MATHEMATICAL EDUCATION IN THE OTTOMAN EDUCATIONAL SYSTEM: THE CASE OF *CĀMİʿÜ'L-ḤİSĀB*

Osmanlı Eğitim Sisteminde Matematik Eğitimi: Cāmiʿü'l- Ḥisāb Örneği

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Abstract: The linguistic aspects as well as stylistic features of course books matter as much as their contents and place in the curriculum. In the Ottoman lands, scientific education was made in Arabic and the course books were prepared accordingly. This was as well the case for mathematics. However, some manuals in this field were prepared in Turkish, the foremost vernacular language. Turkish must have been used especially as a medium for the initiation to the subject matter while its use must have been related to students' linguistic capacities in Arabic and/or Persian. In this article, *Cāmiʿü'l-Ḥisāb,* written by Yûsuf bin Kemāl el-Bursevî, a former student of İskender Çelebi, a renowned *defterdar* of Suleiman the Magnificent which was completed in Muharrem 934 (October/November 1527) is analyzed. Our focus here is the examination of the stylistic features of the text as well as the use of Turkish as a pedagogic medium.

Keywords: *Cāmiʿü'l-Ḥisāb*, Ottoman Scientific Curriculum, Maths, Pedagogical Methods, Pedagogical Style

Öz: Osmanlı medreselerinde okutulan ders kitaplarının içerik, okutulma sıklıkları kadar dili de önemlidir. Osmanlı'da bilim dilinin Arapça olması sebebiyle işlenen ders kitaplarının çoğunluğunun dili Arapçadır. Bu durum matematik ders kitapları için de geçerlidir. Arapça eserlerin yanında Türkçe yazılmış matematik ders kitapları da vardır. Eğitimde Türkçe, daha çok öğrenciye ulaşmak için bir aracı dil konumundadır. Bu sebeple, öğrencinin bildiği dil üzerinden bir anlatım gerçekleşir. Yazarın kullandığı dil, üslup ve matematik terimlerinin kullanımı muhatabın sadece Türkçe veya Türkçe yanında Arapça ve / veya Farsça bilmesine göre değişiklik gösterir. Bu çalışmada Kanunî dönemi baş defterdarı İskender Çelebi'den dersler almış olan Yûsuf bin Kemāl el-Bursevî tarafından Muharrem 934'te (Ekim / Kasım 1527) yazılmış *Cāmiʿü'l-Ḥisāb* adlı eserden hareketle matematiğin öğretim dili muhatap, yazar / öğretici arasındaki ilişki dikkate alınmış ve Türkçenin yapısı üzerinden değerlendirilmiştir. Buradaki odağımız, metnin üslup özelliklerinin incelenmesi ve Türkçenin pedagojik bir ortam olarak kullanılmasıdır.

Anahtar Kelimeler: *Cāmiʿü'l-Ḥisāb*, Osmanlı Bilimsel Ders Programı, Matematik, Pedagojik Yöntemler, Pedagojik Üslup

Introduction

Mathematics was, as it is the case in the Western Scholastic system, a part of the *Quadrivium* in the Middle Eastern educational institutions, comprising arithmetic, geometry, astronomy and music.[1] Ottoman madrasa course books were prepared, with some exceptions, in Arabic and mathematical works, either *muhtasar* (summary) or *müfîd*, were also in that language. Among these, treatises written by Nizamüddin el-Nisâburî, İbnü'l-Havvâm Kemâlüddin el-Fârisî, İbn'l-Hâim, Bahâuddin el-Âmili and Ali Kuşçu were largely read and taught.[2] There were, however, depending on pedagogical needs, some manuals prepared in

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[1] C. İzgi, *Osmanlı Medreselerinde İlim*, C.I Riyaziyyat, İz Yayıncılık, İstanbul, 1997, p. 208. When compared to the astronomical literature, arithmetical works were Turkified in a later period and when compared to the geometrical one, in an earlier phase.

[2] Cevat İzgi, *op. cit.*, p. 207-252.

Turkish, such as Hacı Atmaca's *Mecmâʿü'l-Kavâʿid* and Matrakçı Nasuh's *Umdetü'l-Ḥisâb*.[3] Historians of science had studied these texts for their contents and place in the curriculum.[4] Still, these works have to also be analyzed for their linguistic and stylistic aspects since the language is not only the medium of communication but also that of pedagogical transmission. Moreover, the content and style of the works written in Turkish are of importance for the analysis of the development of Turkish as a scientific language. In this study, our focus will be on one of the earliest examples of the genre, *Cāmiʿü'l-Ḥisāb*. Its author and contents will be briefly introduced and then, it's linguistic and pedagogic aspects will be examined.[5]

1. On *Cāmiʿü'l- Ḥisāb*

We have very few information about the author of the *Cāmiʿü'l- Ḥisāb*. It was prepared by Yûsuf bin Kemāl el-Bursevî and completed in Muharrem 934 AH (October/November 1527). The author attests in the preface that "from some time, this humble servant Yūsuf bin Kemāl Bursevî kisses the exalted dust of his Excellency İskender Çelebi Efendi's –that his fortune continue!– feet (*ḥazret-i İskender Çelebi dāmet meʿālihu ḥazretlerinüŋ ḥāk-i pāy-i şeriflerine bu bende-i naḥīf Yūsuf bin Kemāl Bursevî bir niçe müddet yüz süriyü*)".[6] One may deduce from this assertion that author was a clerk working under İskender Çelebi, a renowned *defterdar* (comptroller) during the reign of Suleiman the Magnificent.[7] Famous Ottoman bibliographer Katip Çelebi confirms this information and adds that *Cevāmi'ül-Hisāb* (*sic*!) was written in Turkish.[8] Most probably, the author was from the city of Bursa, former capital of the Ottoman State, famous for its educational institutions. Kepeci's *Register of Bursa* concisely informs that the author "was the son of a certain Kemal. He was a clerk during the reign of Suleiman the Magnificient and had a work known as *Cevami'ül- Ḥisab* (*sic*!)."[9]

OMLT enumerates seven copies of the treatise. During the research, two other copies were found. Here is its list in chronological order:

1- Süleymaniye: Lala İsmail, 288. Autograph. 120 folios, twenty-one lines each, written in *nesih* calligraphic style with diacritical marks (*harekeli*). Completed in Muharrem 934 AH (October/November 1527) by Yūsuf bin Kemāl Bursevî.

2- National Library: A.541. Autograph. 175 folios, thirteen lines each, *nesih* with diacritical marks. Completed in Safer 934 AH (November /December 1527). However, first eight folios are missing.

3- Fatih Millet Library: nr. 40. 113 folios written in *nesih* calligraphic style. Copied probably in the 11th century AH (1592-1688). The work is entitled as *Terceme-i Cāmiʿü'l-Ḥisāb*. Copyist's name is not mentioned.

4- Zeytinoğlu Provincial Public Library: nr. 1709/2 (303/2). Part of a collection of works bound in one volume, folios 60v-156r. Each page has twenty-one lines, with a plain *nesih*. Copied probably in the 11th century AH (1592-1688) by an unknown copyist.

5- Gazi Hüsrev Bey Library, R6930. 68 folios, twenty-six lines with *nesih*. Copied by Ahmed Nakkāş in 1115 AH (1703-1704).

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[3] Cf. Şermin Kalafat, "Anadolu (Osmanlı) Sahasında Yazılmış En Eski Tarihli Türkçe Matematik Risalesi: Mahmûd bin Kâdî-i Manyâs'ın Aʿcebü'l-ʿÜccâb'ı-Hesap Bölümü, *Turkish Studies, International Periodical For the Languages, Literature and History of Turkish or Turkic*, Volume, 12/30, p. 243-298.

[4] C. İzgi, *op. cit.*

[5] This article is extracted from my PhD thesis submitted and defended in 2015.

[6] Lala İsmail, 934: 2a/1-3.

[7] Ekmeleddin İhsanoğlu -Ramazan Şeşen ve Cevat İzgi, *Osmanlı Matematik Literatürü Tarihi* [*OMLT*], IRCICA Yay., II vols. İstanbul, 1999, vol. 2. p. 100; Bursalı Mehmet Tahir, *Osmanlı Müellifleri*, Matbaa-i Âmire, 3 vols., İstanbul, 1342, p. 309.

[8] Kâtip Çelebi, *Keşfü'z-Zunûn*, Rüştü Balcı (trad.), Tarih Vakfı Yurt Yay., 2 vols., İstanbul, 2013, p. 513.

[9] Kâmil Kepcecioğlu, *Bursa Kütüğü*, Hüseyin Algül, Osman Çetin, Mefâil Hızlı, Mustafa Kara (ed.), 4 vols., Bursa, 2008, p. 264.

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6- Museum of Topkapı Palace Library: H1991. 91 folios twenty-one lines with *talik*. Copied by a certain Mustafa in 1157 AH (1744-1745).

7- Cerrah Paşa Medical History Museum Library: 307: 68 folios, 25 lines with *nesih*. The date of the copy and the copyist's name are unknown.

8- Kastamonu Provincial Public Library: 37Hk3816/5, 112r-215v (104) folios, 15 lines with *nesih*. Copyist's identity is unknown.

9- Trinity College (Cambridge): Trinity R.13.11: 170 folios, 12 lines, *nesih* with diacritical signs. The date of the copy and the copyist's name are unknown.

In this article, the first two autograph copies were used. However, since the second (Milli Library A.541) manuscript lacks the eight initial folios, the first, which is Süleymaniye Lala İsmail 288, was taken as the main source and quotations are done from there.

2. Contents of the Treatise

1) First Chapter: On the forms and rules of multiplication, in five sections: The first section is on the multiplication of integral numbers. The second is about the multiplication of integral numbers with the decimals. The third is about the multiplication of decimal numbers with decimals. The fourth one is about the multiplication of integral numbers with the decimals and then the multiplication of the sum with an integral number. The last one is again a composite operation involving the multiplication of integral numbers with the decimals and then the multiplication of the sum again with another sum of a multiplication of integral numbers with the decimals.

2) The second chapter is on the decimals and their uses and comprehends calculations of metrological values such as *mūt*, *zirāʿ*, *misḳāl* and *ḳanṭār*.

3) The third chapter is about division and the operations related with it. It comprises six sections. The first section is on the division of integral numbers. The second is on the division of decimals. The third is about the division of decimal numbers by integral numbers. The fourth is about the division of decimal numbers by integral numbers by another decimal. The fifth is on the division of decimal numbers by integral numbers and then the division of the result again by the result of a division of a decimal number by an integral one. The last is about the divisions whose results are not an integral number but a fractional one.

4) The fourth chapter is on the common denominators and the relevant problems based on the multiplication and division of the fractional numbers, *i.e.*, the proper fractions, compound fractions as well as the subtypes of the latter (discrete and repeating decimals).

5) The fifth chapter is on the division of inheritance. The author tells that he is particularly expert on this (35a/5-8) and explains the particularities and vicissitudes of the operation from his own experience.

6) The sixth chapter is about the rational numbers and comprehends calculations as well as problems regarding to them.

7) The seventh chapter is on the calculations of single and double derivatives and the relevant cases.

8) The eighth chapter is on square roots and their extraction.

9) The ninth chapter is about applied geometry and the relevant problems based on that matter. The angles, polygonal forms (triangle, rectangle, square, pentagon etc.) as well as the circle and the circular forms (semicircles, hemi circles, diameters, diametric ranges, arcs, crescent etc.) are treated here. Moreover, topics such as volume, height, distance as well as applied problems are discussed.

10) The tenth chapter is about equations. In other words, it is the equivalent of algebra and *mukābele* sections of the Ottoman mathematical texts and covers the so-called *mesāʾil-i sitte* (the six problems). The first three are the plain ones and the latter three are the compound ones.

3. The Author and the Interlocutor: Identity, Educational Level of the Student and His Relationship with the Teacher

As is the case in all levels of communication, in pedagogic communication, the subject matter, the power relationships as well as the cultural a/symmetries matter. In other words, the speaker's style depends on his/her interlocutor. Therefore, it is of importance to determine the identity and other basic proprieties of the interlocutor. It is important to identify to whom Yūsuf bin Kemāl is addressing to. The main interlocutors are seemingly Turkish speaking students.[10] As the author specifies in the preface of his work, the target is mostly the beginners and not those who already are experts. (…*mübtedīler içün beyān olınur yoḳsa ehl-i fażıl yanında ne miḳdārı ola*).[11]

Another constituent of the style is the educational level of the interlocutor. Implications, allusions and instructions depend on this decisive factor. Although it is not specified clearly, the contents of the work give some clues. *Cāmiʿüʾl- Ḥisāb* starts directly with the operation of multiplication. In other words, elementary operations such as addition and subtraction are not treated. Then comes up integral numbers, decimals and goes with more complex problems which make us deduce that the interlocutor is not an absolute beginner.

3.1. How to Address the Interlocutor? A Stylistic Matter

In this kind of works, the explanations are mostly in passive voice. However, Bursevî uses more often than not the active and the lessons, examples as well as the problems are given both in first person plural and second person singular active. His style can be summarized as first the precision of the rule, then the question and at last the answer. When the question is formulated in second person singular, the answer is formulated in second person singular. (6b/3-5: *cümlesinüŋ ḳıymeti ne miḳdār olur ḍarb-ı ḳafesiyle istiḫrāc itmek dileseŋ/ … cümle idüp cevāb viresin* 7r/3 [what will be the sum if thou are to extact… Answer to this summarily]). When the question is formulated in first person plural, then the answer is in first person plural. In some cases, there are also some shifts: *eyle olsa beş dirhemi iki şey üzerine ziyāde eyledüŋ yedi şeyʾi kâmil olur. Beş dirhem daḫı maʿādil üzerine... ziyāde iderüz kim yigirmi üç dirhemdür yigirmi sekiz olur* [Thence, when you add two dirhams to five dirhams, that will amount to seven. When we add another five dirhams to the sum of twenty three, that will make twenty eight] (84 v15-85r /8). One may interpret these shifts from the second person singular to first person plural as an attempt to isolate the student in order to facilitate his concentration on the problem. And when the author passes to the plural voice, it is to assure his addressee, especially when the latter has to make some conclusions. Quite often, second person singular is used in easier cases and the plural in complex ones by the author.

4. Pedagogical Style of the Author

Today, mathematics is taught by several techniques such as plain demonstration, terminological, inventive, analytical, application ones etc. In the text, Yūsuf bin Kemāl uses some of them.

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[10] also see, İhsan Fazlıoğlu, "Osmanlı Döneminde "Bilim" Alanındaki Türkçe Telif ve Tercüme Eserlerin Türkçe Oluş Nedenleri ve Bu Eserlerin Dil Bilincinin Oluşmasındaki Yeri ve Önemi", *Kutadgubilig Felsefe-Bilim Araştırmaları*, 2003, p. 151-184.

[11] 2v/20-21.

4.1. Scenario Based Teaching

Scenario based teaching intends to inculcate the logic of the matter to be taught through putting the addressee in concrete contexts.[12] Yūsuf bin Kemāl makes abundant use of this technique as cited below:

"mesʾele-i āḫar iki ḫurmā aġacı olsa bir āb kenārında birinüŋ ṭūlı yigirmi beş zirāʿ olsa ve birinüŋ ṭūlı yigirmi zirāʿ olsa, birbirine ıraḳlıġı altmış zirāʿ olsa, bu ḫurmā aġacınuŋ depesinde 80b/16-19. birer ḳuş olsa, bu şuda balıḳ gözedür olsalar, ikisi bile bir balıḳ görüp berāber uçalar bir ḫaṭṭ-ı müstaḳīm üzere müʾeyyed ile bu balıġa yitişseler, bu balıḳ da şu içinde bir aġacdan bir aġaca bir ḫaṭṭ-ı müstaḳīm farż eyleseŋ, anuŋ üzerinde olsa bilmek isteseŋ kim ol ḳuşlar her birisi ne miḳdār yir uçarlar ola, yā balıḳ olduġı yirden aġac dibine dek ne miḳdār yirdür." [Another riddle. Let's assume that there are two palm trees – one being twenty five *zira*s of height and the other twenty– alongside a pond whose distance to one another is sixty *zira*s. Above each of it there is a bird who watches out a fish. Both see it and prey on it simultaneously following a direct line. At that moment the fish makes the distance of two trees. Now find out the distances that both of the birds have made and the distances from the fish's initial position to the roots of the threes].[13] The question is given with lavish detail. There are many narrative elements which are not of mathematical use *per se* as the details about the tree. Moreover, the initial setting enables the author to ask two separate questions. The narrative sequencing allows the author to develop these questions further without vexing the students.

Here is another example with an engaging narration. "*eger ʿAmuruŋ iki biŋ üç yüz aḳça mālı olsa, bir metāʿa virse; baʿdehū otuz gün geçdükden soŋra Zeyd gelse iki biŋ altı yüz aḳça ol daḫı getürse, birbiriyle şerīk olsalar; baʿdehū on günden soŋra Bekir daḫı gelüp üç biŋ aḳça sermāye ol daḫı getürse şerīk olsalar; baʿdehū diger Bekir daḫı yigirmi günden soŋra gelüp iki biŋ sekiz yüz aḳça ol daḫı getürse, cümle bu dört nefer kimesne şirket ṭarīḳiyle bir yıl ticāret idüp cümle biŋ altı yüz aḳça fāyide ḥāṣıl itseler; ammā ticāretleri şol şarṭ üzere olsa ki fāyidelerin her birinüŋ gününe 36b/5-16 ve mālına göre ḳısmet itmek dileseler; bu taḳdīrce her birinüŋ ḥiṣṣeṣi ne miḳdār vāḳıʿ olur bilmek dileseŋ…*" [Let's suppose that 'Amr has some goods whose worth is two thousand and three hundred aspers. Then he sells some of it. A month later, Zayd comes up with a capital of two thousand and six hundred aspers to form a partnership. And then Bekr arrives twenty days afterwards with a capital of three thousand aspers. Following this, another Bekr comes up with two thousand and eight hundred aspers. Within this partnership, they make their trade during a year and make a profit of a thousand and six hundred aspers. The founding principle of the enterprise was the distribution of the profit according to the sum and daily involvement of each of the capital supplier. Let's now find the profit of each trader].[14] The question is lain out in complex manner. A detailed narration enables an easier focus on the problem.

4.2. Teaching by definition

In teaching by giving definitions first, the teacher explains every term in advance. By so doing, the student learns their use within the proper configuration. In this technique, both the terms that will be of use and those which will not be, given together.[15] In the sections where the

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[12] see, Mehmet Mustafa Toker , "Aktif Öğrenme", *Üniversite ve Toplum Dergisi*, III\1, 2003, p. 7-19; Banu Yaman, "Senaryo Tabanlı Öğrenme Yaklaşımına (Stöy) Dayalı Eğitimde Drama Yönteminin İlköğretim Beşinci Sınıf Öğrencilerinin Okuduğunu Anlama Başarılarına Etkisi", *Ç.Ü. Sosyal Bilimler Enstitüsü Dergisi*, XIV/ 2, 2005, p. 485-492; Esen Ersoy and Neşe Başer "İstatistik ve Olasılık dersinin Senaryo İle Öğretim Süreci Sonunda Öğrencilerin Eleştirel Düşünme Eğilimlerindeki Değişim", *Ondokuz Mayıs Üniversitesi, Eğitim Fakültesi Dergisi*, 33, 2014, p.1-15.
[13] 81a/1-6
[14] 37a/1-3.
[15] M. Toker, *op. cit.*, s. 12.

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author informs about the science of *misaha* (measurement of distance and space), definitions of different terms are given. Often, the author gives detailed explanations without initially giving examples and making allusions. Here is an example: "[c]*ez̲ir aŋa dirler ki bir ʿadedi gendü nefsine urasaŋ ol ʿadede ceẕir dirler ve ḍarbdan ḫāṣıl olan ʿadede mecẕūr dirler ve murabbaʿ daḫı dirler ve māl daḫı dirler.*" [*jazir* is the multiplication of a number with itself. The result is called the *majur*. It is as well called as *murabba* and even *māl*].[16]

4.3. Teaching by rule

Teaching by giving the rules first implies the learning by heart of some of the operations. Even if nowadays this technique is less used, still some operations are still inculcated by this manner such as the extraction of square root as well as some complex operations in algebra.[17] There are many instances in the text where this method is applied. Here, we will give the example of the extraction of the square root: "*faṣl-ı sāmin muḍalliʿāt beyānındadur bir niçe ḳısım üzerine beyān olınur. Ḳısm-ı evvel ceẕr-i manṭıḳ beyānındadur. Ceẕir aŋa dirler ki bir ʿadedi gendü nefesine urasaŋ ol ʿadede ceẕir dirler.*" [Chapter eight: This is about how to extract square roots. It will be explained according to the cases. The first is about the extraction of root of rational numbers. A square root operation involves the multiplication of the same numbers. The result is a perfect square.][18]

5. Use of Synonyms and Deductive Forms

5.1. Teaching the Terms with Their Synonyms

One of the difficulties that the author is affronted with is the fact that his students are monolinguals. The latter probably know only Turkish while the terms are in Arabic. Often the author explains the term starting with an *i.e.* (yaʿnī) or eventually, with a synonym in Turkish.

Here is an example: "*mālı kāmil ḳıluruz; yaʿnī s̲i ḫums mālı dü ḫumsa ilḥāḳ iderüz tā kim bir māl olur ve mālı ziyāde eyledügümüz miḳdārı muḳārinine daḫı **ziyāde iderüz***; *yaʿnī on bir ceẕri on altıya **ḳataruz** tā kim…*" [We complete the square in other words we add up the three fifth to two fifth so as to it make a square. And then, we increase *i.e.* that is to add up the square with another one].[19] Here, the Turkish verb "*katmak*" designs both to make perfect (*kāmil ḳılmaḳ*) and add up (*ilḥaḳ itmek* as well as *ziyāde itmek*).

5.2. Explaining the rule by making use of the "*lāzım*" and "*gerek*" formules

The words "*lāzım*" and "*gerek*" in Turkish are synonyms and both design a necessity. We see in the text their use in many instances generally for two different situations:

"*Aṣıl mālı sekiz farż eyledük; pes sekiz daḫı ilḥāḳ olunduḳda on altı oldı içinden üç dirhemin alduḳ, on üç bāḳī ḳaldı; baʿdehū ol miḳdār daḫı ilḥāḳ eyledük, yigirmi altı olur; içinden on dirhemin alduḳ, bāḳī on altı dirhem ḳaldı; baʿdehū bir ol miḳdār daḫı ilḥāḳ eyledük, otuz iki oldı; pes yedi ʿadedin giderdük, bāḳī yigirmi beş ḳalur; bize ḫōd ṭoḳuz ḳalmaḳ **gerekidi** kim ṣaḥīḥ olaydı; pes ḫaṭā on altı vāḳıʿ oldı zāyiddür.*" [We had assumed that the capital is formed with eight dirhams. When we had added another eight dirhams the sum amounted to sixteen. When we had subtracted three dirhams, we had thirteen in total. After adding to this another thirteen units, we had twenty six dirhams. After subtracting ten dirhams, our capital shrank to sixteen. When we added as much as this, we had thirty two dirhams. After deducting seven, we arrived at the sum of twenty five. But normally we **had to** have nine in order to have a valid operation. We have now a superfluous sixteen. 48a/6-14]. In this example, the author

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[16] 53a/3- 6.
[17] M. Toker, *op. cit.*
[18] 53a/7-11.
[19] 89b/2-5.

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makes use of the "*gerek*" so as to accentuate the necessary condition and as such, accentuates the absoluteness.

There is another use of this formula: "*Pes cevāb virürüz ki ikinci yāḳūtuŋ bahāsı ki bir şey ṭutmışıduŋ yedi yüz yigirmi dinār olur;* **lāzım geldi ki** *bahā-yı yāḳūt-ı evvel altı yüz ḳırḳ dinār ola ve üçünci yāḳūtuŋ bahāsı sekiz yüz ḳırḳ dinār olur; çün bu üç ḳıymeti cemʿ eyledüŋ iki biŋ yüz dinār olur ve her mesʾele ki bu cins vāḳıʿ ola bu ḳıyās üzerine iḫrāc olına.*" [We can respond in this manner: You had taken the value of second ruby as *x*. That makes seven hundred and twenty dinars. The first ***must have been*** worthy of six hundred and forty dinars and the third, eight hundred and forty. Their sum makes two thousand and a hundred dinars. This sort of problems may be thus resolved in comparison to this particular one. 116b/3-9.] Here the use of ***lāzım geldi ki*** implies the result which is required. In other words, he makes a deductive implication.

6. Coherence and Cohesion

One of the basic pedagogic rules is the clarity in the exposition. Another one is the exemplification by asking the similar questions in multifarious manners. The author is reminiscent of these rules and applies them regularly.

6.1. Use of Conjuction Connectives in the Explanation

Often the author makes use of explanatory formulas. Here are some cases:

"***Pes*** *iki yüz elli zāyid olur ḫaṭā vāḳıʿ oldı ve sānīye ṧemen-i elmās sekiz yüz elli dirhem farż eyledüŋ ol taḳdīrce ṧemen-i yāḳūt yedi yüz on altı dirhem ve ṧülüṧān dirhem olur ve ṧemen-i laʿl altı yüz ḳırḳ bir dirhem olur ve ṧülüṧān dirhem olur* **anuŋiçün kim** *ṧemen-i yāḳūtuŋ nıṣfı üç yüz elli sekiz dirhem ve ṧülüṧ dirhem olur biŋden ṭarḥ idecek altı yüz ḳırḳ bir dirhem ve ṧülüṧān dirhem olur* **çünkim** *ṧemen-i laʿl bu miḳdār farż olundı.*" [As such, two hundred and fifty exceeds. But this is a false conclusion since you had assumed the price of the second diamond as eight hundred and fifty dirhams. This makes the value of the ruby 716+1/6 dirhams and that of the other gem, 641+1/6 dirhams. *Because of this*, half of the price of the ruby is 358 +1/3 dirhams. If you are to subtract it from thousand you will have 641+1/6 dirhams *because* the other gem's price was attributed to this value 52a/1-9.] Here we see that the author uses many explanatory connectives such as *anuŋiçün kim, çünkim.*

6.2. The use of opposing conjuction in order to give possibilities and facilitate the answer

The author uses opposing connectives in order to give possibilities and facilitate the answer. As such, he shows the students the means through which they can solve problems similar in nature. Here is an example: "*eger iki ḫaṭṭ birbirine ulaşacaḳ olursa ammā istiḳāmet üzerine degül ol vaḳt ol ṣaṭḥ ki iki ḫaṭṭ ortasında vāḳıʿ olur.* [When two lines coincide *but* not in the same plain thence their axe is in their middle." 72a/13-15]. The author uses here the connective "but" in order to accentuate the point made.

6.3. Use of Conditionals

While teaching, Bursevî uses abundantly the conditionals. The conditional suffix "-sa" is widely utilized with if or when clause. In some other cases, he makes use of "*gerekse…gerek*" formula. By doing so, he enables the interlocutors to seize the means through which they can solve problems similar in nature: "***eger*** *bir şekil olsa ḍılʿlıları müsāvī ammā bilmeseŋ ki ḳāyimüʾz-zāviye midür yā murabbaʿ mıdur yoḳsa muʿayyen midür her iki ḳuṭrını ölçesin* **eger** *mütesāvī olacaḳ olursa murabbaʿ olur eger mütesāvī olmazsa muʿayyen olur ḳāʿidedür.*" [When there is a polygonal form and you do not know if it is a square or a rectangle. You have to

measure the longitudes. *If* they are the same, it is a square and *if not* it is a rectangle. That is a rule 75b/15-19].

7. Order and sequence

One of the crucial points while teaching mathematical operations is the order and sequence of operations. This is often made with the proper usage of sequence connectives which directs the ordering (priority, generality etc). In this, the proper ordering of the question is equally important because this hints as well to the order of the operations to be done. First part of the question refers to the first operation, the second part to the second operation and so forth.

Here is an example: "*eger bir ṭop olsa gümişden, vezni üç yüz seksen beş dirhem olsa; bir top daḫı olsa altūn ile gümişden; büyüklikde evvelki ṭopuŋ ʿaynı olsa, vezni dört yüz yetmiş beş dirhem olsa ol taḳdīrce soŋraġı ṭopuŋ altūnı ne miḳdār ve gümüşi ne miḳdār olur.*" [Let's assume that there is a silver ball which weighs three hundred eighty five dirhams. And if there another ball made with golden and silver of the same size which weighs four hundred and seventy five dirhams. What is the latter's gold and silver ratio? 111b/9-13.] The author first gives the value of the first ball and then, the second. The operation will be made by making an equation.

Here, the author reminds first the rule to be kept in mind: "*…baʿdehū s̱ānīye'l- ʿadedde cümle eyledügüŋ aʿdādı gine mezbūr altı ʿadede ḍarb idesin; ne miḳdār ʿaded ḥāṣıl olursa aṣıl māldan ol miḳdār aʿdād ṭarḥ idesin; eger bāḳī ʿaded ḳalmayup tamām vefā iderse ol vaḳtin māl-ı kaʿb-ı munṭaḳ diyesin ve eger bāḳī ʿaded ḳalursa māl-ı kaʿb-ı āṣamm diyesin.*" [*Afterwards*, you have to multiply the numbers in the second set with the aforementioned six numbers. And then you subtract the result from the initial total sum. If there remains no resting number, then you will have an equivalent of fifth degree of rational numbers; if not, than that of a fifth of irrational numbers 70b/2-9]. The author provides and teaches a rule through solving a problem. While passing to a new operation, he uses a sequencing connective (*baʿdehū*). While designing another operation, he uses another sequencing connective (*gene* [again]) to denote this one. At the end of the case, to point at two probable outcomes, he uses the *eger* and *eger* (if…if not) formula.

Here is another example in which sequencing is carefully made: "[*Mes̱elā iki māl iki māla ḍarbdan dört mālu'l-māl ve illā iki ceẕir illā iki ceẕir dört māl illā iki ceẕir illā iki māl illā dört kaʿb ḥāṣıl olur bu mesʾele de gerekdür ki evvel bir defʿa 84a/19-21 zāyidi zāyide ḍarb ide ikinci bir kerre nāḳışı nāḳışa ḍarb ide üçünci bir kerre nāḳışa zāyidi ḍarb ide dördünci bir kerre nāḳışı zāyide ḍarb ideler tā kim bu cümlenüŋ murabbaʿ ı dört māl'ul-māl ve dört māl illā sekiz kaʿb olur.*" [For instance, the multiplication of two x^2 with another two x^2, yields to four x^4 minus two x (as a root) minus two x and four x^2 minus two x minus two x^2 minus four x^3. So in this sort of operation, it is required first to multiply the positive values, secondly the negative ones, thirdly the positive with the negative one and finally, the negative with the positive one. As such, the square of the sum makes four x^4 minus four x^2 minus eight x^3 84b/1-4.] Here each operation is denoted with the proper sequence as first, secondly *etc*.

8. Use of Compound Verbal Forms

The author does not only notify the probabilities and sequencing with the connectives but also by the use of periphrastic forms.

8.1. Periphrastic Forms

a) {–mış} + ol-: Zeynep Korkmaz defines this compound verbal structure as the precision of a previous act.[20] In our text, when this structure is deployed, it denotes both the problem and

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[20] Zeynep Korkmaz, *Türkiye Türkçesi Grameri-Şekil Bilgisi*, TDK Yayınları, Ankara 2003, p. 151.

the result. In a detailed problem about three couriers who set to their goals in differing moments and who advance in different pace, the result is explained by using this structure: "*pes cevāb viresinkim peyk-i s̱ānī peyk-i evvele biŋ dört yüz ṭoḳuz kām ve bir subuʿ kāmda yetiş**miş olur**; bu peyk-i s̱ānīnüŋ kāmıdur bu taḳdīrce lāzım olur ki peyk-i evvel iki biŋ altı yüz ḳırḳ iki kām ve bir subuʿ kām git**miş olur**; her gāh ki bu aṣıl mesʾele vāḳıʿ ola bu ḳıyās üzere istiḫrāc idesin.*" [Answer to this in this manner: The second courier attains the first in 1409 +1/7 time unit. This is the second courier's pacing time. You can deduce the first courier's pace according to this which is 2642 +1/7. Each time when you will have this kind of problem, solve it thus by comparing to this pattern. 105b/1-7]. Here with the use of this compound structure the event is generalized in the aorist form. Rather than sequencing, it denotes a certainty.

b) {–(U)r} + ol-: According to Korkmaz, this compound structure denotes a "habitude".[21] In our case, it denotes in a similar way, regularity:

"*mesʾele-i āḫar iki ḫurmā aġacı olsa bir āb kenārında birinüŋ ṭūlı yigirmi beş zirāʿ olsa ve birinüŋ ṭūlı yigirmi zirāʿ olsa birbirine ıraḳlıġı altmış zirāʿ olsa, bu ḫurmā aġacınuŋ depesinde 80b/16-19. birer ḳuş olsa, bu şuda balıḳ gözed**ür olsalar** ikisi bile bir balıḳ görüp berāber uçsalar bir ḫaṭṭ-ı müstaḳīm üzere müʾeyyed ile bu balıġa yitişseler, bu balıḳda şu içinde bir aġacdan bir aġaca bir ḫaṭṭ-ı müstaḳīm farż eyleseŋ, anuŋ üzerinde olsa bilmek isteseŋ kim ol ḳuşlar her birisi ne miḳdār yir uçarlar ola yā balıḳ olduġı yirden aġac dibine dek ne miḳdār yirdür.*" 81a/1-6. (For the translation of this quotation, See 4.1.a.). In this case, the author implies with the use of this compound structure that the birds in question are of piscivorous nature and that they do this watch as a habitude. Here we can even say that the author informs the students about daily zoological facts.

8.2. Some compund verbal forms with { –maḳ} + *bul-* and *gör-*

The author sometimes makes use of compound verbal forms with "*bul-* and *gör-* verbal forms in order to hint at necessary operations or conclusions. Here is an example: "…*muvāfaḳat talep eyledüŋ nıṣf ol**maḳ bulundı**/göründi.*" [You have wanted coherence, thence the half]. Here is a concrete case: "*Pes ḳırḳ ikiyle sekizüŋ maḫreci s̱ümündür muvāfaḳat ṭaleb eyledüŋ nıṣf olmaḳ bulundı.*" [The coefficient of forty two and eight are one eightieth. You have wanted coherence, thence the half. 32a/2-4]. In the following case (32a/7-8), the author uses *olmaḳ göründi* form. Each of these cases designates a rule.

8.3. Compound verbal structures with to be form

a) Noun +ol- + {-mış}+ ol- : When compared to a similar but a more simple verbal structure with {–mış ol- }, this refers to an operation previously accomplished. Here is an example: "[*O*]*l taḳdīrce ḳısm-ı evvel yigirmi dirhem ve rubʿ dirhem olur ki şeyi farż olın**mış ola**.*" [According to this, first part is constituted by twenty dirhams and a quart assuming that x is predefined in advance. 94b/1-2.]. In other words, by resorting to this Formula, the author implies that the value of x is already assumed or known by heart.

b) Noun + ol- + {-AcAḳ}+ ol- : According to Korkmaz, the compound verbal structures with {–AcAḳ ol-} designate an intention.[22] Here {- AcAḳ} with an "ol-" in the aorist with a desiderative, makes the intention to evolve to a firm intention, thence to a condition. Here is an example: "[*E*]*ger ikisi bile **zāyid** yā **nāḳış** ol**acaḳ olursa** ziyāde olandan eḳallın ṭarḥ idüp bāḳī ḳalan ʿadedi yazup pes bāḳī-yi evvel diyesin.*" [If both of them happens to be positive or negative, you are subtract the minor from the major and write the result as the first one. 47a/11-13]. Here is another example: "[*E*]*ger āḫir ḫānenüŋ üzerinde ṣıfır vāḳıʿ olacaḳ olursa üzerine bir ʿaded bulup yazup aŋa göre ḳısmet idesin*" [If in the last digit, there is a zero, you have to

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[21] Korkmaz, opt. cit., p. 803.
[22] Korkmaz, opt. cit., p. 806.

add up a rational number and divide according to that. 53a/17-18]. As it is evident from these, the rules are often précised by using this grammatical structure.

9. Use of the Poetical Style and Patterns

In the Ottoman Mathematical Works, and more generally in the madrasa curriculum, use of poetry and poetic patterns are common as a mnemotechnic method. These poems are often in Persian and Arabic. In *Cāmiʿü'l- Ḥisāb* there are three poems in Persian but there is a Turkish one as well:

(1*) ne buyururlar işbu mesʾelede kāşif-i müşkilāt-ı ehl-i ḳalem [*See what they offer in this matter, men of the pen the revealers of the difficulties]

(2) *aldı bir ḫoca üç ʿaded gevher* [The Hodja took three gems]

(2a) *ḳıymeti iki biŋ iki yüz dirhem* [whose value in total is two thousand and two hundred dirhams]

(3) *gel kerem ḳıl aya daḳīḳ-i fikir [*Give us a help oh! the intellligent man]

(3a) *her birinüŋ bahāsın eyle raḳam [*Write down the value of each of them]

(4) *didi ol ḫōca-ı rumūz-güşā [*Said the Hodja the solver of mysteries]

(4a) *bu suʾālüŋ cevābın mübhem [*The answer to this is a bit confuse]

(5) *evvelüŋ ḳıymetine sānīnüŋ [*If to the value of the first]

(5a) *nıṣf-ı ḳıymeti eger olursa żamm [*Is added the half of the second]

(6) *biŋ olur līkī sānī ḳıymetine [*The sum is one thousand]

(6a) *sülüs sālis eger olursa münżamm [*And when one eighteenth is added to the value of the second]

(7) *hem-çü-nān girü biŋ olur ammā [*The sum is one thousand yet gain but]

(7a) *sālise rubʿ evvelki olsa münżamm [*And when one twelfth is added up to the first]

(8) *eger olursa biŋ olur bī-şekk [*The sum is one thousand yet]

(8a) *bunı fikr güde böyle dut muḥkem [*Know it thus firmly]

(9) *her ki māhirdür bu fenn içrekim [*The one who is an expert in this field]

(9a) *müşkilüŋ ḥall ider ḳomaz mübhem.* [Solves every problem and leaves nothing vague] 51b/1-9a.

In these verses, the author narrates a puzzle where there is a problem and a way to resolve it. In the last three verses, "Know it thus firmly: The one who is an expert in this field Solves every problem and leaves nothing vague", exhorts the student to be versed in subtle problems by mastering the technics of the science of Mathematics.

Conclusion

After this scrutiny, we may infer that the author of this mathematical text's style depends mostly upon his primary objective which is to give someone the knowledge of basic rules of mathematics and to train and instruct his students in that subject. However, his text is not dry and boring, at all. It is accurate and concise in order to inculcate the rules and to make figure out the problems. The author, Bursevî, uses mainly three pedagogic techniques: teaching with definition, rule and scenery. He even renders the problems in versified, poetical format in order not only to entertain but also to facilitate the memorisation. Both in explanation and exemplification, he uses basic grammatical and stylistic patterns. He also diversifies the examples as well as cases. In other words, he redefines in accordance with the context. He enriches his explanations with pedagogic plots, descriptions and allusions.

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