The cognitive structures of high school students regarding immunity before the Covid-19 pandemic

Muhammed Salman[a], Bahattin Deniz Altunoğlu[a]*,

[a] Kastamonu University Faculty of Education, Kastamonu, 37100, Turkey

Abstract

In this study, it was aimed to determine high school students' cognitive structures regarding to the immunity, infection, allergy and autoimmunity. In this study, it was tried to reveal the cognitive structures of high school students on immunity, infection, allergy and autoimmunity just before Covid-19. The study was carried out with 77 students. The data collection tool was Words Association Test. The data collection tool was prepared separately for each stimulus word which were immunity, infection, allergy and autoimmunity. These stimulus words were chosen since these are the subthemes of the Immune system in the Turkish Secondary Biology Curriculum. Data analysis was performed for each stimulus word. The content analysis and coding of the data resulted in the categorization of the data. Considering the categories, models of the students' cognitive structures were drawn. In addition, the correlation coefficient was calculated according to the similarity between the answers given to each stimulus word. As a result, in our study, it is seen that the basic concepts of immunity, infection, allergy and autoimmunity are not predominantly structured in the minds of the students. It is worrying that basic concepts such as antibodies, passive immunity, and T cells are very rare or absent in the study.

Keywords: Immunity; high school students; biology education; cognitive structures

* Corresponding author name. ORCID ID.: https://orcid.org/0000-0001-7609-188
  E-mail address: bdaltunoglu@kastamonu.edu.tr

1. Introduction

The need to reorient the science curriculum to a science-environment-health perspective has been discussed extensively (Zeyer & Dillon, 2019). We can look for the reason in this question: Was the current science curriculum able to prepare humanity for the current Corona epidemic or an epidemic that is likely to occur after that? Unfortunately, we can say that the answer to this question is a simple "no" when we look at the chaos that emerged with the Covid-19 pandemic, the increase in anti-vaccination tendencies and the acceptance rate of conspiracy theories.

The mutually beneficial situation between science education, environmental education and health education, three educational dimensions still seems to be lacking in an interdisciplinary dialogue (Zeyer & Dillon, 2014). These three areas stand before us as the main theme of today's world problems. That said, the most important feature of these three main themes is that they are related to living things. In other words, they are within the field of interest of biology by definition. Whether analyzed in the past (e.g., as part of introducing HIV, Spanish flu) or dwelled upon today to discuss the current epidemic, the immune system, which is taught as a subject of biology, is indeed very important for students to gain the knowledge and to use this knowledge to make decisions on some vital issues such as vaccination. A lack of understanding of the basic principles of biology means that students do not and cannot make informed scientific decisions about their health (Lukin, 2013). It should not be overlooked that producing the vaccine, which is very important in ending an epidemic by allocating billions of resources like the Covid-19 pandemic, is no longer sufficient in the post-truth era we live in. In addition to producing a vaccine, unfortunately, fighting against conspiracy theories pertaining to what the vaccine is, what it does, what the epidemic is and how to end it, can be made possible through assuring health literacy and scientific literacy, which starts with having information about the immune system (Kienhues et al., 2020; Sarıbaş & Çetinkaya, 2020). Arguably, vaccination plays a vital role in ending any relevant pandemic. Vaccination provides direct protection to the vaccinated individual and indirect protection to the community with the benefits of herd immunity, also called herd immunity. When a sufficiently high proportion of the population is vaccinated, an overall reduction of disease transmission in the population can prevent epidemics and thus protect unvaccinated individuals (Griffith et al., 2020). Learning immune information then becomes highly critical to ensure this in individuals. Understanding the immunological processes is also essential in terms of being able to recognize and explain the threats to the survival of individuals when they are exposed to health problems caused by viruses such as HIV-covid, and finally to make a sound scientific decision (Mosothwane, 2009). Verily, comprehending how the immune system works is significant for assessing the etiology (cause), progression, and treatment of a wide variety of diseases (Justement & Bruns, 2021). Therefore, immunology education has historically been

tightly linked to infectious diseases (Bruns et al., 2019). Human immunology is never an easy subject for students to learn though. Although the studies on immunity, especially at the high school level, are few, this difficulty is mentioned in all of the studies. Regulation of human immunological defenses is a physiological process that intertwines both humoral and cellular interactions between various cell types and antigens, and students are often confused and experience difficulty learning about this topic (Da Rosa et all., 2003). Even for teachers, knowing how to consistently explain to students the molecular and biochemical aspects of the immune system seems like a challenge. Thereupon, most teachers are likely to use relatively more traditional courses to teach human immunology. Howbeit, traditional didactic guidelines are often teacher-centered enabling almost no interaction between students and teachers or amongst student peers, all of which make lessons boring and ineffective (Su et al., 2007).

When we take a closer look at the studies on immunity, it appears that studies are mostly carried out in the departments of health sciences such as medicine and nursing, and in countries with high populations such as Africa, India, China, where epidemics are very common. Specifically, it has been observed that there are not many studies that concentrate on the learning of immunity at the high school level. It is noteworthy herein that due diligence studies, which are very common in other areas of the field of biology and health education, are scarce when it comes to immunity. Considering the pandemic, we are going through and the infodemics that emerged with the pandemic, it is urgent to carry out studies focusing on ways to teach the immune system well at the high school level. One can italicize that studies on immunity at the university level are more than those at the high school level. That said, when the studies conducted on the immune system and other fields (e.g. microbiology and neuroscience) at undergraduate and graduate levels are examined, it is clear that studies on immunity are less (Bruns et al., 2019). From this point of view, it can be concluded that immunity is not given the importance it entails at any level of education viz. from basic education to postgraduate education. The relative abundance of undergraduate and graduate research on immunity should worry us because it is obvious that trying to teach the subject of immunity in today's age with only university-level studies will not be that effective (James et al., 2019). It is of crucial importance to teach the immune system systematically at all levels of education.

The aim of this study is to unearth the cognitive structures of high school students respecting immunity with the data collected in a time just before the Covid-19 epidemic broke out. It is thought that the results of this research will contribute to the prediction of students' evaluations of the current pandemic.

2. Method

This study was carried out to determine the concepts that shape the mental models of High School students regarding the concepts of Immunity, Infection, Allergy and Autoimmunity. We used the free word-association approach to uncover qualitative data that was then analyzed using content analysis.

2.1. Participants

As the study group, 77 students of the 11th and 12th graders in Kastamonu Province of Turkey in the 2018-19 academic year were selected. An easily accessible sampling method was preferred in determining the participants. Kastamonu is a city with a population of 130000 and is located on the west side of the Black Sea region of Anatolia. Participant (subject) characteristics.

2.2. Data collection tool and data collection process

In accordance with the purpose of the research, the Free Word Association Test was employed to determine how the concepts related to the concepts of Immunity, Infection, Allergy and Autoimmunity were formed. The secondary Education Biology Curriculum (Ministry of National Education-MoNE, 2018) was examined to determine the stimulus words. Accordingly, the words Immunity, Infection, Allergy and Autoimmune were selected as the stimulus words, taking into account that they are the basic themes structured in the curriculum as subject matter of the immune system. In essence, immunity is the function that a system performs, so it can be described as a super concept. The word "infection" has been chosen as a related upper concept because it is one of the situations where the immune system performs its duty to protect and defend the body. The words "allergy" and "autoimmune" have been chosen because they are upper concepts that define the malfunctions in the functioning of the immune system within a certain framework.

Actually, Johnstone (1967) used the Word Association Test (WAT) firstly in terms of science concepts. The WAT is a method that is frequently used to determine the words or concepts in the mental structure in relation to the stimulus word or concept in the long-term memory of individuals (Bahar et al., 1999). By identifying the words (concepts, adjectives, singular examples, and alike) that shape the cognitive structure within the framework of a particular subject area, the Word Association Test can be described as one of the tools that can be adopted to determine whether meaningful learning has taken place (Özatlı & Bahar, 2010). The data obtained with WAT are evaluated using different methods. One of these methods is based on the correlation coefficient calculation proposed by Garskoff and Houston (1963). In this calculation, the order in which the common response words produced by participants for different stimulus words are

written on the WAT form is significant. The closer the common ones and the order of the concepts that two concepts are associated with, the more these two concepts or words are acknowledged to be related in the mental structure. In the present study, the correlation coefficient was calculated to determine the extent to which the connotation words given to two stimulus words overlap. It was calculated according to the formula suggested by the correlation coefficient Bahar et al. (1999).

In the second part of the WAT form, participants were asked to make a sentence about the response words they wrote about the stimulus words. The explanations of the participants in relation to the stimulant words were discussed in reference to the categories that appeared in the WAT.

Whilst grouping the statements according to categories, meaningless and non-propositional statements were not taken into account. In addition, alternative concepts that contradict overall scientific knowledge were tried to be determined within the expressions of the participants. WAT was presented to the participants in the form of separate sheets for each stimulus word. For this reason, four different WAT forms were presented to the participants. 40 seconds for the first part of the WAT form and 20 seconds for the second part were allocated. With the help of the data collection tool, the participants were asked to write the words that evoked in their minds within the time given into the blanks opposite the stimulus word listed 10 times one after the other.

The form of the first part of the WAT is as follows:

1-Immunity

2-Immunity

3-Immunity

….

10-Immunity

The second part of the WAT is in the following form: Make a sentence with the words above: …………………… formatted. With this type of application, it is intended to determine how the association words are used in the context of the stimulus word. In this way, how the participants define their concepts, the relationships they establish between the concepts and their alternative concepts can be disclosed (Kurt, 2013b; Kurt & Ekici, 2013)..

Data analysis

In the current study, the data obtained in the first part of the WAT form are the association words associated with the keyword in the minds of the participants. In the analysis of the response words, the frequency of that word was determined by identifying how many participants wrote the words in WAT form. Response words are classified under categories according to their semantic relations. In this classification process, the

words written by two or more participants were paid attention to, and the words expressed by a single participant were not included in the analysis. Two researchers and a biology education specialist semantically analyzed the data collection tools filled in by the participants separately. Analysis by these dissimilar experts was warranted with a view to minimizing the subjectivity problem that may arise due to the nature of qualitative data (Yıldırım & Şimşek 2005). Analysts came together and discussed the categories in which the response words were clustered and reached an agreement on the categories. During the gathering process, first of all, similar categories of each analyst were spotted, and different expressions that emerged with the same meaning for the category names were agreed upon. In this way, common names were detected for the categories with a consensus. In the classification of the categories and response words with disagreement, discussions took place until a consensus was arrived at. In cases where there is no consensus, the condition that the two analysts agree is considered sufficient.

3. Results

The cognitive structures of the students participating in the study related to Immunity, Infection, Allergy and Autoimmunity which are regarded as major concepts were obtained with the Word Association Test (WAT). Within the framework of stimulant words, the distribution of the words obtained as a result of WAT by categories and their models of cognitive structure are shown in Figure 1 for Immunity, Figure 2 for Infection, Figure 3 for Allergy, and finally Figure 4 for Autoimmunity.

When the WAT data of the concept of immunity were evaluated, it was realized that seven categories emerged (see Figure 1). When these categories are scrutinized according to the frequency of the words they contain, the most dominant category is the Immunity definition (f=84) category. The words in this category are generally synonymous of the word immunity or describe the concept of immunity. When these words are delved into, it is witnessed that students write especially the words Resistance (f= 19) and Health (f=15) were prominently more frequently written compared to other words in the category. When we look at the other dominant categories in terms of word frequency, these categories are perceived as Immune response stimulators, Immune response of the organism, Structures involved in immunity and Artificial immunity. It was figured out that the frequencies of these categories varied between 67 and 62. When the word frequencies are examined in the category of structures involved in immunity, it is noticed that the most repeated words are White blood cell (f=10) and Lymphocyte (f=9). When Figure 1 is examined, it is notable that the word frequency in this category, which comprises the elements of the immune system, is high, but the frequency of words varies between 10 and 2. It has been specified that the first three words in the frequency order of the words related to the concept of immunity are Illness (f=37), Virus (f=28) and Germ

(f=22). Since the frequencies of words such as Antibody, Antigen, Lymphocyte, T-Lymphocyte, B-Lymphocyte, White blood cell, and Thymus vary between 10 and 3, it can be suggested that the basic concepts in the category of structures involved in immunity are not included in the cognitive structures of most of the participants. It is the word Disease (f=37), which has a significantly higher frequency than other words in the category of responses given by the organism in immunity.
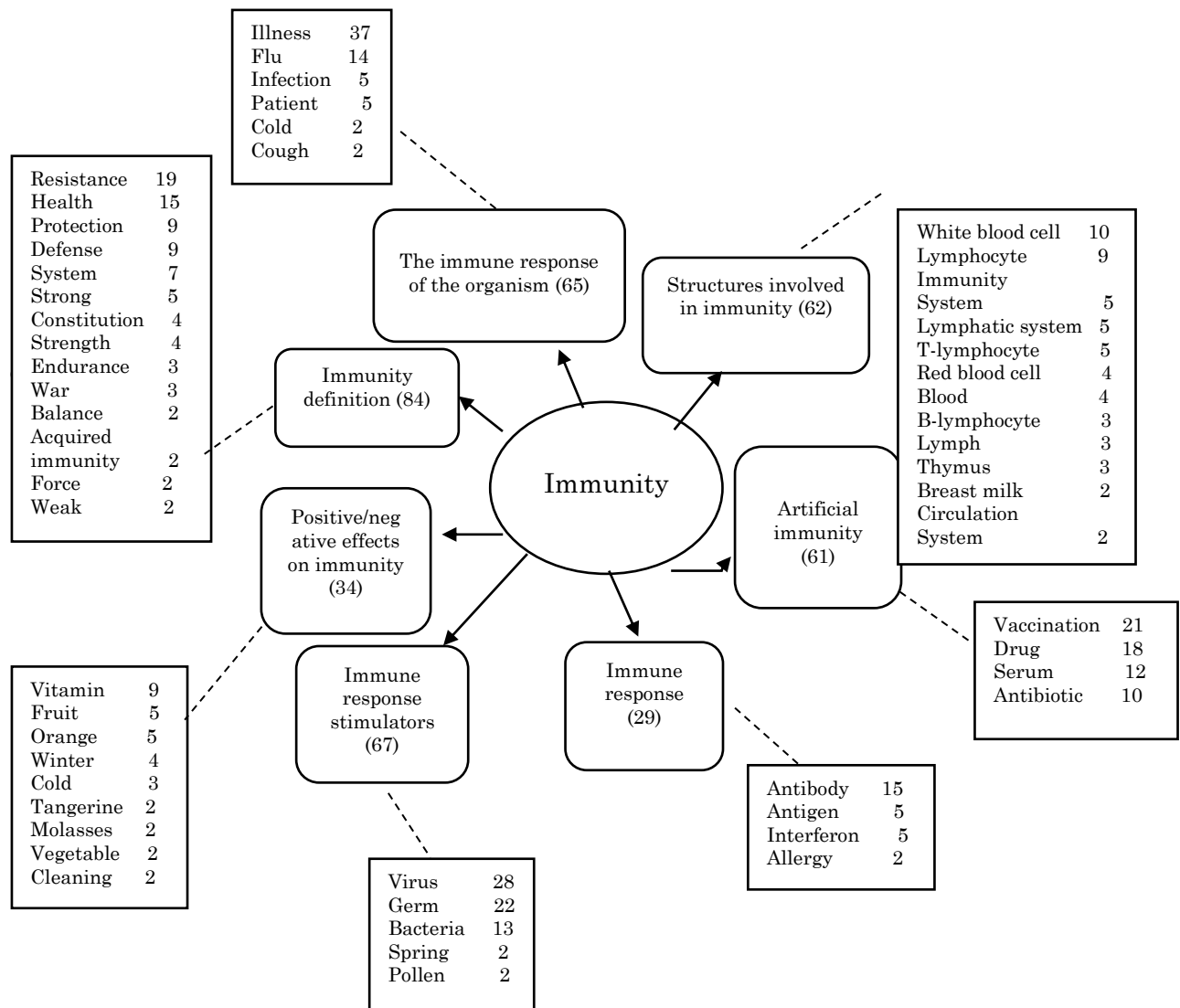

Figure 1 High school students' cognitive structures related to Immunity

It was concluded that most of the students did not focus on special concepts that are expected to be in this category within their cognitive structures, such as Influenza (f=14), Cold (f=2), Infection (f=5), Allergy (f=2). According to the results of WAT, the category

with the lowest frequency is Immune response (f=25). It has been discovered that Antigen, Antibody and Interferon in this category are included in the cognitive pattern of very few of the students participating in the study.

Participants' explanations as regards the immune-stimulant word were discussed vis-à-vis the categories that emerged in the WAT test. While grouping the statements according to categories, meaningless and non-propositional statements were not attended to like "White blood cells and lymphocytes fight against defects" in the category of "structures involved in immunity" (Students- S2), "B-lymphocytes provide immunity by producing antibodies" (S54). In the category of "Immune definition", there exist statements like "People with weak immunity are not resistant to diseases" (S12), "Primary immune response lasts for about ten days" "We get sick when our immune system collapses"(S22), "We must strengthen the resistance of the immune system"(S23), "I have a disease due to bacteria" in the category of "stimulators of immune response", In the artificial immunity category, the following are come across "Vaccination is not possible when sick"(S8) "Vaccination is given because the immune system is weak"(S16), I have got vaccinated today to gain immunity, "Vaccinations made before we get sick allow us to have a strong immunity against bacteria and viruses" In the category of "positive/negative effects on immunity", on the other hand are "Immune system weakens when winter comes" (S61), "I strengthened my immune system by eating fruit" (S21), and in the category of immune response "The drugs we use can cause allergies" (S53).

In addition to these, there are expressions that point to an alternative conception that contradicts scientific knowledge in participant expressions. For instance, "There are antibodies against antigens and there are interferons against viruses" (S7), "Antibiotic suppresses the immune system" (S5), "Our white blood cells fight against macrophages" (S3), "Vaccination is given because the immune system is weak" (S16), "Microbes cause disease because our antibodies are weak" (S55), "She reduced disease resistance by using antibiotics continuously"

Considering the WAT results performed with the concept of infection, it was determined that the students' answers were gathered in the most intense Diagnosis/treatment (f=95) category (see Figure 2). Other categories were determined as Infection agent (f=64), Infection symptoms (f=61), Infection definition (f=48), Infected organ (f=35) and Infection type (f=21). The word drug, is included in the most dominant category, diagnosis/treatment, has the highest frequency (f=26). The frequencies of other words in this category vary between 8 and 2. When Figure 2 is examined, it is realized that the words in the diagnosis/treatment category are medical procedures, the materials used in these procedures, health institutions and health workers. As the second dominant category, the infectious agent category is weaker in terms of word diversity compared to other categories. Microbe, the word with the highest frequency in this category, can be said to express a general concept. Other words in the category in

question are Virus(f=18), Bacteria(f=14) and Harmful creatures(f=3). It has been determined that they do not include a specific disease agent or pathogen examples, and connotation words express general groups. Considering the WAT results related to the concept of infection, it was determined that the concepts directly related to immunity were not included in the cognitive structures of the students participating in the study. Considering the total frequency of infection type category (f=21), it can be put forth that the dominance of students' cognitive structures is quite low.

Hospital	18
Drug	12
Needle	11
Doctor	10
Plaster	8
Antibiotic	6
Cream	6
Serum	4
Assay	4
Tincture diode	3
Emergency	2
Syrup	2
Dressing	2
İntensive care	2
Health	2

Germ	29
Virus	18
Bacteria	14
Harmful creatures	3

Illness	27
Immunity	8
To get infected	5
Patient	3
Contagion	3
Reaction	2
Inflammation	2

Wound	31
Open wound	5
Surgery	5
Stitch	2
Cut	2
Cleaning	2

Infectious agent (64)

Infection definition (50)

Way of infection (47)

Diagnosis/treatment (92)

Infection

Inflammation	20
Pain	8
Ache	6
Fever	5
Sneezing	4
Swelling	4
Inflammatory response	3
Whiteness	3
Yellowing	3
Stream	2
Inflammation	2
Bleeding	2
Irritation	2
Allergy	2

Possible infected organ (35)

Signs of infection (66)

Urinary tract	8
Throat	6
Lung	4
Ear	4
Tonsil	3
Eye	3
Respiratory tract	3
Intestine	2
Body	2

Type of infection (21)

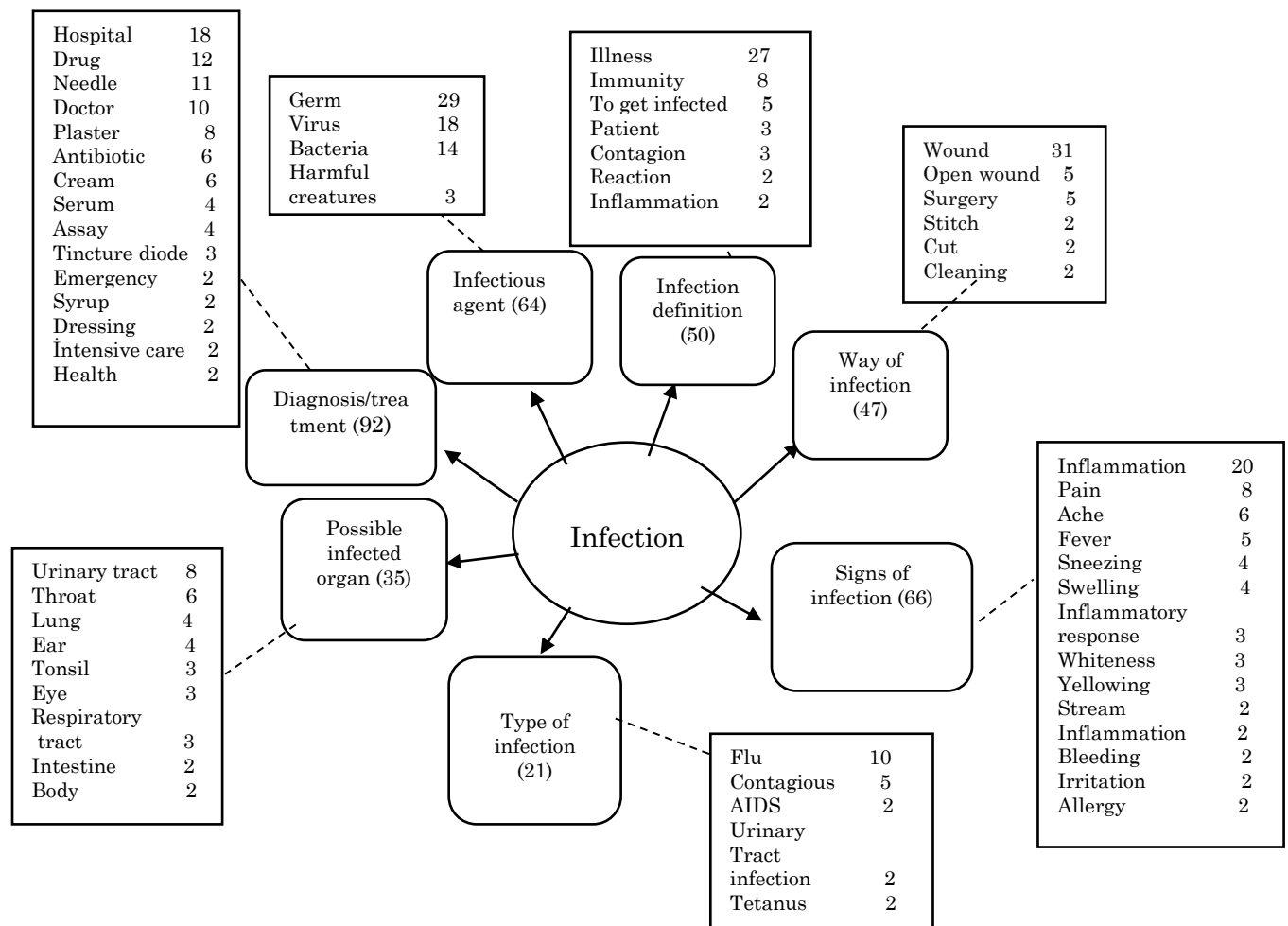| Flu | 10 |
Contagious	5
AIDS	2
Urinary Tract infection	2
Tetanus	2

Figure 2 Infection-related cognitive structures of high school students

The explanations of the participants concerning the infection stimulant word were discussed in connection with the categories that appeared in the WAT test. When the expressions of the participants concerning the stimulus word are examined, it can be put forward that they are mainly grouped under the category of "being infected".

Examples of expressions in the category of being infected are as follows "Infection may occur in the wound that is stitched after surgery" (S28), "Wounds on our skin may cause infection" (S57), "After stitching the wounds are covered with a cloth so that they do not get infected" (S53), "To prevent infection" the wound should be treated"(S36), "Rusty nail injuries can cause infection"(S73), "He cut his finger with a knife and the wound became infected" (S55), "If the wound becomes infected, it becomes inflamed"(S66), "If our wounds become infected, infection may occur"(S72). In the category of infection definition, "Inflammation occurs in the body with the introduction of antigens and can pass into the blood", "The disease transmitted by sneezing and coughing causes infection in our people" (S57), "infection occurs as a result of germs, bacteria, cold, wrong treatment or delayed treatment from wounds" (S70).

That being said, examples in the category of infected organs are "my tonsils are swollen" (S6), "I have an infection in my tonsils" (S7), "My throat is inflamed", "I learned that I have a urinary tract infection as a result of the urine analysis" (S65)

In the diagnosis/treatment category, "The infected area should be wiped with a clean cotton and bandaged" (S49), "We should make regular dressings to avoid infection from the wound" (S10).

The categories obtained by examining the data obtained with the WAT in respect of the concept of allergy, according to the frequency they contain, are respectively in the following form: Allergic reaction (f=164), Allergens (f=147), Allergy definition (f=45), Diagnosis/treatment (f=39) and it was determined that it was allergy type (f=15). Considering the frequency of categories, it is understood that the dominant categories are: Allergic response and Allergens. It was found out that the words with the highest frequency in the allergic response category were common reactions such as Redness, Itching and Sneezing. It was determined that the word with the highest frequency in the category of allergens was Pollen (f=52), and the frequency of other words varied between 14 and 2. It can be punctuated that there is a wide variety of words in this category and possible allergenic foods are the factors that increase this diversity. In the category determined as the definition of allergy, it can be stressed that there are words describing the concept of allergy. In the category determined as the definition of allergy, it can be indicated that there are words describing the concept of allergy. The frequency of words in this category varies between 12-2. When the words are considered in general, it can be underpinned that allergy mostly manifests itself in the cognitive structure as a disease, and it also takes place in the cognitive structure as a result of the response shown to an external factor with the word reaction/reaction. However, when it is considered in terms

of word frequency, it should be pinpointed that there is a clear predominance of the allergic response in the cognitive structure.

Illness	12
Response	11
Immunity	5
Infection	3
Blood	3
Adverse effect	3
Warning	3
Malfunction of body	3
Boredom	2

Redness	43
Itching	39
Sneezing	27
Swell	15
Watering of eyes	10
Coughing	9
Inflate	7
Nose stream	5
Eczema	3
Wound	2
Antibody	2

Drug	17
Doctor	7
Injection	5
Allergy test	4
Hospital	3
Cream	3

Allergic reaction (162)

Allergy definition (45)

Diagnosis/treatment (39)

Allergy

Pollen	52
Dust	14
Flower	12
Virus	7
Foods	7
Bee	6
Egg	6
Spring	7
Vaccine	5
Spice	5
Chocolate	4
Germ	4
Strawberry	3
Grass	3
Kiwi	3
Fruit	2
Feather	2

Sun allergy	6
Peanut allergy	4
Seasonal	3
Course diseases	2

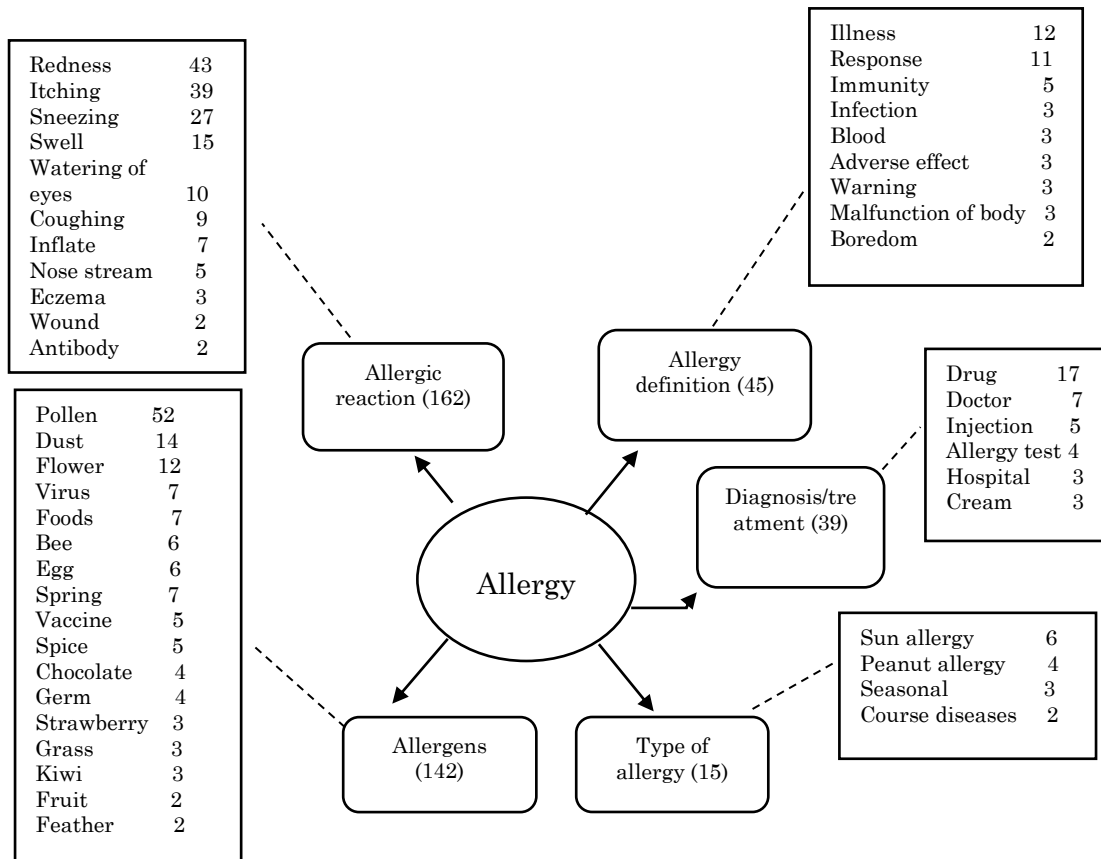Allergens (142)

Type of allergy (15)

Figure 3. Cognitive structures of high school students about Allergy

Apart from this, it is seen that the words Anaphylactic shock, Histamine, Anti-histaminic drug, Plasma cell, Mast cell do not exist, although they are important for health and are included in the curriculum. When Figure 3 is studied, it has been determined that the frequencies obtained with WAT in the matter of Allergy are significantly higher than the frequencies of the categories determined for the concepts of Immunity and Infection. The explanations of the participants relating to the allergy stimulant word were discussed in to the context of the categories that appeared in the WAT test. Examples of sentences in the category of allergic reaction are "Allergy is itching and red" (S1), "Symptoms of being allergic start with itching and redness" (S4), "Signs of allergy are blistering and itching on the skin" (S9), "Symptoms of allergies to sun and pollen are usually like redness, rash, swelling, itching" (S45), "Red spots on the body are signs of allergy" (S50), "Pollens cause me to cough" (S62).

Examples of sentences in the category of allergy definition are: "Allergy is the occurrence of redness, itching, vomiting, etc. in the body due to genetically allergic conditions" (S6), "Immune system collapses due to allergy" (S10),

Examples of sentences in the diagnosis/treatment category are "Allergy to pollen is detected by allergy test" (S59), "I am getting an injection for my allergy to pollen and I am taking rupafine [anti-histamine drug]" (S35)

As a result of the analysis of the WAT data related to the concept of autoimmunity, it was determined that the connotation words of the students participating in the study were collected in 4 categories: Autoimmunity definition (f=132), Immune structures (f=64), Autoimmune diseases (f=43) and Diagnosis/treatment (f=18) determined. As a result of the analysis of the WAT data related to the concept of autoimmunity, it was determined that students' response words were clustered in 4 categories: Autoimmunity definition (f=132), Immune structures (f=64), Autoimmune diseases (f=43) and Diagnosis/treatment (f=18). When Figure 4 is analyzed, it is viewed that the words in the category of Autoimmunity definition, which has the highest frequency, are the words that carry the word meaning of the concept of autoimmunity, define and describe the concept. Considering the Immune structures category, which is the second dominant category in terms of frequency, it can be argued that the connection between the concept of autoimmunity and immunity takes place in the cognitive structures of the students. It should be emphasized that this relationship is not as clear for the concepts of Infection and Allergy as for the concept of Autoimmunity. Bearing in mind the other categories, it can be shared that the Autoimmune diseases and Diagnosis/treatment categories are included in the cognitive structures of the students, reflecting the relationship between the concept of autoimmunity and health. When we investigate the answers of the students collected in the category of autoimmune diseases, it is remarked that solely one fifth of the students who participated in the study gave the example of MS (multiple

sclerosis). Inspecting the word diversity in the category, it was determined that there were four disease examples, and the frequency of these words varied between 16 and 3.
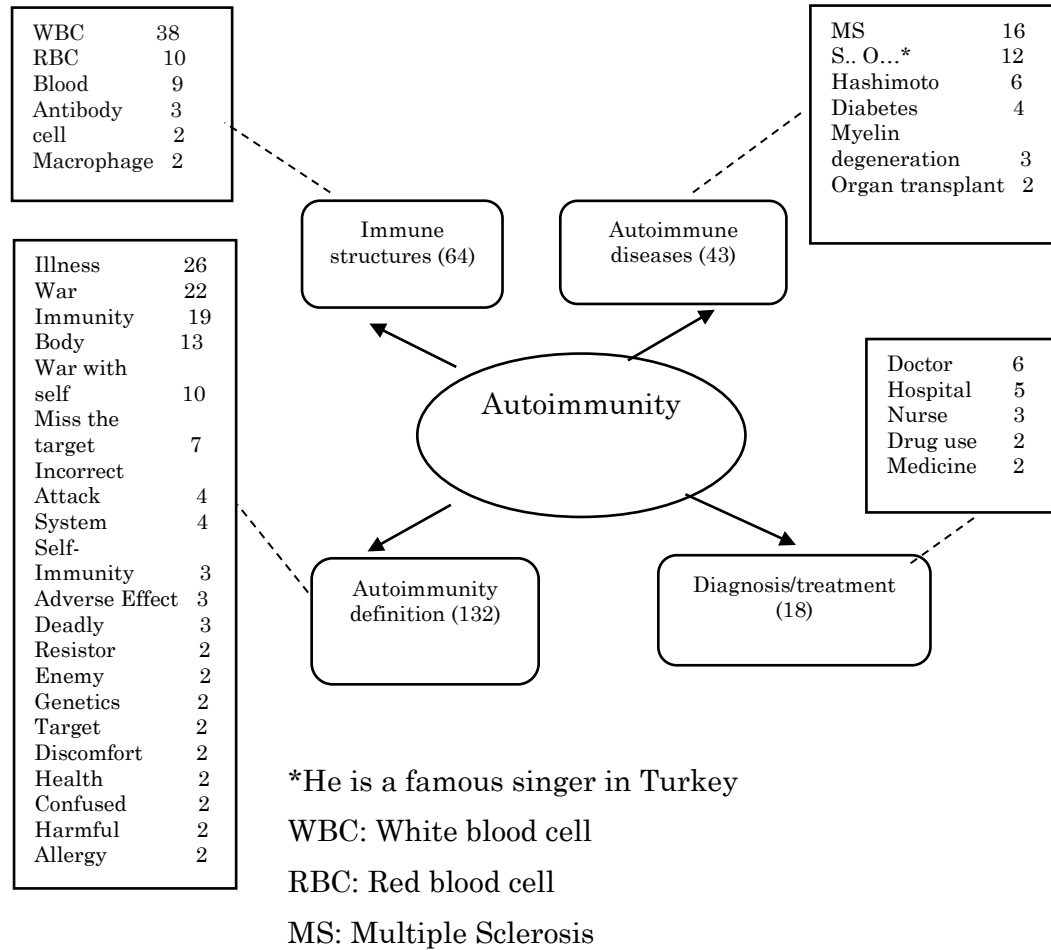
WBC	38
RBC	10
Blood	9
Antibody	3
cell	2
Macrophage	2

MS	16
S.. O...*	12
Hashimoto	6
Diabetes	4
Myelin degeneration	3
Organ transplant	2

Illness	26
War	22
Immunity	19
Body	13
War with self	10
Miss the target	7
Incorrect Attack	4
System	4
Self-Immunity	3
Adverse Effect	3
Deadly	3
Resistor	2
Enemy	2
Genetics	2
Target	2
Discomfort	2
Health	2
Confused	2
Harmful	2
Allergy	2

Doctor	6
Hospital	5
Nurse	3
Drug use	2
Medicine	2

Immune structures (64)

Autoimmune diseases (43)

Autoimmunity

Autoimmunity definition (132)

Diagnosis/treatment (18)

*He is a famous singer in Turkey

WBC: White blood cell

RBC: Red blood cell

MS: Multiple Sclerosis

Figure 4 Cognitive structures of high school students about Autoimmunity

Table 1 *Coefficient of correlation between stimulus words*

	Infection	Allergy	Autoimmunity
Immunity	0,101	0,035	0,053
Infection		0,001	0,027
Allergy			0,012

When the correlation coefficients between stimulus words are explored, it is seen that the correlation coefficient between Immunity and Infection, Allergy and Autoimmunity is

higher than the correlation coefficients of these words with each other. It has been determined that the two most related stimulant words are Immunity and Infection. When the table is scanned, one can point up that the coefficients obtained from the answers given by the students for the stimulant words are quite low. In this direction, it can be underscored that in the cognitive structures of the students participating in the study, these stimulant words are independent of each other or connected with a very limited number of words.

4. Discussion

Turkey's generally low science achievement is demonstrated by the results obtained from national high stakes exams like the university entrance exam and international standard tests like TIMSS. This is also consistent with the results of our current study. It can be propounded that the cognitive models of the students are quite poor pertaining to the basic concepts of immunity, which is also proffered by the researchers that it is difficult to teach (Cheng et al., 2014; Osowski, 2003; Su et al., 2014). The subject of immunity is mainly covered with the participation of students studying in undergraduate and graduate programs and mostly in the field of health (Steinel et al., 2019). It can be said that the studies on this subject are mostly method (Madiraju et al., 2020; Mello et all., 2021) and material (Monkovic et al., 2021; Su et al., 2014) trials toward the teaching of the subject. We hold the belief that the current study will fill a gap in the literature apropos of reflecting the existing concepts in the immune-related cognitive structures of high school students. Even though there are various experimental studies on the teaching of immunity issues, there are no studies that reveal the situation in particular at high school level about how students' lack of knowledge or conceptual understanding are shaped. When we look at the findings of the study, one of the striking results about the word immune stimulant is that the word white blood cell was mentioned by merely10 participants despite the fact that this concept is included in the teaching content at primary school level. On the other hand, it is seen that the word autoimmunity stimulant is associated with the word white blood cell in more participants. It can be declared that this situation arises as a result of recalling the words in the lower order of the mental structure with the effect of the application of the measurement tool. During data collection, the autoimmunity stimulus word was presented to the students in the last application.

The correlation coefficients were calculated as a measure of the connection between the stimulus words in the mental structure. In this process, the spelling order of the common association words they wrote for the stimulus words for each participant is allowed for (see Bahar et all., 1999). When the connotation words related to the stimulant words were compared, it was contemplated that the number of common words was low. As a result of examining these common words, it can be concluded that most of them do not

pertain to subject-specific concepts. To cite an example, for these common words: hospital, illness, doctor, health, and others.

One of the reasons of this result can be shown as the content of the secondary education biology course curriculum. The subject of immunity is discussed as a sub-topic of the circulatory system in the program. Key concepts for each subject are specified in the program. Circulatory system concepts consist of white blood cells, antigens, antibodies, vaccines, immunity, infection and interferon. Nevertheless, it can be expounded that these key concepts are not explicitly included in the acquisitions and explanations. The simplification of the program, which started with the program in 2013, in other words, the change in the direction of reducing the number of acquisitions, teaching suggestions and reducing sample activities is also observed in the program in 2018. According to the 2009 program, it can be postulated that the number of acquisitions and types of acquisitions in both programs were significantly simplified and the examples of methods and activities pertained to teaching the content were quite limited.

As for the explanations regarding the acquisition of "Examples the immune biological response of the body against antigens" in the previously in force program, to illustrate, "Cellular and humoral immunity is exemplified", "Natural and acquired immunity is briefly explained", "AIDS", "Crimean Congo Hemorrhagic Fever", "Swine Flu" (influenza A (H1N1) were observed. It is seen that concepts are emphasized with more detailed expressions such as "viral diseases such as…" and allergies are given as examples. (see MoNE, 2011). Methods and application suggestions that can be used during the period of the course are not included in the explanations regarding the subject and achievements of the current program (see MoNE, 2018). Nonetheless, when it is considered that teaching of immunity issues with teacher-centered and lecture method is not effective, it would be appropriate for the program to guide the teacher by offering alternatives in teaching. Aside from the high school curriculum, it is seen that the subject of immunity is problematic in undergraduate education. For example, in the study conducted by Kurt (2013a), biology teacher candidates' deficiencies in immune system structures, artificial immunity and immune response were revealed.

It can be stated that there is not enough emphasis on the relationship between the concepts of the immune system and infection, allergy, and autoimmunity in the program. The outcome, which is stated in the curriculum as "The relationship between infections and allergies and immunity is explained through examples" (MoNE, 2018), does not contain the concept of autoimmunity, and leaves it to the personal preferences of the teacher, unlike the previous program, regarding examples. Additionally, in this acquisition, the breadth of the content on infection and allergy in the context of its relationship with immunity remains unclear.

Autoimmunity is a concept that is difficult to remember with its foreignness and distance from daily life language. What is more, its similarity with other words can evoke other meanings (automobile and so on) for those who do not know about it. In the study, it is seen that some participants associate this word with a famous singer. With the thought that the artist in question has an autoimmune disease, it can be said that the young people who follow him at least know about the term. In fact, awareness can be created and sustained on such issues using various characteristics (illness, diet and lifestyle) of those that are popular with young people.

When it comes to the mental structures about infection, it is seen that most of the sentences of the students are on the transmission route of the infection. Notwithstanding, it is understood that the opinions on this subject are intense, the thoughts of the contamination of microbes as a result of surgical sutures, open wounds and injuries. With that being said, only one example of a sentence describes droplet infection. For this reason, it can be stated that there is no structure in the minds of the students regarding droplet infection and infections spread by vectors. In the WAT test, in contrast to this situation, it is seen that the recurrence rate of tetanus as a disease with an agent that can be transmitted by injury is 2, whereas the flu transmitted by droplets is expressed by 10 people. This situation can be interpreted as that students do not have the adequate awareness of the spread types of infectious agents or that a single form is dominant in the mental structure. It can also be claimed that this mental structure that had relevance to the development of infection from injuries or wounds is culturally caused by suggestions and warnings made by the elderly (Jones & Rua, 2008). In other words, by emphasizing cleanliness in cases of injury by adults, young participants may have created a mental structure that indicates that infectious agents are transmitted in this way. On the other side of the coin, since the current study is not related to a specific infection sample, it should be stated that caution should be exercised in such judgments. The fact that the students participating in the study gave very few examples of specific infections associated with the word "İnfection stimulant" can be interpreted as the fact that epidemics are not common in daily life, as well as that they do not have awareness about the current Covid-19 pandemic or similar epidemics. Vaccination is discussed in the Biology Curriculum. The program hightens the vaccine as one of the most effective tools in the fight against infections and insists on the necessity of renewing the vaccines (see MoNE, 2018). Even so, in the current study, the word "Vaccine" is not included in the connotation words associated with the "İnfection stimulant" word. At any rate, it should be noted that the participants included the word "Vaccine" (f=21) in connotation words in conjunction with the word immune stimulant. To put it in another way, it can be said that the concept of vaccine is not associated with the concept of infection in the minds of the participants, although one third of the participants have cognitive structures. One of the reasons of this may be that the word infection is perceived as a state in which the individual is in. For this reason, if a person is now infected, the vaccine

will not function in this situation, so the participants may not have associated the infection with the vaccine with this line of thinking. In fact, it is seen that some of the participants emphasized that the vaccine is the application to individuals who are not sick in the sentences they formed for the words associated with immunity. When the sentence examples related to the connotation words related to infection are scrutinized, it can be stated that the participants concentrate on the subjects such as being infected (mainly adhered to a single form), infection symptoms, rather than being protected from infection. Jeffe et al. (2012) studied young people in secondary education in Germany, and announced that although their knowledge of infectious diseases in the context of Hepatitis-B varies considerably according to grade level, type of school and gender, but their knowledge of hepatitis-B transmission, ways of protection from the disease and vaccination is surprisingly low. Likewise, Maghfirah and Priyandoko, (2020) in their study with high school students, determined that the level of knowledge about infectious diseases is quite low. Jones and Rua (2008) stated that there are great gaps in the understanding of students and teachers about the immune system response, the working mechanism of vaccines and the treatment of diseases. In the current study, it is seen that students have misconceptions about the effect of the vaccine from their explanations about the vaccine. To give an instance, there are explanations pointing to alternative conceptions such as the vaccine being for "people with a weakened immune system" or the administration of the vaccine as "antibodies weak".

5. Conclusions

With the impact of Covid-19, concepts such as antibodies, passive immunity, and T cells have begun to enter the daily language of all people. Considering the discussions and research results, it was revealed that the general public population and even scientists in other disciplines misunderstood the conceptualizations of immunology and immune response (Bottaro et al., 2021). In our study of these concepts, the data of which were taken before the pandemic of Covid-19, it is worrying that basic concepts are not encountered very rarely or unfortunately in the answers given by the students about immunity.

It is vital to raise scientifically literate individuals in order to combat infodemics in health problems affecting the world such as pandemics and to ensure that humans administer the vaccines developed. One of the basic conditions of being a scientifically literate individual is to know the basic concepts in the subject area. Withal, in the study, it is seen that the basic concepts of immunity, infection, allergy and autoimmunity are not predominantly structured in the minds of the students. Giving consideration to the fact that there is a consensus among scientists that those who do not have knowledge about any subject cannot be scientifically literate, it is of priority and urgency to have knowledge about immunity.

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