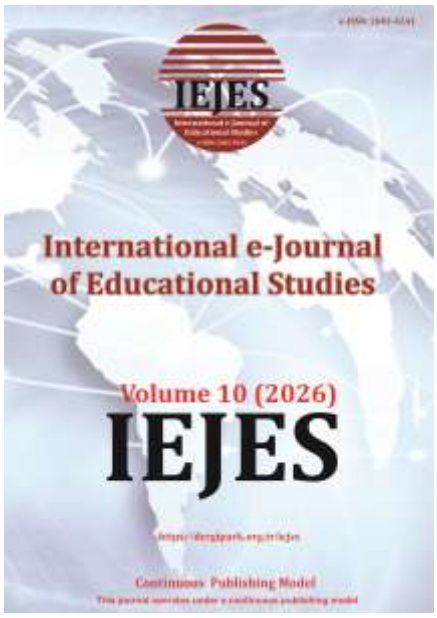


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Abstract

The study aimed to identify and examine high school students' mental images related to the fields of arithmetic and algebra. In this context, the phenomenological research design one of the qualitative research methods has been adopted. The sample for the study consists of 184 students attending a public high school. Students were given two forms containing the statements "Arithmetic is like … because …" and "Algebra is like … because …". Content analysis was used to examine all the collected data. 140 students generated valid metaphors related to arithmetic, and 157 students generated valid metaphors related to algebra. The study concluded that students possess a broad metaphorical understanding of both algebra and arithmetic. As a result of the analysis, the metaphors generated for both arithmetic and algebra were divided into 14 categories each. According to the findings of the study, students emphasized that arithmetic should be clear and straightforward, containing known elements, requiring basic operational skills, having a structured and systematic framework, involving unchanging processes, and being necessary. Regarding algebra, they focused on the fact that it involves unknowns, is full of uncertainties, requires effort, and is difficult. In addition, it was observed that common categories emerged regard to the fields of algebra and arithmetic, such as being fun, requiring expertise and experience, difficulty, and necessity aspect.

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Research Article

High School Students' Metaphorical Perceptions of Arithmetic and Algebra *

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Abstract

The study aimed to identify and examine high school students' mental images related to the fields of arithmetic and algebra. In this context, the phenomenological research design one of the qualitative research methods has been adopted. The sample for the study consists of 184 students attending a public high school. Students were given two forms containing the statements "Arithmetic is like … because …" and "Algebra is like … because …". Content analysis was used to examine all the collected data. 140 students generated valid metaphors related to arithmetic, and 157 students generated valid metaphors related to algebra. The study concluded that students possess a broad metaphorical understanding of both algebra and arithmetic. As a result of the analysis, the metaphors generated for both arithmetic and algebra were divided into 14 categories each. According to the findings of the study, students emphasized that arithmetic should be clear and straightforward, containing known elements, requiring basic operational skills, having a structured and systematic framework, involving unchanging processes, and being necessary. Regarding algebra, they focused on the fact that it involves unknowns, is full of uncertainties, requires effort, and is difficult. In addition, it was observed that common categories emerged regard to the fields of algebra and arithmetic, such as being fun, requiring expertise and experience, difficulty, and necessity aspect.

Keywords: Algebra, arithmetic, metaphorical perceptions

1. INTRODUCTION

Mathematics is a science based on various relationships within a systematic framework and characterized by a coherent body of knowledge (Akkan et al., 2017). Given its significant role in terms of structure and relationships, it is possible to say that algebra is an essential component of mathematics courses (Ministry of National Education [MoNE], 2024). Therefore, it is emphasized that all students should be taught algebra in order to understand mathematics (National Council of Teachers of Mathematics [NCTM], 2000). Algebra is a field that involves discovering relationships, drawing conclusions, expressing generalizations, and constructing arguments to support all of these (Blanton & Kaput, 2003). The abstract concepts in algebra lead students to perceive it as a difficult subject (İlhan et al., 2022). It can be said that one of the main reasons for this difficulty is the challenges students face when transitioning from arithmetic to algebra. Indeed, it is emphasized that algebra is a field that emerged through the abstraction and generalization of arithmetic (Akgün, 2006). Arithmetic is a field that encompasses comparisons, numbers and the relationships between them, operations, and various calculations involving these operations (Akgün, 2006). It is also defined as a mathematical language created to explain algebraic relationships (Stacey & MacGregor, 1997a).

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In this context, it can be noted that arithmetic and algebra are complementary fields and that these concepts form an important part of mathematics education. In their most basic form, the operations of addition, subtraction, multiplication, and division which were used in ancient Egypt and Mesopotamia are the fundamental operations of arithmetic. Over the years, they have evolved into the practical and systematic system we use today (Akkan et al., 2011). Algebra is described as a field that facilitates the transition from concrete arithmetic to the symbolic language of algebra and supports students' abstract understanding (Susac et al., 2014). Algebra contributes to individuals gaining experience in the processes of reasoning, mathematical thinking, abstract thinking, and logical inference (Stacey & MacGregor, 1997b). However, algebra is regarded as an important field of mathematics that uses numbers and symbols to reveal the relationships between them through equations (Baki, 2008). There appears to be a strong connection between arithmetic and algebra (Kieran, 1992). Therefore, it would not be accurate to think of them as separate fields. The same consideration should be given in educational processes as well. The transition to algebra, which arises from the generalization of arithmetic, occurs in stage during the mathematics teaching process (Vance, 1998). In this context, it is important not to overlook the fact that arithmetic lays the groundwork for the teaching of algebra. The teaching of arithmetic in primary school classrooms should be organized in such a way that it can support the algebra learning that will be carried out later (Kaput & Blanton, 2001). If students understand and can explain the arithmetic calculations they perform, they will have made a good start on algebra. At this point, individuals should not view arithmetic merely as a means of performing calculations, should need give it sufficient thought (Carpenter et al., 2003). It is important to remember that the concept of numbers lies at the foundation of arithmetic, while algebra is based on arithmetic (Van Amerom, 2002). Gaps in arithmetic knowledge, the inability to use symbols and models when solving problems, and the inability to use the concept of variables correctly make the transition from arithmetic to algebra difficult (Gürbüz & Akkan, 2010). Individuals establish connections between the algebraic concepts they possess and the arithmetic concepts they have developed through prior experience (Herscovics & Linchevski, 1994). Early algebraic thinking involves recognizing and understanding mathematical relationships, patterns, and arithmetic structures (Carraher & Schliemann, 2015). Viewing elementary school math classes as arithmetic operations and middle and high school classes as algebraic operations leads to certain problems (Kieran, 2007). If individuals learn arithmetic operations, the concept of numbers, and their properties in a meaningful way, they will not encounter difficulties in algebraic thinking processes (Wagner, 1983).

From the perspective of mathematical processes, the importance of the fields of arithmetic and algebra is clear. Identifying and organizing individuals' thoughts and levels of awareness regarding these fields and the relationships between them will contribute to the learning process. Metaphors have an important role and influence in individuals' thought processes (Lakoff & Johnson, 2015). In this context, metaphors are seen as an important tool for uncovering what individuals think about the fields of arithmetic and algebra and how they perceive these fields. It is emphasized that metaphors in mathematics serve as powerful mental models in the process of learning, understanding, and explaining mathematical concepts, which have an abstract structure (Güveli et al., 2011). Metaphors enable individuals to express themselves and the positive and negative situations they experience in a more effective and free manner (Kemp, 1999). Furthermore, metaphors can be effectively utilized at every level, from preschool through higher education (Yılmaz et al., 2013). Because metaphors involve a process that takes different senses into account, they can be useful in understanding and explaining mathematical concepts (Font et al., 2010). It can also make it easier to express abstract mathematical concepts by helping to make them more concrete (Ernest, 2010). Because metaphors provide insights into individuals' thought processes, they can also be used to collect data in educational research (Saban, 2006). In other words, metaphors help us make sense of the lives we lead and enable us to express a concept using familiar terms (Perry & Cooper, 2001). Metaphors help

students understand difficult and abstract concepts, enable them to make these concepts more concrete, and, as a result, help these concepts become more firmly retained (Arslan & Bayrakçı, 2006). In addition to this, İlhan et al. (2022) emphasize that metaphors are used to create students' readiness. Since the algebra learning area in mathematics is difficult, students need to have a certain readiness, especially in teaching many subjects (Altun, 2005). Sitrava (2017) states that secondary school mathematics teacher candidates have incomplete and erroneous knowledge about the definitions of algebraic expression and equation concepts, while Çavuş-Erdem and Gürbüz (2017) and Sert-Çelik and Masal (2018) state that students' conceptual and operational knowledge about equations is not sufficient and they have difficulty in learning the subject. This situation increases the importance of increasing students' readiness in learning mathematics.

A review of the literature reveals studies that examine metaphors related to mathematical concepts (Çenberci et al., 2020; İlhan et al., 2022; Katrancı & Yıldız, 2022; Kebap & Çenberci, 2020; Özsoy et al., 2025; Taşkesen et al., 2026; Uygun et al., 2016; Yee, 2012). Font et al. (2010) examined the metaphors created by teachers during the process of teaching function graphs. The study conducted by Kebap and Çenberci (2020) aimed to investigate the distribution of the number of metaphors used by middle school students regarding the concepts of "mathematics course" and "mathematics teacher" according to their grade levels and genders, and to compare these metaphorical perceptions based on the students' genders. In their 2016 study, Horzum and Yıldırım explored high school students' perceptions of geometry through the use of metaphors. In a study conducted by Şengül et al. (2014), the researchers investigated how the metaphors created by students in grades 6, 7, and 8 regarding the concept of a mathematics teacher differed according to their grade level and gender. The study by Cansız et al. (2024) aimed to identify the metaphorical perceptions of 7th-grade middle school students regarding the concept of ratios and proportions and to examine their abilities to develop metaphors and create metaphorical drawings according to gender. In the study by Çenberci et al. (2020), the authors investigated how middle school students perceive the concept of patterns; the aim was to identify the metaphors students use in relation to this concept and to examine how these metaphors vary by grade level. In a study conducted by Yee (2012), the metaphors used by students in the process of explaining mathematical problem-solving were identified and analyzed. The study by Uygun et al. (2016) aimed to identify university students' perceptions regarding mathematical problems through the use of metaphors. In the study by Özsoy et al. (2025), the metaphorical perceptions of 8th-grade students regarding the concepts of ordered pair and variable were investigated, and variations in these perceptions based on gender and socioeconomic status were examined. In a study conducted by İlhan et al. (2022), middle school students' metaphors related to algebraic expressions and equations were identified, and their perceptions and awareness of this topic were examined. The study by Katrancı and Yıldız (2022) aimed to determine middle school mathematics prospective teachers' perceptions of the concept of algebra through the use of metaphors.

In studies on metaphors related to algebra concepts in the literature, particular attention has been given to the concept of a function (Font et al, 2010), the concepts of ordered pairs and variables (Özsoy et al., 2025), the concepts of ratios and proportions (Cansız et al., 2024), algebraic expressions and equations (İlhan et al., 2022), and the concept of patterns (Çenberci et al., 2020). However, the study by Katrancı and Yıldız (2022), which examined prospective teachers' metaphorical perceptions solely regarding field of algebra highlights. This situation shows that the limited research on metaphors related to fields of algebra and arithmetic. In addition, some studies on algebraic concepts have been conducted with secondary school students (Cansız et al., 2024; Çenberci et al., 2020; İlhan et al., 2022; Özsoy et al., 2025), while some have been conducted with high school students (Font et al., 2010). As can be seen, these studies have focused more on prospective teachers and secondary school students. For this reason, it is thought that studies conducted with high school students will be important. At the same time, it is important to uncover high school students' understanding of algebra

and arithmetic during the abstract operations stage in order to make their learning meaningful. It is thought that identifying positive or negative situations related to algebra and arithmetic, which have an important place in the curriculum, will provide support to teaching. In this context, it is thought that important data will be obtained on issues such as the difficulties experienced by the students, the measures that can be taken, and the planning of education. Considering that one of the most effective ways to achieve this is through metaphors, and given the limited number of studies on algebra and arithmetic, this study is expected to make a significant contribution to filling the gap in the literature. In addition, since arithmetic and algebra are very important branches of mathematics, identifying metaphors related to fields of arithmetic and algebra will be helpful in determining how students perceive and define these fields. Understanding high school students' knowledge of these fields and their thoughts on them will provide valuable insights for making their learning processes more effective. In this context, it is believed that the study will make significant contributions to the literature. Accordingly, the aim of this study is to determine high school students' metaphorical perceptions the fields of arithmetic and algebra. The study identified the following as its research question: "What are high school students' metaphorical perceptions of algebra and arithmetic?" In this context, answers to the following sub-questions were sought in the study:

1. What metaphors do high school students use to describe arithmetic?
2. How are high school students' metaphors related to arithmetic, as distributed across the identified common categories?
3. What metaphors do high school students use to describe algebra?
4. How are high school students' metaphors related to algebra, as distributed across the identified common categories?

2. METHOD

This section of the study provides detailed information on the research design, the study group, data collection tool, the implementation process, validity and reliability, and the data analysis phase.

2.1. Research Design

The aim of this study is to determine the perceptions of high school students about fields of "arithmetic" and "algebra" with the help of metaphors. Qualitative research method was used in the study. Metaphors highlight the distinctive or unique aspects of a phenomenon or event in qualitative research, enabling the generation of important and qualified findings (Larsen et al., 2025). Therefore, it can be stated that metaphors serve as tools for collecting qualitative data and contribute to the generation of rich findings (Yıldırım & Şimşek, 2013). Considering that metaphors are important tools to describe students' perceptions and mental structures arising from their experiences with concepts, it will make an important contribution to determining students' thoughts and perceptions about the fields of arithmetic and algebra. In this study the phenomenological research design one of the qualitative research methods has been adopted. In the context of determining the perspectives of the participants on the fields of algebra and arithmetic, which we know but do not have a clear idea about, the phenomenology design was evaluated as an appropriate model for this study. Indeed, phenomenology is the study of phenomena that we are not completely unfamiliar with, but at the same time, we do not fully grasp the meaning and do not have a detailed understanding (Yıldırım & Şimşek, 2013). It also serves as a research design that examines students' thought processes and mental patterns (Wolff, 2002).

2.2. Study Group

The sample for this study consists of enrolled at a public high school in the Central Anatolia Region during the second semester of the 2025–2026 academic year. The study included 184 students who volunteered to participate. There are 99 female and 85 male students in this group who agreed to participate in the study. Participants were selected in accordance with the convenience sampling

method, one of the purposeful sampling methods used in qualitative research (Yıldırım & Şimşek, 2013).

2.3. Data Collection Tool and Implementation Process

A form was used as a data collection tool, consisting of the phrases *"Arithmetic is like ... because ..."* and *"Algebra is like ... because ..."*. Students were asked to write a metaphor for the "arithmetic" and "algebra" and to explain in detail, in the space provided, the relationship between the source of these metaphors and the subject they present. Before this form, students were provided with an informed consent form and a voluntary participation consent form. The researcher provided the necessary explanations to the students and asked them to express their thoughts in their own words without any restrictions. In addition, students were instructed not to include their names so that they could express their true feelings and thoughts. Thus, during the implementation process, students were able to freely answer the open-ended questions posed to them. It was assumed that all students participating in the study provided accurate and honest answers and wrote their true thoughts on the form.

2.4. Validity and Reliability

In qualitative research, the process of ensuring validity and reliability is carried out in accordance with strategies for credibility/ dependability and transferability (Yıldırım & Şimşek, 2013). For this reason, these steps were taken into account in this study, which was conducted using qualitative research methods. To ensure credibility and dependability, the researchers conducted the processes of category formation and evaluation separately. The differences that emerged were discussed, and a consensus was reached. For example, researchers debated whether to include "difficulty" and "requiring effort" as separate categories for metaphors related to algebra. Considering the students' explanations of the metaphors, some emphasized the difficulty of algebra, while others stressed the need for effort. Therefore, it was decided that they should be presented as two separate categories. Additionally, in the student response, "Algebra is like a forest: once you enter it, it's not easy to get out, but if you put in the effort, you can make your way out," there was disagreement about which category the "forest" metaphor belonged to. Since the student emphasized the need for more effort in their explanation, a compromise was reached to include it in the "requiring effort" category. The findings obtained throughout the study have been thoroughly documented, explained, and interpreted to ensure their transferability. In addition, the research data was categorized and interpreted step by step, taking into account the stages of content analysis. In light of the findings and conclusions of the study, due care has been taken to ensure that the data is clear, plausible, consistent with individuals' experiences, and easy to read. To determine the degree of agreement among researchers during the data categorization process, Miles and Huberman's (1994) reliability formula [Reliability=Agreement / (Agreement + Disagreement)] was used. The percentage of agreement was calculated based on the classifications made independently by the researchers. Following these calculations, the percentage of agreement was found to be 93% for metaphors related to arithmetic and 91% for metaphors related to algebra. Since a reliability of 70% or higher is considered sufficient in the literature, this finding indicates that the coding process was highly consistent and reliable (Miles & Huberman, 1994).

2.5. Data Analysis

The collected data was analyzed using content analysis. The fundamental process involved in content analysis is to group similar data under specific concepts and themes and to organize and interpret them in a way that is understandable to the reader (Yıldırım & Şimşek, 2013). The process described in Saban's (2009) study was taken into account during data processing. In the study, metaphors related to arithmetic and algebra were grouped separately and the same analysis process was carried out for both groups. At this stage, the whole metaphor is tentatively listed. Afterwards, it

was examined whether the students expressed the metaphors clearly. At this stage, the metaphors listed were reviewed in terms of the subject of the metaphor, the source of the metaphor, and the relationship between the subject of the metaphor and its source. Those who did not comply were excluded from the analysis. In addition, any papers that did not specify a metaphor or were left blank were eliminated.

It has been observed that some students provide explanations related to algebra and arithmetic rather than creating a metaphor. The statements “Algebra is a deep, complex, and mysterious subject” can be cited as example of this. Some of the participants, however, were unable to provide a logical and understandable explanation for the metaphor they created. In this context, examples include the statements, “Algebra is like paying a bill, because it’s an unnecessary unit". It is evident here that the students have not provided a logical and understandable explanation for the metaphor they have created. As a result of the screening and elimination process, it was determined that 140 valid metaphors related to arithmetic and 157 valid metaphors related to algebra remained.

According to their common characteristics, 14 conceptual categories were identified in each group for metaphors related to arithmetic and algebra. The categories were created by focusing on how students explained the fields of arithmetic and algebra through metaphors and which aspects they highlighted. When considering the explanations regarding the origins of the metaphors identified in this study, some metaphors were also found in different categories. For example, the metaphor of “dreams” in relation to algebra has been included in both the “requiring effort” category and the “abstract aspect” category. Similarly, it appears that the “ghost” metaphor falls into both the “difficulty” and “involving uncertainty or the unknown” categories. In the process related to arithmetic, the “school” metaphor was categorized as both the “being boring” and the “being structured and systematic”. Indeed, the differences between the explanations reveal different semantic contexts.

3. FINDINGS

In this section, the mental images of the high school students participating in the study regarding the “arithmetic” and “algebra,” as well as the expressions they used to describe them, are explained and interpreted under subheadings corresponding to the research questions. In this context, examples are provided of the metaphors created by the students and the phrases they used to explain these metaphors. For this study, 114 different metaphors were generated from 140 valid data on the arithmetic, and 97 different metaphors were generated from 157 valid data on the algebra. The metaphors generated by the students have been categorized into 14 different conceptual categories for arithmetic and 14 for algebra. The metaphors and conceptual categories developed in relation to arithmetic and algebra are presented in tables.

3.1. Students' Metaphors about Arithmetic

The first sub-problem of this study is: “What metaphors do high school students use to describe arithmetic?” With regard to this sub-problem of the study, the data on the metaphors related to the arithmetic presented by the participating students are presented in Table 1.

Table 1. Distribution of metaphors generated by students regarding arithmetic

Metaphors	f	Metaphors	f	Metaphors	f
friend	10	countries	1	philosophy	1
family	3	course schedule	1	practice board	1
order	3	cycle	1	problem	1
school	3	daily life	1	psychologist	1
construction	2	daily routine	1	people you trust	1
cooking	2	dessert	1	religion	1
gold	2	directions	1	routine things	1
life	2	discipline	1	rules	1

mirror	2	driving	1	science	1
path	2	dough proofing	1	slide	1
past	2	eating dessert	1	someone close to me	1
school rules	2	elementary school	1	someone we know	1
the sky	2	emotion	1	spider	1
the universe	2	events in the future that we do not know about	1	split the atom	1
water	2	exam	1	star	1
a good person among bad people	1	experience	1	story	1
a fun game	1	farmworkers	1	straight hair	1
an innocent child	1	finger	1	studying	1
a language you know	1	flowing river	1	surgery	1
an expert in the field	1	game	1	tailored clothing	1
alphabet	1	home	1	take a step	1
a mother's love	1	lemonade	1	the foundation of the house	1
a path to heaven	1	love	1	the meal in the kitchen	1
a simple recipe	1	look into the solution	1	the path you know	1
bad	1	me	1	the people who will be with us along the way	1
behavior	1	meal	1	the things we do every day	1
book	1	menu	1	the world of toys	1
broken radio	1	money	1	to daydream	1
building stone	1	mother	1	to draw a picture	1
calculator	1	my heart	1	to lie down	1
chart	1	my mom	1	to sleep	1
chronological order	1	my room	1	to work systematically	1
comfort	1	my wardrobe	1	treasury	1
cooking for a small group	1	navigation	1	test books	1
cook pasta	1	our organs	1	tree	1
cooking recipe	1	open-field battle	1	walk	1
cotton thread	1	oxygen	1	wheat	1
counting	1	plain pasta	1	1 + 2	1
					Total 140

Table 1 shows that 140 students generated a total of 114 different metaphors related to arithmetic. Among these, the most frequently used metaphor was identified as the “friend” metaphor, with 10 mentions. In addition, 3 participants generated the “order” metaphor, 3 the “school” metaphor, 3 the “family” metaphor, and 2 each the “construction”, “school rules”, “past”, “gold”, “cooking”, “water”, “mirror”, “path”, “the sky”, “life”, and “the universe” metaphors. It was found that the other students participating in the study each generated one each metaphor that differed from the others.

3.2. Categories of Metaphors Created by Students Regarding Arithmetic

The second sub-problem of this study is: “How are high school students' metaphors related to arithmetic, as distributed across the identified common categories?” Table 2 shows the distribution of the metaphors generated by the students regarding this sub-problem according to the identified common categories.

Table 2. Distribution of metaphors created by students regarding arithmetic by category

Categories	f (%)	Metaphors
Requires basic operational skills	19 (13.57)	an innocent child(1), a simple recipe(1), cook pasta(1), cooking(1), cotton thread(1), counting(1), driving(1), elementary school(1), game(1), look into the solution(1), money(1), my heart(1), plain pasta(1), straight hair(1), take a step(1), the things we do every day(1), to daydream(1), to lie down(1), water(1)
Being structured and systematic	13 (9.28)	school(2), daily routine(1), my wardrobe(1), order(3), religion(1), routine things(1), spider(1), studying(1), to work systematically(1), walk(1)
Including processes that do not change	18 (12.86)	friend(4), family(2), , path(2), a mother's love(1), behavior(1), broken radio(1), chart(1), cycle(1), discipline(1), exam(1), past(1),school rules(1), sky(1)
Containing known elements, being clear and well-defined	34 (24.29)	friend(6), mirror(2), a language you know(1), a path to heaven(1), alphabet(1), book(1), cooking recipe(1), countries(1), course schedule(1), emotion(1), family(1), home(1), lemonade(1), love(1), me(1), menu(1), mother(1), my room(1), open-field battle(1), past(1), practice board (1), rules(1), school rules(1), someone we know(1), story(1), the path you know(1), water(1), 1 + 2(1)
Necessity aspect	12 (8.57)	a good person among bad people(1), building stone(1), calculator(1), farmworkers(1), finger (1), gold(1), life(1), our organs(1), oxygen(1), philosophy(1), the people who will be with us along the way(1), wheat(1)
Being a basic field	4 (2.86)	construction(1), cooking(1), the foundation of the house(1), tree(1)
Requiring expertise and experience	5 (3.57)	an expert in the field(1), cooking for a small group(1), construction(1), experience(1), surgery(1)
Being fun	6 (4.29)	a fun game(1), comfort(1), eating dessert(1), the world of toys(1), to draw a picture(1), treasury(1)
Being fluent	4 (2.86)	daily life(1), flowing river(1), slide(1), to sleep(1),
Being boring	2 (1.43)	dessert(1), school(1)
Step-by-step	7 (5.00)	chronological order(1), directions(1), dough proofing(1), life(1), meal(1), navigation(1), problem(1)
Difficulty	5 (3.57)	bad(1), someone close to me(1), split the atom(1), test books(1), the meal in the kitchen (1)
Infinite and unique	3 (2.14)	the universe (2), star(1)
Other	8 (5.71)	events in the future that we do not know about(1), gold(1), my mom(1), people you trust(1), psychologist(1), science(1), tailored clothing(1), the sky(1)

When Table 2 is examined, it can be seen that the categories derived from explanations of arithmetic-related metaphors are as follows: containing known elements, being clear and well-defined (24.29%), requires basic operational skills (13.57%), including processes that do not change (12.86%), being structured and systematic (9.28%), necessity aspect (8.57%), step-by-step (5.00%), being fun (4.29%), requiring expertise and experience (3.57%), difficulty (3.57%), being fluent (2.86%), being a basic field (2.86%), infinite and unique (2.14%), being boring (1.43%), and other (5.71%).

Category 1: Containing known elements, being clear and well-defined

The category describing arithmetic as Containing known elements, being clear and well-defined is represented by 28 metaphors generated by 34 participants (24.29%). In this category, the metaphors "friend" (f=6) and "mirror" (f=2) stand out. Examples of metaphors related to this category are as follows:

"Arithmetic is like my friends because I know the characteristics of my friends."
"Arithmetic is like a friend because you know what's inside your friend."
"Arithmetic is like water because it lies before us in all its transparency."
"Arithmetic is like a practice board because, since the numbers are known, you can try anything."
"Arithmetic is like rules, because everyone knows them for certain."

As a result of the analysis of the data collected, it was observed that students in this category emphasized that arithmetic is a well-known field, and that its operations and properties are clear and distinct.

Category 2: Requires basic operational skills

The category "requires basic operational skills" is represented by 19 metaphors generated by 19 participants (13.57%). In this category, metaphors such as "cook pasta" (f=1), "game" (f=1), "to daydream" (f=1), and "cooking" (f=1) can be observed. Examples of metaphors related to this category are as follows:

"Arithmetic is like cook pasta anyone can do it."
"Arithmetic is like to daydream, because operations with numbers are just as easy as daydreaming."
"Arithmetic is like elementary school because it consists of addition, subtraction, multiplication, and division."
"Arithmetic is like the things we do every day. Because everything works out very easily and simply."

According to the data collected, students in this category emphasize that arithmetic is an easy field consisting of basic operations that anyone can perform.

Category 3: Including processes that do not change

The category of "including processes that do not change" is represented by 13 metaphors generated by 18 participants (12.86%). In this category, metaphors such as "friend" (f=4), "family" (f=2), and "path" (f=2) stand out. Examples of metaphors related to this category are as follows:

"Arithmetic is like a path because no matter which way you go, you know it will lead you to the same place."
"Arithmetic is like a family because it never changes."
"Arithmetic is like a friend, because it's always the same—it never changes."
"Arithmetic is like the past because no matter what we do, it stays the same."

According to the data collected, students in this category state that arithmetic involves unchanging processes and results and is always the same.

Category 4: Being structured and systematic

"*Being structured and systematic*" category is represented by 10 metaphors generated by 13 participants (9.28%). In this category, metaphors such as "order" (f=3), "school" (f=2), and "spider" (f=1) stand out. Examples of metaphors related to this category are as follows:

"Arithmetic is like an order because it has a certain way of working."
"Arithmetic is like school because we go there regularly on a specific day of the week."
"Arithmetic is like a spider because it weaves its web in a specific pattern."
"Arithmetic is like a walk; it involves moving along a certain path."

Students in this category note that arithmetic is a systematic and structured field comprising specific rules and operations.

Category 5: Necessity aspect

The category of "necessity aspect" is represented by 12 metaphors generated by 12 participants (8.57%). In this category, it can be seen that all metaphors such as "oxygen" (f=1), "finger" (f=1), and "life" (f=1) appear exactly once. Examples of metaphors related to this category are as follows:

"Arithmetic is like oxygen you can't do without it."
"Arithmetic is like a finger it's always by your side."
"Arithmetic is like life, because it's used in real life."

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In this category, students emphasize that arithmetic is a necessity and is used in the context of daily life.

Category 6: Step-by-step

The "step-by-step" category is represented by 7 metaphors produced by 7 participants (5.00%). In this category, it can be seen that each metaphor such as "directions" (f=1), "chronological order" (f=1), and "dough proofing" (f=1) appears exactly once. Examples of metaphors related to this category are as follows:

"Arithmetic is like directions because we describe every step."

"Arithmetic is like a chronological order because it is arranged step by step, just like history."

"Arithmetic is like dough proofing because it requires a process and steps."

In this category, students emphasize that the field of arithmetic involves a step-by-step process.

Category 7: Being fun

The category of "being fun" is represented by 6 metaphors created by 6 participants (4.29%). In this category, it can be seen that each metaphor such as "eating dessert" (f=1) and "the world of toys" (f=1) appears only once. Examples of metaphors related to this category are as follows:

"Arithmetic is like eating dessert because it brings joy."

"Arithmetic is like the world of toys because you learn while having fun."

In this category, it is evident that students find the field of arithmetic fun and enjoyable.

Category 8: Requiring expertise and experience

The category "requiring expertise and experience" is represented by 5 metaphors generated by 5 participants (3.57%). In this category, it can be seen that each metaphor such as "an expert in the field" (f=1) and "surgery" (f=1) appears exactly once. Examples of metaphors related to this category are as follows:

"Arithmetic is like an expert in the field, because it ponders what it knows and explains and repeats the same thing."

"Arithmetic is like surgery because even the smallest details must be taken into account."

In this category, students note that arithmetic is a task that requires expertise and experience.

Category 9: Difficulty

The "difficulty" category is represented by 5 metaphors generated by 5 participants (3.57%). In this category, it can be seen that each metaphor, such as "split the atom" (f=1) and "bad" (f=1), appears once. Examples of metaphors related to this category are as follows:

"Arithmetic is like split the atom because it's so hard."

"Arithmetic is bad because it's hard."

In this category, students emphasize that arithmetic is difficult.

Category 10: Being a basic field

The "being a basic field" category is represented by 4 metaphors generated by 4 participants (2.86%). In this category, it can be seen that each metaphor such as "construction" (f=1) and "cooking" (f=1) appears only once. Examples of metaphors related to this category are as follows:

"Arithmetic is like construction because it forms the foundation of the work."

"Arithmetic is like cooking because arithmetic is more fundamental."

In this category, students note that arithmetic is a basic field.

Category 11: Being fluent

The "being fluent" category is represented by 4 metaphors produced by 4 participants (2.86%). In this category, it can be seen that each metaphor, such as "flowing river" (f=1) and "slide" (f=1), appears only once. Examples of metaphors related to this category are as follows:

"Arithmetic is like a flowing river; it flows on and remains constant."

"Arithmetic is like a slide because the operations keep going."

In this category, students state that arithmetic operations are performed fluently.

Category 12: Infinite and unique

The category of "infinite and unique" is represented by 2 metaphors produced by 3 participants (2.14%). In this category, the metaphors "the universe" (f=2) and "star" (f=1) are observed. Examples of metaphors related to this category are as follows:

"Arithmetic is like the universe because it is as infinite as the universe and contains as many numbers as there are unique stars and planets."

"Arithmetic is like a star: infinite and unique."

In this category, students have expressed that they view arithmetic as a unique and infinite field.

Category 13: Being boring

The "being boring" category is represented by 2 metaphors generated by 2 participants (1.43%). In this category, the metaphors "dessert" (f=1) and "school" (f=1) are observed. An example of a metaphor related to this category is provided below:

"Arithmetic is like school because it's always boring."

In this category, students emphasize that arithmetic is boring.

Category 14: Other

The "other" category is represented by 8 metaphors generated by 8 participants (5.71%). In this category, students generated metaphors such as "science" (f=1) and "gold" (f=1). It has been determined that the metaphors here cannot be classified into any category.

3.3 Students' Metaphors about Algebra

The third sub-question of this study is: "What metaphors do high school students use to describe algebra?" The data on the metaphors students generated regarding the algebra in relation to this sub-problem are presented in Table 3.

Table 3. Distribution of metaphors created by students regarding algebra

Metaphors	f	Metaphors	f	Metaphors	f
human	13	car	1	mole	1
life	8	chaos	1	mountain	1
puzzle	8	chemistry	1	ocean	1
maze	5	clotted cream	1	overcast	1
jigsaw puzzle	4	computer	1	philosophy	1
love	4	darkness	1	pi	1
dreams	3	day	1	physics	1
ghost	3	death	1	police	1
the future	3	detective	1	problem	1
the universe	3	driving a tractor	1	question mark	1
world	3	emotion	1	riddle	1
apple seed	2	fire	1	road	1
forest	2	foreigner	1	sea	1
hide and seek	2	friend	1	secret	1
hot pepper	2	game	1	secret agent	1
mathematics	2	gift package	1	sister	1
mood	2	gemini	1	surgery	1
mind reading	2	hair	1	surprise box	1
sudoku	2	high yield	1	tangled rope	1
tangled hair	2	Higher Education Institutions Exam	1	the hidden person	1
tangled necklace	2	human needs	1	the meaningless one	1
the space	2	intention	1	The Pyramids of Egypt	1
the stranger	2	junk food	1	the silent child	1

thoughts	2	learning the game	1	the spice of the meal	1
scientist	2	news	1	treasury	1
a father's love for his son	1	market	1	treasure detector	1
alphabet	1	meal	1	unknown button	1
a mysterious character	1	mental	1	unknown password	1
an infinite operation	1	mixed nuts	1	uncertainty	1
attempted infiltration	1	mine	1	unraveling emotions	1
bad person	1	mom's meal	1	untangling the knot	1
book	1	money	1		
				Total 157	

Table 3 shows that 157 students generated a total of 97 different metaphors related to algebra. In this context, it was observed that the most frequently used metaphor among the 13 participants was the "human" metaphor. Subsequently, 8 participants generated the "life" metaphor, 8 the "puzzle" metaphor, 5 the "maze" metaphor, 4 the 'jigsaw puzzle' metaphor, 4 the 'love' metaphor, and 3 each the "world", "the future", "the universe", "dreams" and "ghost" metaphors. While the 14 students who participated in the study each generated two metaphors, the other students each generated one metaphor.

3.4. Categories of Metaphors Created by Students Regarding Algebra

The fourth sub-problem of this study is: "How are high school students' metaphors related to algebra, as distributed across the identified common categories?" The distribution of metaphors related to algebra generated by students, categorized according to the identified common categories, is presented in Table 4.

Table 4. Distribution of metaphors generated by students regarding algebra by category

Categories	f (%)	Metaphors
Involving uncertainty or the unknown	36 (22.93)	human(7), life(5), the future(3), a mysterious character(1), apple seed(1), chaos(1), death(1), day(1), ghost(1), Higher Education Institutions Exam(1), intention(1), junk food(1), mathematics(1), mind reading(1), mixed nuts(1), mole(1), mountain(1), ocean(1), overcast(1), problem(1), question mark(1), surprise box(1), the universe(1), world(1)
Complexity	15 (9.55)	life(2), friend(1), human(1), jigsaw puzzle(1), maze(1), mental(1), mind reading(1), tangled cables(1), tangled necklace(1), the universe(1), the silent child(1), thoughts(1), unraveling emotions(1), world(1)
Being in a state of change/being variable	15 (9.55)	human(3), love(2), mood(2), an infinite operation(1), book(1), dreams(1), emotion(1), gemini(1), market(1), renewable energy(1), sister(1)
Containing unknown elements	16 (10.19)	alphabet(1), chemistry(1), computer(1), darkness(1), foreigner(1), ghost(1), maze(1), philosophy(1), physics(1), pi(1), puzzle(1), scientist(1), space(1), the stranger(1), the universe(1), world(1)
The process of reaching the unknown or the outcome	16 (10.19)	puzzle(6), jigsaw puzzle(2), a father's love for his son(1), hide and seek(1), maze(1), mom's meal(1), space(1), sudoku(1), the hidden person(1), uncertainty(1)
Difficulty	18 (11.46)	hot pepper(2), human(2), tangled hair(2), clotted cream(1), forest(1), ghost(1), life(1), love(1), mathematics(1), maze(1), money(1), tangled detective(1), tangled rope(1), the meaningless one(1), treasury(1)
Step-by-step/ profundity	7 (4.46)	apple seed(1), gift package(1), hair(1), sea(1), sudoku(1), the spice of the meal(1), untangling the knot(1)
Requiring effort	18 (11.46)	bad person(1), car(1), dreams(1), forest(1), hide and seek(1), jigsaw puzzle(1), love(1), maze(1), meal(1), news(1), riddle(1), road(1),

		scientist(1), secret(1), secret agent(1), tangled necklace(1), the stranger(1), unknown password(1)
Being fun	4 (2.55)	driving a tractor(1), game(1), learning the game(1), puzzle(1)
The mysterious aspect	3 (1.91)	attempted infiltration(1), The Pyramids of Egypt(1), unknown button(1)
Abstract aspect	2 (1.27)	dreams(1), thoughts(1)
Necessity aspect	2 (1.27)	fire(1), human needs(1)
Requiring expertise and experience	1 (0.64)	surgery(1)
Other	4 (2.55)	high yield(1), mine(1), police(1), treasure detector(1)

When Table 4 is examined, it can be seen that the categories derived from explanations of algebra-related metaphors are as follows: Involving uncertainty or the unknown (22,93%), requiring effort (11.47%), difficulty (11.47%), the process of reaching the unknown or the outcome (10.19%), being in a state of change/being variable (9.55%), complexity (9.55%), containing unknown elements (10.19%), step-by-step/ profundity (4.46%), being fun (2.55%), the mysterious aspect (1.91%), abstract aspect (1.27%), necessity aspect (1.27%), requiring expertise and experience (0.64%), and the others (2,55%).

Category 1: Involving uncertainty or the unknown

The category of "involving uncertainty or the unknown" is represented by 24 metaphors generated by 36 participants (22.93%). In this category, the metaphors "human" (f=7), "life" (f=5), and "future" (f=3) stand out. Examples of metaphors related to this category are as follows:

"Algebra is like life because the end of life is also unknown."
"Algebra is like life because we may not know the outcome of what lies ahead."
"Algebra is like life because it is full of uncertainties."
"Algebra is like a human because it gets lost in the unknown."
"Algebra is like the future—you never know what's coming."
"Algebra is like a surprise box. You never know what's inside."

In this category, students have emphasized that algebra is a field involving uncertainty and unknowns.

Category 2: Complexity

The category of "complexity" is represented by 14 metaphors produced by 15 students (9.55%). In this category, it can be seen that metaphors such as "life" (f=2), "the universe", and "jigsaw puzzle" (f=1) appear once each. Examples of metaphors related to this category are as follows:

"Algebra is like the universe because it is full of complexity."
"Algebra is like a tangled cables because it is very complicated."
"Algebra is like a jigsaw puzzle because it's so complicated."
"Algebra is like mind reading because it can sometimes be complex and unknown."

Students in this category emphasize that algebra is complex.

Category 3: Being in a state of change/being variable

The category of "*being in a state of change/being variable*" is represented by 11 metaphors generated by 15 students (9.55%). In this category, the metaphors "human" (f=3), "love", and "mood" (f=2) stand out. Examples of metaphors related to this category are as follows:

"Algebra is like a human because it changes as it grows."
"Algebra is like a human because it's always changing."
"Algebra is like a mood because it's always changing."
"Algebra is like a mood because it is variable and abstract. The results can change."

In this category, students describe algebra as a changeable, dynamic field.

Category 4: Containing unknown elements

The "containing unknown elements" category is represented by 16 metaphors generated by 16 participants (10.19%). In this category, metaphors such as "physics" (f=1), "ghost" (f=1), and "world" (f=1) appear, and each has been generated once. Examples of metaphors related to this category are as follows:

"Algebra is like physics because it's full of unknowns."
"Algebra is like chemistry because it's full of unknowns."
"Algebra is like a ghost because there are so many unknowns."
"Algebra is like the world because it is the unknown."

In this category, students define algebra as a field containing unknowns.

Category 5: The process of reaching the unknown or the outcome

The category of "the process of reaching the unknown or the outcome" is represented by 10 metaphors generated by 16 participants (10.19%). In this category, the metaphors "puzzle" (f=6) and "jigsaw puzzle" (f=2) stand out. Examples of metaphors related to this category are as follows:

"Algebra is like a puzzle because in the end you figure out what x is."
"Algebra is like a puzzle because we're figuring out the unknown."
"Algebra is like a puzzle because it generates solutions, and in the end, you find them."
"Algebra is like a jigsaw puzzle because by putting the pieces together, it reveals the unknown picture to us."

In this category, students emphasize that algebra involves the process of finding the unknown or the result.

Category 6: Difficulty

The "difficulty" category is represented by 15 metaphors generated by 18 students (11.46%). In this category, the metaphors "human" (f=2), "hot pepper" (f=2), and "tangled hair" (f=2) stand out. Examples of metaphors related to this category are as follows:

"Algebra is like human because, like some people, it's hard to solve."
"Algebra is like a hot pepper because we struggle so much until we reach the end of it, as our mouths burn the whole time."
"Algebra is like tangled hair because we have trouble solving it."
"Algebra is like a treasury because it is very difficult to discover."
"Algebra is like money it's hard to come by."

In this category, students emphasize that algebra is difficult to learn, explore, or solve.

Category 7: Step-by-step/ profundity

The category of "step-by-step/ profundity" is represented by 7 metaphors generated by 7 participants (4.46%). In this category, metaphors such as "sea" (f=1), "hair" (f=1), and "apple seed" (f=1) have emerged. Examples of metaphors related to this category are as follows:

"Algebra is like the sea: the deeper you go, the closer you get to the true result."
"Algebra is like untangling the knot because it is unraveled step by step."
"Algebra is like an apple seed you can't get to the seed without eating the apple."

In this category, students have focused on the step-by-step processes involved in algebra. They have also emphasized situations that require depth.

Category 8: Requiring effort

The "requiring effort" category is represented by 18 metaphors generated by 18 participants (11.46%). In this category, metaphors such as "tangled necklace" (f=1), "maze" (f=1), and "forest" (f=1) were each used once. Examples of metaphors related to this category are as follows:

"Algebra is like a tangled necklace it can be untangled, but it's a hassle."
"Algebra is like a maze because it takes a lot of effort to reach the solution."
"Algebra is like an unknown password because you can arrive at the truth by trying different passwords. But if we don't try and work at it, we won't be able to do it."
"Algebra is like a forest: once you enter it, it's not easy to get out, but if you put in the effort, you can make your way out."

In this category, students emphasize that algebra is a field that requires effort.

Category 9: Being fun

The category of "being fun" is represented by 4 metaphors created by 4 participants (2.55%). This category includes metaphors such as "learning the game" (f=1) and "game" (f=1). Examples of metaphors related to this category are as follows:

"Algebra is like learning a game because it's fun."

"Algebra is like a game because it's enjoyable.

In this category, it is seen that students focus on the enjoyable and fun aspects of algebra.

Category 10: The mysterious aspect

"The mysterious aspect" category is represented by 3 metaphors generated by 3 participants (1.91%). This category includes metaphors such as "The Pyramids of Egypt" (f=1) and "attempted infiltration" (f=1). Examples of metaphors related to this category are as follows:

"Algebra is like the Pyramids of Egypt, because it is just as mysterious."

"Algebra is like an attempted infiltration because you do it without realizing it and in secret."

In this category, students emphasize the mysterious aspects of algebra.

Category 11: Abstract aspect

The category of "abstract aspect" in algebra is represented by 2 metaphors generated by 2 participants (1.27%). This category includes the metaphors "thoughts" (f=1) and "dreams" (f=1). The metaphors related to this category are as follows:

"Algebra is like my thoughts because it's always abstract."

"Algebra is like dreams because it also appears in an abstract form in mathematics."

In this category, students emphasize that algebra is abstract.

Category 12: Necessity aspect

The "necessity aspect" category is represented by 2 metaphors generated by 2 students (1.27%). This category includes the metaphors "human needs" (f=1) and "fire" (f=1). The metaphors related to this category are as follows:

"Algebra is like human needs because it is necessary in every aspect of our lives."

"Algebra is like fire because you need it everywhere."

In this category, students emphasize that algebra is a necessity everywhere.

Category 13: Requiring expertise and experience

The "requiring expertise and experience" category is represented by 1 metaphor produced by 1 student (0.64%). In this category, the metaphor "surgery" (f=1) has been generated. The metaphor for this category is as follows:

"Algebra is like surgery it looks difficult from the outside, but an expert knows exactly what to do."

In this category, it is stated that algebra is a field that requires expertise and experience.

Category 14: Other

"Other" category is represented by 4 metaphors generated by 4 participants (2,55%). In this category, it is observed that students generate metaphors such as "high yield" (f=1) and "mine" (f=1). It has been determined that the metaphors here cannot be classified into any category.

4. DISCUSSION and CONCLUSION

The study aimed to examine high school students' metaphorical perceptions of arithmetic and algebra field. The results of this study indicate that students possess a broad metaphorical understanding of arithmetic and algebra. Perceptions that arise from past knowledge and experiences are important for determining students' situation with regard to a particular field or concept. In this sense, metaphors also indicate that students possess a certain level of readiness in algebra and arithmetic. Indeed, students' readiness levels are important when learning algebra, since the algebra is a field where students often have difficulty in math class (Altun 2005). High school students have focused on the fact that algebra involves uncertainty and unknowns, whereas arithmetic is clear and

straightforward, consisting entirely of known quantities. It was determined that categories such as "being fun," "requiring expertise and experience," "difficulty", and "necessity aspect" obtained from metaphors created by students are common to both arithmetic and algebra.

When considering the metaphors created for the algebra, the "life" metaphor refers to the difficulty of algebra and its containing of unknowns; the "puzzle" metaphor refers to the process of eventually finding and reaching the unknown; the "tangled necklace" metaphor refers to the effort it requires; the "untangling the knot" metaphor highlights the need for a step-by-step process during the solution, the "thoughts" metaphor emphasizes the abstract nature of algebra, the "Egyptian pyramids" metaphor underscores its mysterious nature, and the "learning the game" metaphor emphasizes its fun aspect. When considering metaphors created for arithmetic, the "friend" metaphor stands out for being filled with containing known elements, being clear and well-defined, the "cooking pasta" metaphor focuses on its composition of basic operational skills; the "order" metaphor highlights its being structured and systematic; the "school rules" metaphor emphasizes its inclusion of unchanging processes; and the "oxygen" metaphor emphasizes that it is a necessity aspect. In addition, one student explains the "ghost" metaphor by saying that algebra is full of unknowns, while another student uses the same "ghost" metaphor to describe how difficult algebra is. Similarly, students offered two different explanations for the "school" metaphor associated with arithmetic: that arithmetic is both boring and rule-based and systematic. This situation has arisen as a result of explanations regarding the origin of metaphors.

It was found that 157 high school students developed 97 different metaphors related to algebra, while 140 students developed 114 different metaphors related to arithmetic. Consequently, it is evident that students generate many different metaphors for algebra and arithmetic. This finding is consistent with the observations made by Güveli et al. (2011) regarding the use of a wide variety of metaphors to describe a particular concept. It was found that high school students most frequently generated metaphors related to arithmetic, in the following order: "friend", "family", "school", "order", "cooking", "water", "construction", "mirror", "path", "sky", "past", "school rules", "life", "gold", and "the universe". It was found that the other students each came up with a different metaphor. In this context, it is fair to say that the metaphors produced are many and varied. In his 2003 study, Yob states that the emergence of a large number of different metaphors related to a single concept is a positive and significant development in the field of metaphor studies. Similarly, high school students have a wide variety of metaphors related to algebra. It can be said that the reason for this situation is that algebra is abstract and there is incomplete and erroneous information in students' infrastructure. Sitrava (2017) found that the majority of prospective mathematics teachers had incomplete and erroneous knowledge about the definitions of algebraic expression and equation concepts. It can be said that this is due to the fact that algebra is an abstract field. Indeed, Yob (2003) points out that a wide variety of metaphors are created for abstract concepts. It was concluded that the most commonly used metaphor related to algebra is the "human" metaphor, followed in order by "life", "puzzle", "maze", "love", "jigsaw puzzle", "future", "the universe", "world", "dreams" and "ghost". As Levine (2005) also noted, it can be argued that in this study as well, individuals' perspectives on the past, present, and future are reflected in the metaphors they generate.

When looking at the data, it is evident that metaphors consisting of a few words related to both algebra and arithmetic have been generated. In this context, we can give examples of metaphors related to the algebra, such as "mind reading", "unraveling emotions", and "the spice of the meal", as well as those related to the arithmetic, such as "a good person among bad people," "cooking for a small group," "a path to heaven," and "events in the future that we do not know about". This situation may stem from the tendency to try to express algebra and arithmetic by establishing relationships between them and situations found in daily life, rather than simply explaining their basic meanings. This situation can be interpreted as an effort to help students deepen their explanations, strengthen

their expressions, and focus on action when explaining abstract in algebra and arithmetic, as well as the operations and processes involved. The fact that Horzum and Yıldırım (2016) also identified metaphors consisting of more than one word is consistent with the findings of this study.

The analysis of metaphors generated by high school students in the study resulted in the identification of fourteen distinct categories. The metaphors of algebra have been examined under the following categories: “involving uncertainty or the unknown”, “requiring effort”, “difficulty”, “the process of reaching the unknown or the outcome”, “being in a state of change/being variable”, “complexity”, “containing unknown elements”, “step-by-step/ profundity”, “being fun”, “the mysterious aspect”, “abstract aspect”, “necessity aspect”, “requiring expertise and experience” and “other”. Katrancı and Yıldız (2022) show that the categories they obtained as “difficult and complex,” “effort-intensive,” “abstract,” and “fun,”, in their study examining the metaphors of the prospective teachers for the algebra, are parallel to the categories of the study. Upon examining the categories, it becomes clear that the one involving uncertainty or the unknown, difficulty and complexity stands out. In this context, high school students perceive algebra as a challenging subject filled with uncertainties and difficulties that require a great deal of effort. One reason they find it difficult may be that algebra topics are abstract. In their study, İlhan et al. (2022) noted that the abstract concepts in algebra are what cause students to perceive the subject as difficult. It is noteworthy that there is little emphasis on the category of abstract aspect. In this context, it can be said that students focus on the difficulty of algebra stemming from its abstract nature. Although the number is small, it is evident that students have created metaphors within the category of being fun. Similarly, in the studies by Katrancı and Yıldız (2022), prospective teachers used metaphors to emphasize that algebra is not only difficult and complex but also fun. It is seen that negative categories such as uncertainty and being full of unknowns, requiring effort, and difficulty emerge from high school students' metaphors related to algebra. Similarly, Katrancı and Yıldız (2022) concluded in their study that prospective teachers hold negative perceptions of algebra. These negative perceptions cause students to struggle with algebra learning. In their study, Kuzu et al. (2018) highlight a positive relationship between prospective teachers' attitudes toward mathematical concepts and their metaphorical perceptions. Thinking about this study, it should be noted that high school students’ negative perceptions will have a negative impact on their learning of algebra. This difficulty in learning algebra may lead to a negative attitude toward mathematics. For this reason, teachers should also incorporate activities aimed at developing students' metaphorical understanding into the teaching process. Since show that students have a bias against algebra and struggle to understand algebraic concepts, it is important to change this attitude, as studies on algebra (Erbaş et al., 2009; Stacey & MacGregor, 1997a). Indeed, mathematics teachers should plan their instruction to eliminate students’ prejudices against the field of algebra, which involves abstract thinking, and to support their belief in the value of effort (Kaya, 2019).

The analysis of metaphors generated by high school students regarding the arithmetic resulted in the identification of fourteen distinct categories. The metaphors of arithmetic have been examined under the following categories: “containing known elements, being clear and well-defined”, “requires basic operational skills”, “including processes that do not change”, “being structured and systematic”, “necessity aspect”, “step-by-step”, “being fun”, “requiring expertise and experience”, “difficulty”, “being fluent”, “being a basic field”, “infinite and unique”, “being boring”, and “other”. In this context, the most important categories highlighted are: containing known element, being clear and well-defined, requires basic operational skills, including processes that do not change, being structured and systematic, and necessity aspect. In this case, it is seen that students describe the field of arithmetic as a clear and well-defined area containing known concepts. According to them, there is no ambiguity when working in the field of arithmetic; everything happens exactly as it should. The fact that the students are at the high school level and are primarily engaged with the abstract aspects of mathematics may have led them to define arithmetic in this way. In another category, students

emphasized the need for basic arithmetic skills. This indicates that high school students are aware that arithmetic involves counting, number relationships, and the four basic operations. Indeed, arithmetic comparison is a field that encompasses numbers, relationships between numbers, operations, and various calculations involving these elements (Akgün, 2006). It is observed that students who construct metaphors in the category of including processes that do not change indicate that, in the field of arithmetic, the process or the steps leading to the result do not change but remain the same. In this context, students describe arithmetic as a field in which similar processes are constantly carried out and repeated. In the category of being structured and systematic some students emphasize arithmetic as a structured field governed by rules. This may be because they are aware that mathematics, compared to other subjects, is a field with a more strongly sequential structure one that is sequential and cumulative. In addition, students note that arithmetic is a field that is used and needed in life. Ulum (2022) states that the practical benefits of numbers and operations are evident in everyday life, and that mathematics is used in every moment of life. In this context, it can be said that students emphasize the category of necessity aspect. Other categories that emerged based on the metaphors and explanations students created regarding arithmetic were described under the following headings: step-by-step, being fun, requiring expertise and experience, difficulty, being a basic field, being fluid, infinite and unique, and being boring. It can be said that the metaphorical perceptions obtained from students also reveal their thoughts about mathematics. In this context, it is worth noting that high school students draw on a wide variety of metaphors and categories related to arithmetic.

In general, it can be seen that high school students are aware that arithmetic has a concrete structure filled with known quantities, while algebra has an abstract structure filled with unknowns and uncertainties. In this case, it can be said that students view arithmetic as consisting solely of numbers and operations, and are unaware that they need to reflect on it and arrive at various generalizations. It is emphasized that individuals should not view arithmetic merely as a means of performing calculations but should give it sufficient thought (Carpenter et al., 2003). In this context, it is recommended that students be encouraged to think critically when learning arithmetic, that they be steered away from rote memorization, and that the reasons and underlying principles behind the concepts be explained to them. However, no indication has been found of any understanding of the importance of the relationship between arithmetic and algebra, specifically that arithmetic serves as a prerequisite for algebra. Van Amerom (2002) states that the concept of numbers lies at the foundation of arithmetic, while algebra is based on arithmetic.

This study recommends that the teaching process reflect the fact that arithmetic and algebra are not separate, unrelated concepts. Alibali et al. (2007) point out that establishing a connection between equations and equalities is important for solving equations. Accordingly, the transition from arithmetic to algebra and the relationship between them must be properly structured. In addition to this study proposes that, the arithmetic be effectively utilized during the transition to algebra and that instruction be designed with students' perceptions in mind. Students' level of readiness plays an important role in their learning of algebra. Consequently, knowledge of arithmetic and perceptions of this subject influence the transition to algebra. In this context, it is recommended that teachers, who play a significant role, design the teaching process by taking into account students' perceptions of arithmetic and algebra.

Ethical Committee Permission Information

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