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# Ordering multiple adjectives for naming special prisms and pyramids in the Turkish mathematics language: The case of Ada

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*We characterized a Turkish prospective mathematics teacher's use of semantic and syntactic characteristics of nominal groups of words used for naming geometric solids with a focus on her use of adjectives (e.g., right, triangular) and nouns (prisms and pyramids). An individual task-based interview with our participant, Ada, enabled us to identify her linguistic awareness with a focus on the semantic and syntactic features in her noun phrases during the process in which she provided more special names with denser nominal groups of words (e.g., right prism with a right triangular base). The results showed that Ada made non-cumulative semantic characterizations and syntactic changes in her noun phrases in the Turkish mathematics language, in particular forming subordinated meaning units drawn on unusual combination of attributes (e.g., 'oblique triangle' as in 'oblique triangle prism').*

*Keywords: Order of adjectives, semantics, syntax, the Turkish mathematics language, geometric solids.*

## Introduction

As Wilkinson (2019) underlines, “to meet the requirement of linguistic informativeness that is inherent to academic language, complexity may be achieved through varied combinations of the lexical/semantic-syntactic, and text levels” (p. 87). Complex lexical density of composite structures assembled in a relational sequence is created in a *structural assembly*. Langacker (1999) refers to a structural assembly which is consisted of composite structures (e.g., adjectival phrases) that are put into a specific sequence to certain dependency relations within a nominal group of words.

Researchers like Davidse and Breban (2019) delineate the modifier-modified relations with a focus on the order of adjectives within noun phrases. For example, using the necessary adjectives in a correct order to name a geometric solid (e.g., oblique square pyramid) is one of the semantic-syntactic tasks students are required to accomplish. Prior mathematics education research most often prioritizes students' *syntactic awareness* - that refers to individuals' abilities to manage the grammatical structure of a language (e.g., Dröse & Prediger, 2020; Peake et al., 2015). For instance, Dröse and Prediger (2020) posit that *syntactic obstacles* “occur when students cannot grasp the text base due to difficulties with lexical features (related to vocabulary) or syntactic features (related to grammar)” (p. 394). However, it is also important to note that “the syntactic properties of a lexical item can largely be predicted from its semantic description. Semantics is thus held to be prior to syntax” (Dixon, 1982, p. 8). Little research indicates how students use syntactic and semantic features in mathematical noun phrases with a focus on how semantics informs syntactic properties of a structural assembly of words in mathematics.

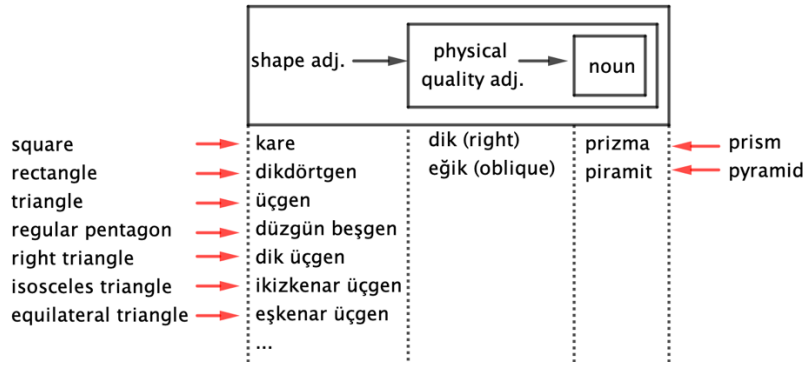
In the current study, we depict a Turkish prospective mathematics teacher's (Ada) structural assembly of adjectival modifiers that are uttered to name geometric solids with a focus on the semantics of lexicogrammar and syntactic relationships idiosyncratic to the Turkish mathematics language. The research question that guides our study is: In her grammar construction for naming special prisms and pyramids, what frame of semantic reference does Ada make in her noun phrases to elucidate her syntactic changes?

## **Theoretical background**

Our research question necessitates foregrounding the modifier-modified relationships to characterize how the interviewee of our research makes semantic descriptions that lead her to alter meaning through syntactic changes in her noun phrases, therefore, revising the grammar construction in her nominal groups of words. We used a cognitive-functional approach to address Ada's grammar construction (Davidse & Breban, 2019). Grammar construction within a semiotic tradition prioritizes how a group of adjectives modifies a head noun (e.g., modifier-modified relations) and the relationship between/among adjectives (e.g., cumulative) (Davidse & Breban, 2019). The Cambridge Dictionary (n.d.) lists several types of adjectives such as opinion and size and notes that "when more than one adjective comes before a noun, ... adjectives which describe opinions or attitudes (e.g. amazing) usually come first, before more neutral, factual ones" (para. 1).

Physical quality (e.g., right, oblique) and shape (e.g., triangular, pentagonal) adjectives are the most common types to name geometric solids. Also, in naming geometric solids, physical quality and shape adjectives are coordinated and built upon one another to modify the head noun. In other words, they are cumulative adjectives, and a comma cannot be added between them. Suppose a right prism with a triangular base. Here, the physical quality adjective, 'right,' depicts the physical appearance of the prism (right prism). The shape adjective, 'triangular,' indicates the type of the polygonal base of the prism (triangular prism). According to the predetermined rules and regularity of the English language, a physical quality adjective precedes a shape adjective. Then, a right prism with a triangular base must be named a 'right triangular prism.'

Similar to the English language, "modification within nominal phrases in Turkish operates from left to right" (Göksel & Kerslake, 2005, p. 185). However, the structural assembly of naming special types of pyramids and prisms in the Turkish mathematics language follows a "shape adjective + physical quality adjective + head noun" pattern. For example, a right prism with a triangular base must be named as 'triangle right prism' ('üçgen dik prizma' in Turkish). Note the shape adjective 'triangle' ('üçgen') does not have an adjectival suffix. A reverse order between triangle ('üçgen') and right ('dik') gives birth to a new sub-classification, namely it refers to a 'right triangle prism' ('dik üçgen prizma') signifying a prism with a right triangular base. The phrase, 'right triangle prism,' does not contain a physical quality adjective (see Figure 1).



**Figure 1: Cumulative structural assembly of shape and physical quality adjectives to name a prism/pyramid in the Turkish mathematics language**

## Methods

We designed a case study to identify the types of adjectives that a group of prospective mathematics teachers used for naming oblique and right pyramids/prisms. At the beginning of a methods course, all students took an open-ended test. Among those, six prospective mathematics teachers participated in an individual task-based interview.

A semi-structured interview protocol was designed to analyze, first, what kind of physical quality adjectives prospective mathematics teachers used for prisms and pyramids and what meanings they attributed to those adjectives, and then, in what ways prospective mathematics teachers found a ground for physical quality and shape adjectives in their Turkish noun phrases. During the interviews, the participants were provided with their answers from the open-ended test and acknowledged that they could rename or modify their prior answers if they wished. The interviewer gave the interviewees physical models of the indicated prisms/pyramids. The interview questions included a right and oblique pair of the same type of prisms/pyramids on the test in the following order: square prisms, square pyramids, rectangular prisms, triangular prisms, and tetrahedrons.

The interviews took place in three stages. In the first stage, the interviewer (the second author) went through the interviewees' written responses making little intervention about their responses. For those who used a physical quality adjective, the interviewer asked their rationale for their naming without emphasizing the order of the adjectives.

In the second stage, the interviewer used prompts to reveal the participants' use of structural assembly of words such as what a shape or physical quality adjective in their naming signified. For example, for those who gave a 'right square prism' answer, the interviewer asked: "how did you order the geometric terms in your naming?" and "what does 'right' modify here?" From there, the participants revisited their answers and made changes if they found them necessary.

In the third stage, the interviewer requested the participants to refer to the special type of the triangle on the base of the given prisms/pyramids, asking questions such as "suppose you want to indicate in your naming that your 'triangle prism' has an isosceles triangle on the base. How would you name it with a focus on its orientation?" Next, she asked them to specify the name of a geometric solid such that the base was a right triangle, which enabled them to revisit their

ideas, in particular those who used ‘right triangle prism’ where ‘right’ was used for the orientation of the referred geometric solid.

For the current study, we limited our results to one of the prospective mathematics teachers, Ada (pseudonym). We were motivated to interview Ada because she provided a variety of shape and physical quality adjectives such as scalene and regular, in the open-ended test. Also, different from our other interviewees, Ada used a physical quality adjective for each geometric solid (except ‘cube’). In the test, Ada’s physical quality adjectives always came before her shape adjectives, namely she used a “physical quality adj. + shape adj. + noun” pattern. Her adjectives at her disposal and her consistent uses of the adjectives made us wonder how she named the given geometric solids and ordered her multiple adjectives. In the test, Ada used the adjective, ‘regular,’ to refer to right geometric solids such as ‘regular rectangles prism’ and ‘regular triangle prism.’ On the other hand, she used the adjective, ‘oblique,’ for non-right geometric solids such as ‘oblique rectangles prism.’ During the interview, the interviewer used the exact noun phrases Ada used, without correcting her answers. For example, Ada’s naming of ‘right prisms’ as ‘regular prisms’ was incorrect in the Turkish mathematics language. Yet, the interviewer used the noun phrase of regular prism<sup>1</sup> when she posed her questions related to right prisms.

After the interview with Ada, the data were transcribed. We identified Ada’s physical quality and shape adjectives and characterized how the adjectives as pattern units were put into her noun phrases. We delved deeper into her adjective choices and their orders, drawing on her rationale for putting them in order with a focus on semantic and syntactic characteristics. We characterized Ada’s semantics of Turkish lexicogrammar when she referred to the meaning of composite structures assembled in a relational sequence, including unusual combinations between adjectives (e.g., treating an adjective as a non-adjectival noun). When she referred to the order of the adjectives in her noun phrases, for example, we interpreted her reasoning as signs of syntactic characteristics of her lexical items.

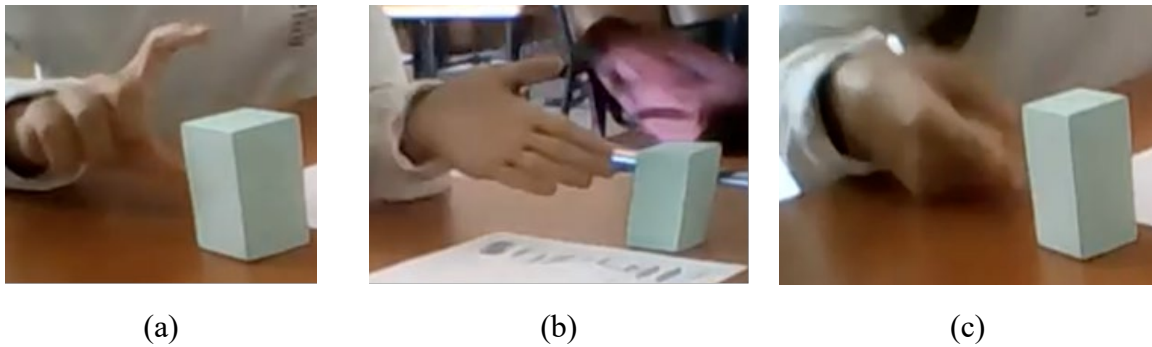
## Results

In the first stage of the interview, Ada was asked to go through her answers in the open-ended test. Similar to her written answers, Ada used a “physical quality adj. + shape adj. + noun” pattern when she was asked to name the given pairs of prisms/pyramids. She used the physical quality adjective “oblique” (*eğik* in Turkish) for the non-right geometric solids, which was correct in the Turkish mathematics language. On the other hand, her choice of physical quality adjective for right prisms/pyramids was “regular” (*düzgün* in Turkish). However, this geometric term was incorrect in the Turkish mathematics language. The meanings she attributed to the “regular prisms” concerned all edges of the prisms’ forming a right angle with the polygonal base and the innerness of the altitudes of the prisms. Then, she elaborated on her reasoning emphasizing that the edges of the right prisms were also altitudes. Ada said:

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<sup>1</sup> In spatial geometry, a regular prism refers to “a right prism whose bases are regular polygons” (Welchons et al., 1957, p. 112).

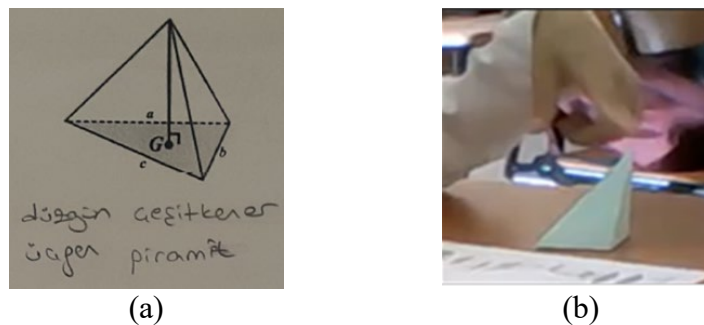
I said it was a ‘regular square prism’ because its altitude is perpendicular to the base (Figure 2a). That's why I named it ‘regular.’ For this one, I named it an ‘oblique square prism’ because it is positioned obliquely to the base (Figure 2b).



**Figure 2: (a) Ada shows the perpendicularity of the altitude to the square base, (b) she makes an oblique gesture with her palm along the edge of the oblique square prism, (c) she points out that the altitude of the right square prism could be one of the edges**

Ada also added that “the bases are squares for the two geometric solids (referring to the pair of right and non-right square prisms). I can measure the altitude outside of the prism (referring to the non-right square prism), but I assumed the altitude of this prism (pointing the right prism) was inside the prism or it was one of the edges (see Figure 2c).” Later, Ada explained what she took into consideration while she was naming a right triangular prism. She made syntactic descriptions focusing on the semantic characteristics for each word in her noun phrase. She said:

It is because when I say ‘regular,’ I want it to evoke in our mind first, whether it (the altitude) drops down obliquely or perpendicularly in a straight manner [to the base]. After that, I thought what shape they (the bases) were. Whether they were all prisms (oblique and right triangular prisms) would come to my mind later. That’s why I made such an order.



**Figure 3: (a) Ada wrote ‘regular scalene triangle pyramid’ in the written test, (b) Ada points out that the apex was not dropping down to the center of the base**

Ada added a mathematical quality to the adjective of regular by describing how she labeled the geometric solid as shown in Figure 3a with a ‘regular scalene triangular pyramid.’ She had a linguistic obstacle and emphasized that the expression ‘regular scalene’ in her naming was non-sense. She said:

Well, when I said ‘regular,’ I thought about the altitude, but when regular polygons are referred to, like a regular hexagon, it must evoke in mind a hexagon whose side lengths are equal. When we think so, if we call this a ‘regular scalene,’ there is a logical error. For that reason, it is more reasonable if I leave it as ‘scalene triangle pyramid.’

Here, Ada treated the adjectival phrase, ‘regular scalene,’ as a detached lexical item from the whole noun phrase, ‘regular scalene triangle pyramid.’ Then, she contended that in a regular geometric solid, all the side lengths of the base shape were equal, and dropped the physical quality adjective, ‘regular,’ in her naming for the tetrahedron as shown in Figure 3a.

The meanings she attributed to the ‘oblique prism/pyramid’ for the non-right geometric solids concerned the orientation and outerness of the altitudes of the geometric solids. Concerning the orientation of the geometric solids, Ada stressed: “when I compared the right geometric solid in the given pair, I needed to use an adjective to distinguish it from the oblique one.” She added: “in the ‘oblique square prism,’ I named it an ‘oblique square prism’ because of its oblique orientation to the base.” Concerning the outerness of the altitudes of the geometric solids, for example, she pointed out that the apex of the pyramid was not dropping down to the center of the base in the ‘oblique pyramid’ (see Figure 3b) and that the altitude was positioned outside of the given pyramid model.

In the second stage of the interview, the interviewer delved deeper into the order of the adjectives. Ada had another linguistic obstacle when she was asked about the order between the physical quality and shape adjectives in her naming. When the interviewer asked if a ‘regular triangle prism’ would also be called a ‘triangle regular prism.’ Although Ada favored “triangle regular prism” from a syntactic perspective, she was also fine with changing the order of the shape and physical quality adjectives. She said: “So when we say it in that way (triangle regular prism), it is reasonably okay, but I have never heard that it is used in that way. So, the ‘regular triangle prism’ sounds more accurate.” Shortly after, in response to the interviewer’s question whether ‘regular’ as in ‘regular triangle prism’ characterized the ‘triangle’ or the ‘prism,’ Ada put the shape adjective to the front and the physical quality adjective to the second place. She posited:

Let me call this a ‘triangle regular prism’ because it (regular) characterizes the ‘triangle prism’... When we say ‘regular triangle,’ it sounds like it characterizes the triangle. It is like a prism whose sides (bases) are all equilateral triangles. When we say a ‘triangle regular prism,’ it is like characterizing the ‘prism.’ In what I just wrote down, it characterizes the ‘triangle.’

In this case, Ada treated the adjectival phrase, ‘regular triangle’ as a noun phrase where ‘triangle’ no longer functioned as an adjective. Yet, the base of the pyramid was not an equilateral triangle, nor had she meant to refer to an equilateral triangle in her naming. To resolve her linguistic obstacle, she swapped the adjectives and used a “shape adj. + physical quality adj. + noun” pattern. In a similar vein, she changed the order of her shape and physical quality adjectives while she was going through her answers given to the oblique geometric solids. Ada said: “When I name it an oblique triangle prism, ‘oblique triangle’ is meaningless here. That’s why I say ‘triangle oblique prism’ makes more sense to describe this prism.” Here,

Ada treated the adjectival phrase, ‘oblique triangle’ as an individual noun phrase. Then, she renamed all the oblique geometric solids such as ‘triangle oblique pyramid’ and ‘square oblique prism’ using a “shape adj. + physical quality adj. + noun” pattern.

In the third stage of the interview, the interviewer prompted Ada to form denser noun phrases. For example, the interviewer asked how she would name a right prism with a right triangular base where the adjective ‘right’ was a shape adjective modifying the triangular base. The interviewer used the physical quality adjective ‘regular’ when she posed her question since Ada had used the adjective of regular to refer to right prisms/pyramids before. In response to the interviewer’s prompt, she labeled the right prism with a right triangular base with a ‘right triangle regular prism’ noting that the ‘right’ as in ‘right triangle prism’ did not indicate the prism was ‘right.’ In Ada’s explanation, here, the adjective of right as in ‘right triangle’ functioned as a shape adjective signifying the base of the prism. Ada maintained her use of ‘regular’ as a physical quality adjective to refer to right geometric solids. She, for example, labeled the right prism with a right triangular base with a ‘right triangle regular prism’ and added: “I have never heard of it.” The pattern she used was in the form of a “special shape adjective for the triangle + shape adjective + physical quality adjective + noun” structural assembly.

The interviewer asked Ada what she would call a right prism with a regular hexagonal base to see how Ada would organize her noun phrase in which the adjective of regular would be used twice. Afterwards, Ada said that she would label it with ‘regular hexagon regular prism.’ Then, for a non-regular hexagonal base, she used ‘hexagon regular prism’ and spontaneously added: “I could have said ‘right’ instead of ‘regular’ that I have put here. We could also indicate the angle that this edge makes... Like triangle right prism.” Afterwards, she claimed that the physical quality adjectives of regular and right could be used interchangeably. However, she was unsure about the correct physical quality adjective needed to name right prisms/pyramids, and stressed that using ‘right’ instead of ‘regular’ sounded more familiar to her.

### **Concluding remarks**

We characterized Ada’s use of physical quality and shape adjectives to name special prisms/pyramids with a focus on her use of semantics and syntactic characteristics of the Turkish mathematics language. The results indicated that Ada made semantic characterizations and syntactic changes in her structural assembly of words, forming subordinated meaning units between two successive adjectives such as oblique triangle and regular scalene. In some cases, Ada treated adjectival phrases as individual noun phrases, which urged her to change the order of adjectives. By changing the order between the shape and physical quality adjectives, she believed that a possible misunderstanding of non-sense or unintended expressions such as ‘oblique triangle’ would be eliminated since the syntactic change would allow for no subordination between the adjectives.

Although regular prisms and pyramids exist in solid geometry, Ada’s attributed meaning to the ‘regular’ was incorrect. Her incorrect choice of the physical quality adjective (‘regular’) to refer to right prisms/pyramids prompted her to change the order of the shape and physical quality adjectives. She made semantics-driven subordination between adjectives such as



‘regular triangle’ as in ‘regular triangle prism’ without making a cumulative modification in her structural assembly of words.

We limited our results within a cognitive-functional approach to grammar construction. However, more research from different theoretical perspectives (see Erath et al., 2021) may show overriding factors that influence individuals’ syntactic and/or semantic awareness. In particular, some mathematics educators, embracing a functional linguistics perspective of language, advocate for “lexical and syntactical features not as ends in themselves but as means for realizing discourse patterns” (Erath et al., 2021, p. 246). Also, new research grounded in a sociolinguistic view may indicate social and cultural entrenchments of grammar construction to better understand individuals’ word use and naming in mathematics.

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