite topics in physics and physics perceptions

	Favorite topics										
physics	ast	em	et	invalid	mech	mod	nop	nothing	opt	therm	Total
boring/meaningless	0	5	2	2	9	2	0	5	1	0	26
branch of science	1	21	4	9	46	22	1	6	8	6	124
chemistry	0	1	1	2	0	0	0	1	0	0	5
concepts	0	2	0	5	11	6	0	3	0	2	29
course	0	8	0	7	14	3	1	9	3	2	47
don't know	0	0	0	7	2	0	0	7	0	2	18
everything	1	9	0	1	13	9	0	0	2	0	35
formulas	0	1	0	1	7	3	0	1	0	1	14
fundamental science	1	2	0	0	4	2	0	1	2	0	12
holly	0	2	0	0	6	7	0	0	3	0	18
laws	0	3	0	0	8	1	0	0	0	1	13
nature/life	3	10	5	5	32	19	1	1	7	4	87
philosophy	1	0	0	0	1	2	1	0	0	0	5
physical appearance	0	1	4	29	8	0	0	11	1	3	57
science	0	1	0	1	1	1	0	3	0	0	7
universe	0	7	0	1	5	1	0	1	1	0	16
other	0	1	2	13	10	3	0	0	0	1	30
Total	7	74	18	83	177	81	4	49	28	22	543

Abbreviations: ast: astrophysics, em: electromagnetism, et: every topics, mech: mechanics, mod: modern physics, nop: nature of physics, opt: optics, therm: thermodynamics

Offline survey

The offline survey was taken by 22 undergraduate physics students. Five of these students explained physics as a branch of science that makes people's life easier. For example one of the students defined physics as follows: *"Physics is a branch of science that shows the ways to make life easier. Little information supplied by physics makes challenging jobs easier."* Similarly one of the students defined physics as *"... a branch of science that that tries to make the work we do in our daily life easier".* On the other hand more than half of the students (f=13) defined physics as a branch of science that explains the events in nature. One example of these answers is as follows: *"Physics is a branch of science that explains what happens in daily life."* One other answer was as follows: *"It is the science of nature. It aims to find the consequences and reasons of every event on earth. It explains physical properties of everything."* Two of the students gave several physics concepts such as force as the definition of physics. Two of the students defined physics as a hard course.

In answer to the second question these students were asked why they were learning physics. Four of the students, who also defined physics as a branch of science that makes life easier, stated that we learn physics to have the knowledge required to make life easier. On the other hand, one of them stated that they learned physics for employment purposes. Ten of the students (who also defined physics as a branch of science that explains the events in nature) stated that we learn physics because in that way we will know our life and nature better. However, three students stated that they studied physics because it was a necessary component of their future job. Three of the students stated that they did not know why they had to learn physics.

In the third question, these students were asked to give several daily life examples of physics. From the results it was found that female students and male students answered these questions

in distinctly different ways. For the female students the most popular answers were related with *in-house physics* such as heating, room temperature, use of scissors, and so forth. The following answers are examples of this issue:

"Wheelbarrow, scissors, choice of boots in winter"

"Clock"

"Glasses, machines, electricity that we use"

"Calculation of travel duration, calculating how long it takes to make an ice cream"

"Boling water when cooking, construction, temperature of room"

"Motion in car, temperature, heating and expansion"

On the other hand, male students gave examples related to cars, motion, and construction. The following answers are examples of this:

"Inertia and acceleration when we are in a bus. Wind, solar system, sound waves, hot chocolate"

"Heating with sunlight, car engines"

"Law of gravity, velocity, acceleration, glasses"

"Car engines, electrical devices, automobiles, planes"

"Screw drivers, opening cola cans, writing"

"Construction, light bulbs, electronic devices"

Finally, in the fourth question, participants were asked about their favorite physics topics. However, no interesting themes emerged from their answers. It was seen that mechanics related topics such as *work/energy*, *kinematic*, *motion*, and *momentum* were the most popular topics among both females and males. However, it was seen that *quantum* was a popular answer among males (f=3).

Semi-structured interviews

The first part of the semi-structured interviews was conducted with two male undergraduate science students. The following extract of that interview outlines the important part of the interview about what physics is. 'I' stands for the researcher, 'S1' stands for Student 1, and 'S2' stands for Student 2. Student 1 and Student 2 had similar high school experience, but Student 1 had one year of experience in another undergraduate program (Mechanical Teaching) and had studied several undergraduate level physics courses such as electricity and static. Student 1 liked to read the books of Stephen Hawking, and he stated that he hated physics until he came to the Science Teaching undergraduate program. On the other hand, Student 2 stated that he used to read popular science magazines before he started his undergraduate program.

I – *"What is Physics?"*

S1 – *"Physics is a branch of science that helps us to have the meaning of the events that happen around us... With the help of physics and the laws and theories that physics has we understand life, for example, the motion of a car or photosynthesis."*

I – *"So, something happens in our life that is meaningless for us at the beginning. And studying physics helps us to clearly understand that is happening"*

S1 – *"Yes"*

I – *"Student 2, what do you think about physics? Do you agree with your friend?"*

S2 – *"I agree with what he says. Physics is our life. For example, this shining light around us is physics."*

I – *"If you think physics is our life, so what are chemistry and biology? You are science students. There is chemistry and biology as well as physics in your major. So if physics is our life what are the others?"*

S1 – *"When a physical event happens, there are several sub events. With respect to that we can see chemistry and biology as sub-branches of physics. For example, when we think about the water cycle, there are chemical and biological events there."*

I – *"Where is the biology in that event?"*

S1 – *"Ecosystem. This can be counted as biology. This cycle helps the living to have the water that they need."*

I – *"Student 2, do you agree with him?"*

S2 – *"I can say that all of these are intertwined together. Each of these gives us the meaning of life."*

I – *"But, before, you said physics does this. Now you are saying that chemistry and biology do the same. So should I understand that there are other things than physics to understand life?"*

S2 – *"Yes, but physics is superior to the others."*

I – *"So, is physics more comprehensive than the others?"*

S2 – *"Yes"*

S1 – *"Yes, but physics is the core of them. If we think that physics is a core, we can say that this core has products that are chemistry and biology."*

As it can clearly be seen from the extract given above, these two male students thought of physics as the *major branch of science* that covers biology and chemistry, and helps us to understand our world. This result is parallel with one of the results from the online structured interviews (15.6% of the participants from those interviews stated that physics is *life/nature*). Another interesting extract from this interview is given below.

I – *"You have learned physics concepts from primary school to now. As an undergraduate student, do you think your thoughts about physics changed during that time? In other words, do you think that physics is different from what you previously thought?"*

S1 – *"Yes, it has changed for me. Before, in chemistry or biology, I was thinking that each event was only biological or chemical. But now, I am thinking that each of these events is linked together and they have physics in them. Therefore, I concluded that physics is basic for the chemistry and biology."*

I – *"Student 2, do you agree with him?"*

S2 – *"Yes."*

I – *"Can you define physics?"*

S2 – *"I can't define it exactly, but, from sunshine to nature, there is physics. Therefore I can say that physics is life."*

As can be seen from the extract given above, the students thought that their education changed their views on physics. They see each event connected and all of these have physics in them. The interview continued with asking them about the reasons for learning physics.

I – *"Why do we learn physics?"*

S2 – *"Because, learning physics allows us to understand life better."*

S1 –*"I agree with him. Additionally, we learn physics in order to make life easier and to know unknowns. Now we don't know many things in life. We don't know reasons for many events. In order to know them, we need physics."*

This extract showed that the students thought that they learned physics because it would help them to understand life. It was seen that these two students tried to connect each of the physics concepts they learned from physics courses with the several events they had seen in science-fiction movies. For example, later in this interview, the students stated that they thought about time-travel with respect to the concept of time in physics.

In the third question of the interview, the researcher asked students to give several distinct examples of physics in their life. Student 2 stated that *"sunlight coming through the windows"*, *"temperature of the water used to wash his hands"*, *"motion of the school bus"*, and *"friction between foot and ground that helps walking"* as examples. On the other hand, Student 1 gave the examples of *"energy that allows us to walk"*, *"relative speed of the things when I look from the moving bus"*, and *"when entering to a hot place the feeling that I felt"*. In the last question of the interview, the students were asked what their favorite topics in physics were.

I – *"What are your favorite physics topics?"*

S2 – *"Motion and acceleration"*

I – *"Why are these topics?"*

S2 – *"Because I face these much in my daily life"*

S1 – *"Modern physics concepts such as relativity and astrophysics"*

I – *"Why are these topics?"*

S1 – *"Because Newtonian mechanics is not current. I follow the things that are helpful to me. For example I wonder about the time concept a lot. And learning these concepts will be good for me. Modern physics allows me to answer the questions that I am curious about."*

This illustrates how these two students differ with respect to their favorite topics and their reasons for enjoying these topics. Student 2 liked the topics that he faced in life. He further explained in the interview that he liked to learn these topics because they would allow him to understand his daily life better. However, Student 1 was more into the mysterious side of the events. From the interview, it was found that he liked the topics that allow him to satisfy his curiosity.

The other part of the semi-structured interview was carried out with two female undergraduate science students. Student 3 had two years of experience in another undergraduate program (environment engineering). She stated that she hated physics when she was in high school, but that she likes it a lot now. She described the reason for her previous dislike of physics as being due to the amount of mathematics involved. On the other hand, this was the first undergraduate program for Student 4. The girls were asked to answer the question regarding what they thought physics is.

I – *"What is Physics?"*

S3 – *"As for me physics is both life and all of the rules together. In such a manner it covers our life directly. I said it is all of the rules because everything in physics includes a rule. It is both life and all of the rules together. Rules and life have a relationship."*

I – *"What type of rules are these?"*

S3 – *"For example, there are the rules of inertia and Newton's laws of motion. They are all rules. Something like, if something happens, that will happen too. These rules affect our life. We don't follow the rules every time but it affects our life."*

S4 – *"Actually, Isn't it the lack of rules? For example there is something going wrong. There is lack of something. And when you make efforts to explain these things you formulate the rules. I think it is like that."*

S3 – *"If we ask people about rules of the physics, they don't know what it means. An apple drops to the ground, and this has a reason. But when we ask people why is that, they don't know if they were not taught about it in school. But it affects our life even so."*

I – *"How does it affect our life? If I know what makes that apple drop, what can I do with that knowledge?"*

S3 – *"Actually we can't do anything. All I want to say is that there are these rules and we are not aware of these. But they affect us. We don't question each of the rules as they affect us. Such as the rules of mathematics, etc. However, I think these rules affect our life absolutely."*

S4 – *"We live under this effect. If there is no gravity, nothing will stand like this (shows the things on the table)."*

I – *"I am trying to figure out how these rules affect us. If we didn't know these rules, what would happen? Why do we need physics in that case?"*

S3 –*"With the help of these rules, we are aware of the events happening around us. I mean it when I say it affects. I can understand life more clearly with these rules. It directs me to the new way. My life has more meaning with it. .....There are already many things happening, and I can have an idea what will be next if I know the rules. That is the purpose of science."*

I – *"So Student 4, let's back to you. What is physics for you again?"*

S4 – *"It is all of the irregularities. There is lack of rules. There is something happening and there are no rules for how it happened. Some people bring all these together, and explain with the rules. That is physics. Physics exist for this ....in order to understand life."*

As can be seen in the extracts given above, the female students' reasoning regarding physics is much more complicated than the males who gave straightforward definitions of physics. However, in both interviews it was seen that both male and female students thought that physics is something that helped them to *understand life better*.

After that question the students were asked about why they were learning physics. The dialogue quoted below outlines their views.

I – *"Why do we learn physics?"*

S4 – *"It is all about the education system. We have to learn. Government says us to that you have to study this. Otherwise we can't have higher education. However, the reason behind offering physics in schools is making people aware of the world. Making them conscious about their life.... Helping people to question the events happening around them."*

I – *"For you, Student 3?"*

S3 – *"In order to learn about life. In other words we need it to see life. It makes life easier. That is why we learn physics."*

These two students were different in respect to their answers. Student 4 approached this question in two ways: first, as the requirement of the education system; and second as making people aware of the world. However, Student 3 had a similar reason as Student 1.

In the third question, the researcher asked the students to give several distinct examples of physics in their life.

I – *"Can you give several examples of physics around you?"*

S4 – *"Gravity. Dropping an apple. Motion of the object when you touch it.... Light, waves...."*

I – *"For you, Student 3?"*

S3 – *"Nature. Sky.... Eclipse. Volcanoes. They are all physics."*

While male students gave examples directly from their daily life, the female students were more concept-oriented.

Finally as a last question, the students were asked what their favorite physics topics were. The extract given below shows the students' answers.

I – *"What are your favorite physics topics?"*

S3 – *"Modern physics. I don't like mechanics. I understand modern physics topics easily.... Photoelectric event"*

I – *"For you, Student 4?"*

S4 – *"I like the conceptual part of physics.... Atoms"*

S3 – *"I don't like the physics with formulas."*

It is clearly stated that both female students enjoy physics without formulas and math. These two students were enrolled in the 'Introductory Modern Physics' course that is taught in a conceptual manner. This fact might have affected their answer, which outlines several modern physics related topics.

Focus Group

In the focus group, physics graduates were simply asked "What is physics?" From the focus group discussion, it was found that the participants did not have a deep understating of physics and they did not go beyond the simple answer that "physics is life". This result is surprising because these are almost the same as the thoughts of non-physics majors. The following extract from the discussions outlines this issue.

I – *"What is physics?"*

STA – *"Physics everything in life."*

I – *"For example?"*

STA – *"Sky is blue and physics is there to say why that is."*

STB – *"Physics explains every event in life."*

I – *"So what is chemistry? What is biology? Don't they help us to understand events in nature?"*

STA – *"They help too. But physics is in them too."*

STC – *"Ehmm. Is chemistry same as physics?"*

STA – *"No. (Stuck!)"*

STD – *"It investigates matters and components of matter. With respect to this, it is like chemistry."*

STE – *"Physics helps us to explain the events in nature."*

In this focus group, when the participants discussed chemistry and biology, the researcher asked for the differences between a physicist and a chemist/biologist. The students insisted that physicists give the answers to how and to demonstrate this they gave examples of physical events in chemistry and biology, such as breathing. One of the students stated that *"…. while breathing, the diaphragm moves and pressure changes. So this event is also physics itself".* This is a logical approach; however, it seemed that the students overlooked biology and chemistry and continued to state that physics is everywhere with the following statements: *"Physics is something that allows us to understand everything in the whole universe."*, *"Physics helps us to determine how much we understand our life."*

The researcher wanted to have more a specific definition of physics and guided participants towards this. The following extract of the discussion gives details of how they further perceived physics.

I – *"Can you give me a more concrete/specific definition of physics?"*

STF – *"The word physics comes from nature; therefore, physics is natural philosophy"*

I - *What is philosophy?*

STD – *"Philosophy is thinking about thinking."*

I – *When does this process of thinking about thinking begin?*

STD – *"When we become to see."*

I – *"More concrete definition?"*

STD – *"The answers to how and why type of questions."*

I – *"What are these questions about?"*

STD – *"It is about nature"*

STE – *"Physics is something about matter.... Physicists are the one questioning about behavior of matter."*

STE – *"…. Someone cannot compare the color of the water in a bottle and water in the sea. However, physicist can explain why we see the blue color of the sea."*

As can be seen from the extract given above, the participants defined physics as nature or *natural philosophy*. However, they could not be more specific and couldn't supply coherent information to delimit the interests of physics and physicists. One of the students stated, *"As for me, we can't define physics with sentences"*. Further he expressed that physics needs mathematics to express the ideas. Additionally, it was observed from the focus group discussion that most of the participants were confused about the conceptual definitions and they tried to give examples of physics topics with formulas/mathematics such as F=m.a for Newton's Second Law of motion.

Discussion, implications and conclusion

The analyses of the data collected with the online survey, offline survey, semi-structured interviews, and focus group interviews showed that people perceive physics in different ways. It is seen that their perceptions of physics are fragmented. The results of the online survey

showed that public perceptions of physics were structured around 15 themes as follows: branch of science, nature/life, physical appearance, course, everything, concepts, emotions, mystic, universe, formulas, laws, fundamental science, science, chemistry, and philosophy. The results of the current study showed that females perceived physics differently from males. It was found that *branch of science*, *physical appearance*, *course*, and *emotions* themes were more superior for female participants.

The results of the study showed that language is one of the factors that affect how people perceive physics. In the current study it was found that a significant number of the participants described physics as the physical appearance of people. Additionally, 8.1% of the teachers perceived physics in the same way. It is not clear if this shows that these people have no idea of what physics is, or if they just link it with the closest word they know. However, it is worth noting that in Turkish, we have the exact same word (fizik) that is used for both physics and physical appearance (build). Similar findings were found by IOP (2008). In that study, 11% of the participants connected physics with physical exercises.

Moreover, the results of this study showed that even undergraduate students of physics and physics graduates perceived that physics is different from what it actually is. Their definitions of physics were mostly broad, and it was found that the students see physics as something that helps them to understand nature. This finding also coincides with that by Marx (1983). This is not wrong; however, it would be expected that physics majors would have a definition with more specific examples. Physics, as defined by the undergraduate science students and the physics graduates is somehow similar to the definitions of *science* held by primary level students (Squires 1980; Zeman 2005; Karakas 2011). It was also determined that both the science and physics majors who participated in the current study see physics as the *major branch of science* that covers both biology and chemistry. From this point of view, it is hard to differentiate physics, even all other branches of science, from the broad definition of science itself. However, as a discipline, physics should have its own definition with respect to its perspective to nature and the universe.

The results from the offline survey with undergraduate physics students revealed that female students and male students differed in the examples of physics that they provided. For female students, the most popular answers were related with *in-house physics* such as heating, room temperature, and use of scissors; whereas, for male students the answers were more related to cars and construction. It was discovered that female students' reasoning on physics is much more complicated than their male counterparts who had straightforward definitions. Additionally, it was seen from the semi-structured interviews with science undergraduate students that the previous education of the students could change their views on physics.

The results of this study add an important contribution to physics education researches. If we know more about how people perceive physics, we can design physics instruction that takes these perceptions into account to produce a more effective, interesting, and formative learning environment. However, it should be noted that this study is limited to public perceptions as well as higher education students' and graduates' perceptions. As the nature of the research methodology, it is not intended to generalize the results of the study to the population. Future researches can be carried out with younger students especially the ones at K-12 level. Additionally, empirical studies can be conducted to relate the possible effects of students' views on physics, as well as their understanding.

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