



# Examining the key factors affecting teachers' translation of a theoretical framework from English into a native language: the Turkish case

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## Abstract

This study was aimed at exploring the key factors affecting postgraduate students-teachers' translation of a theoretical framework from English into their native language. The research was carried out with 21 Turkish postgraduate students who were also mathematics teachers, based on the theoretical framework of the documentational approach to didactics. The research was designed as a case study. The data were obtained from postgraduate students' weekly translation papers, the recordings of collective translation sessions, and the researchers' and the postgraduate students' reflective notes over a period of 7 weeks. The data were analyzed using descriptive and content analysis in order to investigate the factors influencing difficulties the postgraduate students had while translating. The analyses showed that the task of translating a theoretical framework at the postgraduate level led student-teachers to work on the meaning of the concepts and the unity of the framework and to reinterpret the source text. The research showed that the translation of the theoretical framework was strongly influenced by syntactic, sociocultural, and academic/educational differences, and these factors were interrelated.

**Keywords** Conceptualization · Documentational approach to didactics · Postgraduate students · Teacher education · Translation difficulties

**Mathematics Subject Classification** 97C70 Teaching–learning processes in mathematics education · 97C50 Language and verbal communities (aspects of mathematics education)

## 1 Introduction

This section discusses the increasing importance of taking language into account in the field of mathematics education (Sect. 1.1), then sets the context of this paper and its objective (Sect. 1.2), and finally situates its significance (Sect. 1.3).

### 1.1 Language in mathematics education

In the past few decades, there has been a crucial focus on language in educational research, including mathematics education research. The ZDM Special Issue on “Language and Communication in Mathematics Education” is an example of this rising trend (Morgan et al., 2014). The increase in the number of participants in working groups on “language and communication” in the most prestigious congresses in the field, such as the International Congress on Mathematics Education (ICME), the Conference of the International Group for the Psychology of Mathematics Education (PME), and the Congress of the European Society for Research in Mathematics Education (CERME), also reveals this attention towards language (e.g., TWG09: Mathematics and Language in CERME 12 received 18 papers and six poster proposals) (Planas, 2022). Such attention reflects a “social turn” in which the understanding of students' learning and awareness can be seriously affected by the social

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environment, with a significant role of linguistic and cultural diversity (Lerman, 2000).

Concerning the importance of language in students' learning at all levels, translation in mathematics education research gives rise to a number of issues. In postgraduate (PG) education, especially in non-English-speaking countries, the translation of frameworks and theories into the mother tongue is crucial, since PG students and researchers translate and interpret research articles and theses in English or other foreign languages into their mother tongue in order to utilize them in their own studies.

## 1.2 Context of this paper and its objective

In this paper, we (the authors of this study) examine possible factors that have a key influence on PG students' translation of a theory written in English after an initialization in French, into their native language Turkish. Since language has an impact on the cognitive aspect of learning (Radford & Barwell, 2016), we wanted to focus on the first professional activity performed by researchers when learning a new theoretical approach that is not in their mother tongue: translation and hence interpretation.

The aim of this study is to explore the key factors affecting difficulties encountered by PG students-teachers (PSTs) when translating the concepts of the documentational approach to didactics (DAD) theoretical framework from English into their native language (Turkish).

Although translation is done professionally by a translator and the difficulties related to equivalence and sociocultural context are taken into account within this profession, translation is also frequently used in the academic community by academicians whose native language is not English. In this context, it is important to examine and depict the key factors affecting scholars' translations, as these translations might have an influence on their further academic work.

## 1.3 Significance of the article

In the literature, most of the studies on translation have been conducted in the field of languages. There are only a few studies in other fields reporting translation difficulties, such as the Lexicon Project (Mesiti et al., 2022) and the DAD-Multilingual Project (DAD-ML) (Trouche et al., 2020). However, studies on translation in other fields also contribute significantly in respect of international comparative research (Clarke, 2013).

PG students' constructions of the concepts in mathematics education could be considered as a genesis that occurs by understanding and interpreting frameworks in mathematics education. As is known, previous information and contexts are crucial in structuring new information. In this perspective, culture and language are really important in

understanding and interpreting different frameworks that are rooted in other cultures' contexts. Therefore, translating and adapting theoretical frameworks and research articles into their own language and culture could be considered as the most important elements of PG learning.

From this perspective, exploring the factors influencing the translation process of young scholars would contribute to their conceptualization and interpretation of a theoretical framework that is not in their mother tongue.

## 2 Theoretical background of the studies

This section provides a short literature review on the issue of language and translation (Sect. 2.1), then sets the theoretical framework (DAD) which was translated by the scholars (Sect. 2.2), specifies the theoretical work which has already been carried out by the authors within the framework of the DAD-ML (Sect. 2.3), and finally, presents the research questions (Sect. 2.4).

### 2.1 Literature review on the issue of language and translation

There are many educational theories in mathematics education that have been translated into native languages, e.g., into Turkish. Various translations of different researchers may result in different meanings. For example, the educational term "constructivism" was translated into Turkish in the late 2000s with different words, and all these words had the meaning "to construct" but also another meaning with a nuanced conceptualization of the term: "konstrüktivizm" (Turkish spelling of the English word), "oluşturmacılık" (from the verb "oluşturmak," to form, to construct: a recall on giving form and shape to something), "inşacılık" (from the verb "inşa etmek" to build, to construct: a recall on the building construction profession), and "yapılandırıcılık" (from the verb "yapılandırmak," to structure, to construct: a recall on the organization of something). It took until the reforms of the Ministry of National Education in 2005 to obtain a standardization for "constructivism" in teaching and in academia; the translation "yapılandırıcılık" being used from then on in official texts, the academicians also opted for this translation in the early 2010s. This example shows the complexity of translation work for theoretical frameworks and that the acceptance of a translated term in the academic field is not self-evident.

A number of researchers in the wider literature also pointed out that translation is not a trivial process. For instance, although some researchers (Sun & Wen, 2017) reported the simple steps of translation, Hurdato Albir and Alves (2009) indicated that it is a much more complicated process requiring problem-solving, decision-making, and

the use of translation-specific strategies. Such complication might also be related to the difference between the specific sociocultural context of source language (SL) and target language (TL). This difference is of crucial importance in particular when it comes to translating a theory which is deeply rooted and developed within sociocultural and linguistic contexts. In this light, translators need to consider not only the context of source text (ST) where the cognitive, linguistic, visual, cultural, and ideological phenomena are an integral part, but also the target text (TT) with its own sociocultural and linguistic constraints and richness (Gustini & Baihaqi, 2021). Reiss (2000) also argues that while translating a theory, TT should convey the full referential or conceptual content of the ST since a theory as an informative text type should transmit the information. In order to transmit the information accurately, it is necessary to understand ST and reconstruct TT according to a different set of values and variables of different language and culture while maintaining equivalence with respect to the degree of accuracy for both ST and TT (Venuti, 2000). Even though full equivalence is accepted as a fiction, it is fundamental in the sense that any translation aims to regenerate the TT (Pym, 2014). Indeed, the reproduction of the meaning in the TL is essential for translation with a concern for semantic, syntactic, and epistemological equivalence (Ruthven, 2022).

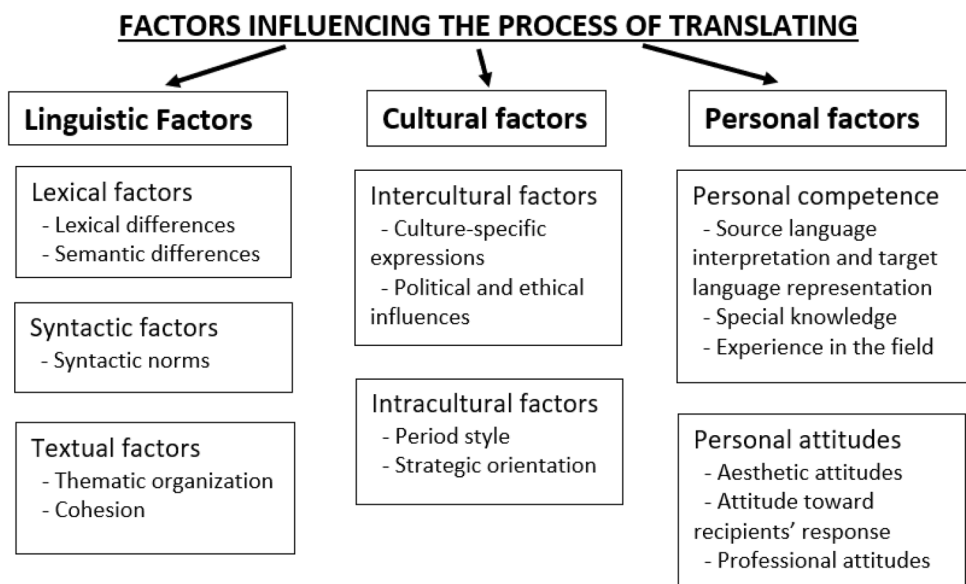
One equivalence type that is crucial in translation is semantic equivalence, which suggests a “sense-for-sense” instead of a “word-for-word” approach (Munday, 2016; Pym, 2014). In translation studies, the literal translation of a word in the SL can sometimes cause misunderstandings in the TL. In order to ensure equivalence, a more appropriate word that makes sense should be used.

Another equivalence type, syntactic equivalence, points out the differences in the sentence structures of SL and TL. In order to ensure equivalence in translation, sentences should be redesigned according to the TL, without changing the meaning (Pym, 2014).

Finally, epistemological equivalence refers to equalizing the differences between languages in terms of grammatically encoding logical temporal and spatial relations (Hewson, 2012). In addition to providing equivalence, the translation should be “plain prose” without redundancy, but with the use of explication when required (Munday et al., 2022, p. 101). Although the aim is to provide an accurately translated “plain prose” TT, it should not be ignored that there are factors affecting the translation process.

In this perspective, Wong and Shen (1999) identify the factors influencing the process of translation as linguistic, cultural, and personal factors (cf. Fig. 1). Linguistic factors are lexical factors including lexical and semantic differences, syntactic factors including the interpretation and reconstruction of the SL structure on the basis of TL syntactic norms as the differences in word order, textual factors including thematic organization, and cohesion with regard to the semantic relations between sentences. According to Wong and Shen (1999), cultural factors also have an impact on the translation process. They identify cultural factors in two subfactors which are intercultural and intracultural. Intercultural factors include culture-specific expressions and political and ethical influences. Intra-cultural factors are period style which is about the style of writing and strategic orientation which is about the strategies of translational methods. Personal factors are identified as personal competence and personal attitudes of the translators. Personal competence is about the translator's competencies in SL interpretation and TL

**Fig. 1** Factors influencing the process of translating (adapted from Wong & Shen, 1999)



representation; it is also about the special knowledge and experience in the field concerned. Another personal factor important in the translation process is the experience. According to Wong and Shen (1999), only experienced translators can skillfully and organically bring their competence and knowledge into play in SL interpretation and TL representation. Personal attitudinal factors involve the individual translator's subjective orientations within a certain historical and cultural context. Figure 1 resumes the key factors affecting the process of translating/interpreting according to Wong and Shen (1999).

The literature shows that there are key factors affecting the translations from SL to TL. The framework including the linguistic, cultural, and personal aspects of the translation and interpretation process appear to be useful to explore these key factors. Linguistic factors are mainly about the differences between the SL and TL with a concern for semantic, syntactic, and epistemological equivalence as well as cultural aspects. Personal histories of translators/interpreters can be examined in a professional and in an educational context. The context/tasks of translation factors incorporate the accommodation to the context of translation, in the case of this study an accommodation to the academic culture and knowledge about different approaches in education, and the different methods used for translation and interpretation.

## 2.2 Theoretical framework concerning translation

The DAD is a framework designed to understand teachers' interaction with their resources, and the usage schemes and possible revisions of the resources (Guedet & Trouche, 2009). It offers an insightful perspective towards teachers' professional development in terms of resources. The DAD developed its own specific concepts such as resource, document, documentational genesis, instrumentation, instrumentalization, and usage schemes. Instrumentation, instrumentalization, and genesis come from the instrumental approach (Trouche, 2005). The concept of scheme (Vergnaud, 1998) has been adapted by DAD to the usage schemes of resources. The relationship between resource and document in the DAD is similar to the relationship between artifact and instrument in the instrumental approach. Therefore, DAD has different concepts that are related to other theories and concepts in the literature. The DAD is rooted in the French didactic tradition that includes concepts such as didactical situation and didactical contract (Brousseau, 2004). It is also affected by sociocultural theory, which includes concepts like mediation as a base for cognitive processes (Vygotsky, 1978). While these concepts are familiar in the French

didactic tradition, they may not be easy to understand in other cultures.

## 2.3 Turkish language within the framework of the DAD-ML project

The DAD-Multilingual Project (DAD-ML) aimed to make the DAD available for more researchers in different languages (Trouche, 2020). The DAD-ML included both translation and discussion on translation issues (through "translation issues reports"). We (the authors of this paper) took part in the project concerning the Turkish language in 2020–2021. In the translation issues report, we mentioned the difficulties we met and how we managed to overcome them. In reviewing our translation, we requested help from our doctoral students. We observed that when they read the translation and tried to give it a more understandable structure, they met difficulties. They also shared their experiences and noted how this work on translation helped them find the opportunity for more sophisticated second thinking on the concepts of the DAD. Hence, this experience led us to conduct this study to investigate the factors influencing the translation of the DAD in PG classes. Since English is the "lingua franca" in the research community (Ruthven, 2022), the translation into native languages is a real problem when it comes to PG students who need to understand and translate academic papers written in English into their native language in order to write their theses and research papers.

Considering the fact that any translation is an interpretation, this interpretation process and the factors influencing it should be taken into account. During the translation and revision processes in the DAD-ML concerning the Turkish language, we noticed that the linguistic differences between SL and TL, the cultural elements integrated in both languages, the professional experience, and the educational background were important factors in interpretation and translation processes concerning the difficulties encountered.

In this research, we explore the key factors affecting difficulties encountered by PSTs in the translation process used in PG education for the DAD theoretical framework. In line with our literature review, the key factors structuring this research are designed under three dimensions, namely linguistic, cultural, and personal factors.

## 2.4 Research questions

How do the factors that affect the difficulties of the PSTs when translating the concepts of the DAD from English into Turkish influence the process of translation?

The related sub-questions are:

1. How do the differences between the source language (English) and the target language (Turkish) affect the difficulties encountered by the PSTs during translation?
2. How do the cultural aspects of the language affect the difficulties encountered during translation?
3. How do the personal differences of the PSTs affect the difficulties encountered during translation?

### 3 Methodology

This section presents a short description of the research design (Sect. 3.1), information about the participants (Sect. 3.2), procedure (Sect. 3.3), and data collection tools (Sect. 3.4), and details of the data analysis (Sect. 3.5).

#### 3.1 Research design

We designed this research as a case study, which is a qualitative research method used to investigate “a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenology and context are not clearly evident” (Yin, 2009, p. 18). The reason to use the case study method is to explore in depth the key factors affecting the translation processes from English into the native language (Turkish) used in PG education for the DAD theoretical framework.

#### 3.2 Participants

The study was carried out by two researchers (the authors of this study) in their PG classes. One of the researchers (the second author) has been teaching for 11 years at the PG level. The other researcher (the first author) was a 7-year-research assistant of her during the study.

The PSTs (21 PSTs, each having a 4-year undergraduate degree in mathematics education who participated in this study were 11 master's and 10 PhD students in mathematics education at a state university in Turkey. They have already taken a foreign language (English) exam to be accepted into the PG program. We requested their English levels in the personal information forms.

In order to analyze the influence of the education level of the PSTs on the translation difficulties, we have chosen to work with both master's and PhD students. All of the participants were working as mathematics teachers in middle schools except 1 master's student. We conducted the study in the context of PG courses that the participants were taking. All of the participants volunteered to participate in the study. The participants were coded as P1, P2, ... for PhD and as M1, M2, ... for master's degree. Table 1 shows some characteristics of the PSTs.

As seen in Table 1, PhD-level PSTs are more proficient in English; hence their understanding of English and their translations may differ from the master's degree PSTs. Furthermore, PhD-level PSTs are confronted with more teaching and learning frameworks in their academic backgrounds, which may favor their translation processes, because the academic knowledge of other frameworks (which is also requested in personal information forms) and being accustomed to the academic writing may be an important factor affecting the interpretation of the framework to be translated. Additionally, PhD PSTs are mostly older and they have more teaching experience than the master's degree PSTs. There are some important factors to explore beyond translation. As shown in Table 1, although linguistic factors were quite similar for all PSTs, personal factors (English level and academic background), and cultural factors (teaching experience and program type) varied in each PST.

#### 3.3 Procedure

As mentioned above, in this study, the DAD paper (Trouche et al., 2020) was given in parts to the PSTs for translation from English into Turkish so that the translated document could be used as course material and so future PSTs could understand the theoretical approach by reading such a document. The study was organized in two stages.

The first stage was conducted in 6 weeks including three lesson slots (each lasting 45 min) each week and consisted of PSTs' translating the DAD document (one part of the document each week) in written form. This was of particular importance since oral translation requires additional skills such as the simultaneous communication between the two languages and switching automatically. However, written translation does not impose time constraints for the translator and provides the highest level of equivalence to the original version (Sherzodovich & Kizi, 2020). At this stage, PSTs used their own competencies and the strategies that they selected and implemented individually. PSTs were free to use the translation tools they wanted: dictionaries (online or paper), machine translators (online or offline). We (as the researchers and the authors of the study) were fully present in each session and did not cite any tools, or favor or disfavor any strategy. PSTs were able to hear and answer each other when one of them asked a question or made a comment. During the sessions, one researcher (the first author) took observation notes when PSTs asked questions or talked about the translation process. After each translation session, we collected the part of the original DAD paper on which they might have taken some notes on the meanings of words in Turkish, and the papers they performed the whole translation on including their reflective notes regarding which resources and how they performed the translation and their difficulties. With their reflective notes, we aimed to learn

**Table 1** Some characteristics of the PSTs

Program type	Student's code	Age (years)	Teaching experience (years)	English level	Academic background
Master's	M1	23	1	Pre-intermediate	Constructivism
	M2	33	12	Intermediate	Constructivism
	M3	31	9	Intermediate	Could not remember
	M4	23	0	Intermediate	Realistic mathematics education (RME)
	M5	29	7	Intermediate	Computer-aided Teaching
	M6	25	3	Intermediate	Constructivism, 5E instructional model
	M7	27	5	Pre-intermediate	Constructivism
	M8	24	1	Pre-intermediate	Constructivism
	M9	26	3	Pre-intermediate	Constructivism Cooperative learning
	M10	29	6	Pre-intermediate	Constructivism
	M11	31	7	Pre-intermediate	Constructivism
PhD	P1	35	11	Intermediate	Constructivism, cooperative learning, RME, RBC + C
	P2	33	6	Upper-intermediate	Constructivism, computer-aided teaching, mathematical modeling, TPACK, multiple representations, problem posing and solving, spatial thinking
	P3	31	9	Upper-intermediate	Van Hiele, geometric habits of mind, problem solving, mathematical thinking
	P4	33	11	Intermediate	Constructivism, mathematical literacy
	P5	30	8	Intermediate	Constructivism, 5E instructional model, computer-aided teaching, RME, problem solving
	P6	41	8	Intermediate	Could not remember
	P7	37	13	Upper-intermediate	Problem-based teaching, geometric habits of mind, RME, APOS theory
	P8	27	3	Upper-intermediate	Van Hiele, geometric habits of mind
	P9	31	9	Upper-intermediate	RME, didactical transposition, didactical situations, mathematical modeling, mathematical literacy, problem-based teaching
	P10	27	3	Upper-intermediate	5E instructional model

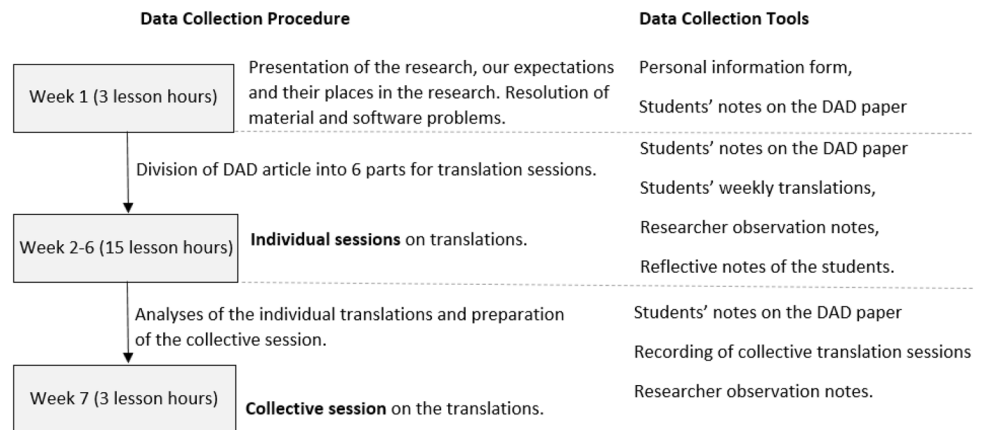
about their reflections, interpretations, and confusion about the translation of the theoretical concepts and also how they made the search and translation.

After the first stage was completed, we analyzed the factors influencing the main difficulties and the common and divergent aspects in the individual translations. Based on this analysis, we prepared the collective sessions. The aim of these sessions was to determine whether there was any influence of the PSTs' professional experience and educational background and the differences between the languages on the translation process.

Accordingly, the second stage of the study included a collective discussion session on their translation experiences and difficulties leading to a final collective translation. At this stage, we chose to alternate moments of individual work and moments of collective work, with the intention of revealing both the PSTs' reflexivity and the potential of collaborative work. In this session, we

conducted a classroom discussion about the translated concepts. In this discussion, by projecting each part of the document to the whole class, we encouraged the PSTs to discuss the points influencing the translations, and their difficulties and confusion experienced while producing the final Turkish version of the DAD paper collaboratively (i.e., "What do you think about the translation of the word 'didactics'? Let's discuss on your own translations!").

These sessions were video-recorded. We used these recordings to analyze the students' reflections about the translation process and the discussions they had to decide on their collective final versions of the translated concepts. Figure 2 illustrates the data collection procedure and the data collection tools used. We organized the collective sessions separately for master's and PhD students since they have different timetables. However, we conducted the exact same procedure for the two groups.

**Fig. 2** Data collection procedure and data collection tools

### 3.4 Data collection tools

Data collection tools used in this study included (i) personal information forms, (ii) PSTs' notes on the DAD paper (Trouche et al., 2020), (iii) PSTs' weekly translations, (iv) recordings of collective sessions, (v) researchers' observation notes, and (vi) PSTs' reflective notes.

At the beginning, characteristics of the PSTs, namely their ages, academic backgrounds, actual professional experiences, and English levels were gathered using the personal information form. The form included open-ended questions to allow the PSTs to write their answers freely.

The PSTs' notes on the DAD paper served as a data collection tool that we did not design thoroughly. The PSTs took notes on the DAD paper while translating. The notes were about their word-to-word translations and their initial unstructured sentence translations. Also, these notes included their confusion about concepts to be translated (e.g., didactics).

PSTs' weekly translations are their translation documents of each week's DAD paper part. These translations are different from the notes on the DAD paper itself. They are separate clean versions of PSTs' translations.

We observed the collective sessions, but we also used the video recordings to methodically analyze the classroom discussions. In order to support our analyses, we used observation notes. The notes were taken by one of the researchers (the first author) while the other researcher managed the sessions. These notes were about the critical concepts that PSTs discussed on how to translate.

Finally, PSTs' reflective notes reflected their own confusion and opinions about the concepts they translated and could not translate. They mentioned their reasons for not translating the concepts or why they translated them as they did in their reflective notes.

### 3.5 Data analyses

We conducted data analysis in two phases. The first phase included the analysis of the individual translations (as stated in the procedure section which allowed us to prepare the collective session). For the analysis of the individual translations, we used the document analysis method and examined each translation paper based on the key factors that are described in the analytical framework as indicated in the first column of Table 2. In this, we focused in particular on identifying the difficulties that might have emerged during the translation. First, we coded each sentence in the translation paper as an adequate or non-adequate translation. Then, we created sub-codes for the non-adequate translations based on the analytical framework revealed by Wong and Shen (1999). To do this, we first examined each translation paper considering the participants' personal factors (English level, professional experiences, and educational backgrounds) that we gathered from their personal information forms. Second, we examined the translations considering the linguistic factors (lexical, syntactic, and textual factors) and then cultural factors (intercultural and intracultural factors) as indicated in the second column of Table 2. We noted the number of PSTs (PhD and master's) for whom the factor category had an influence on the translation in the last two columns. After the coding of the translations, to identify the reasons for such inadequacies, we conducted a content analysis to make inferences systematically and objectively (Holsti, 1968). From the content analysis, we created the following sub-codes for possible reasons indicated in the third column of Table 2. For instance, we have seen that the reasons for the difficulties under the category of syntactic factors were related to sentence structure differences (SSD) and tense accordance problems (TAP). And, the reasons

**Table 2** Themes influencing the PSTs' translation process and emerging from the analyses of the individual translation sessions

Themes for key factors	Categories of factors in translation	Source of the factors	Codes for source of factors	Relevance of the factors	
				PhD ( <i>n</i> = 10)	Master's ( <i>n</i> = 11)
Linguistic factors	Factors related to the syntactic differences between SL and TL	Sentence structure differences (SSD)	SSD1. Word order SSD2. Prefixes/suffixes SSD3. Places of examples SSD4. Use of parentheses	4	8
		Tense accordance problems (TAP)	TAP1. Nonexistence of tenses TAP2. Incoherence of tenses		
	Factors related to lexical/semantic equivalences	Producing verbatim translations of idioms (PVT)	PVT1. Direct translation PVT2. Interpretation PVT3. Estimation PVT4. Omission	7	10
		Similar words in languages (SW)	SW1. Same meaning SW2. Close meaning SW3. Different meaning		
Cultural factors	Factors related to cultural aspects of language	Using culturally acceptable words (CAW)	CAW1. Considering cultural differences CAW2. omitting cultural differences	7	9
Personal factors	Factors related to teaching experience	Teaching and learning concepts (TLC)	TLC1. Omitting unfamiliar concepts translation TLC2. Translating without making sense TLC3. Translating by comparing to own teaching practice TLC4. Searching/learning/interpreting translation	7	4
		Using machine translator (MT)	MT1. Google Translate MT2. Yandex Translate	9	10
	Factors related to the usage style of translation tools	Online dictionary (OD)	OD1. English/Turkish OD2. Turkish/English OD3. German/Turkish OD4. English/German	8	5
		Internet search engines (SE)	SE1. Google SE2. Google Scholar	6	1
	Factors related to conceptual academic culture and knowledge	Academic background (AB)	AB1. Academic readings AB2. Academic writings AB3. Academic frameworks knowledge	6	6

for the difficulties under the category of lexical factors were related to producing verbatim translations of idioms (PVT) and the presence of similar words (SW). And, finally, the reasons for the difficulties under the category of cultural factors were related to using culturally acceptable words (CAW). Then we analyzed PSTs' notes on the DAD paper and their reflective notes; we added codes for the reasons for the difficulties expressed by PSTs; these codes are indicated in the fourth column of Table 2.

To illustrate the analysis process, two examples are given. The first is the translation of an idiomatic expression "to be shadowed" (cf. Fig. 3). The second is the translation of a DAD-specific concept "instrument."

The idiomatic expression "to be shadowed" was not translated adequately in PSTs' individual translations. We coded this as a "lexical factor" under the theme of linguistic factors, and we noted the PSTs who did and did not translate this expression adequately. For the inadequate translations, we marked different expressions translated as "shaded," "retired," "overshadowed," and "to be in someone's shadow." Then we used students' notes on the DAD paper and students' reflective notes to explore this difficulty. We coded the expression as direct translation if the PST wrote the translated word on the DAD paper without any reflection or interpretation (e.g., "shaded"). We coded as interpretation if the PST expressed a reflection on the translated word



**Fig. 3** Example of the analyses for the expression “to be shadowed” for the individual sessions

<b>Expression Not Translated Adequately: To be shadowed</b>	
<p><b>Data Source:</b> Individual Translation  <b>Key Factor identified:</b> Linguistic  <b>Category for the key factor:</b> Lexical  <b>Number of PST having a non-adequacy:</b>                      PhD:7, Master: 10  <b>Different Translations:</b>                      “shaded”                      “to be in someone’s shadow”                      “overshadowed”                      “retired”</p>	<p><b>Data Source:</b> Students’ notes on the DAD paper  <b>Source of the factor:</b> Producing verbatim translations of idioms (PVT)  <b>Code for source factor:</b> PVT1.direct translation  <b>Indicator of the code:</b> Writing the direct translation on the word or on the paper with arrows.</p> <p><b>Data Source:</b> Students’ notes on the DAD paper  <b>Source of the factor:</b> Producing verbatim translations of idioms (PVT)  <b>Code for source factor:</b> PVT2.interpretation  <b>Indicator of the code:</b> Question marks on the direct translation with or without any other suggested translations.</p> <p><b>Data Source:</b> Students’ reflective notes  <b>Source of the factor:</b> Producing verbatim translations of idioms (PVT)  <b>Code for source factor:</b> PVT2.interpretation  <b>Indicator of the code:</b> Student sentences concerning a will to modify the meaning of directly translated expression.</p>
<b>Expression Not Translated Adequately: To be shadowed</b>	
<p><b>Data Source:</b> Researchers’ notes  <b>Key Factor identified:</b> Personal  <b>Category for the key factor:</b> Translation Tools  <b>Source of the factors:</b> Using machine translator (MT) + Online dictionary (OD)  <b>Related source factor:</b> Producing verbatim translations of idioms (PVT)  <b>Related Code for source factor:</b> PVT1.direct translation</p>	<p><b>Data Source:</b> Researchers’ notes  <b>Key Factor identified:</b> Personal  <b>Category for the key factor:</b> Translation Tools  <b>Source of the factors:</b> Online dictionary (OD) + Internet search engines (SE)  <b>Related source factor:</b> Producing verbatim translations of idioms (PVT)  <b>Related Code for source factor:</b> PVT2.interpretation</p>

**Fig. 4** Example of the analyses for the word “instrument” for the individual sessions

<b>Expression Not Translated Adequately: Instrument</b>	
<p><b>Data Source:</b> Individual Translation  <b>Key Factor identified:</b> Linguistic  <b>Category for the key factor:</b> Lexical/Semantic  <b>Number of PST having a non-adequacy:</b>                      PhD:6, Master: 6  <b>Different Translations:</b>                      “tool”                      “related to a tool”                      “instrument (in the sense musical instrument)”</p>	<p><b>Data Source:</b> Students’ notes on the DAD paper  <b>Source of the factor:</b> Similar words in languages (SW)  <b>Code for source factor:</b> SW3.different meaning  <b>Indicator of the code:</b> Writing the word spelled in Turkish (enstrüman) in the sense musical instrument.</p> <p><b>Data Source:</b> Students’ notes on the DAD paper  <b>Source of the factor:</b> Similar words in languages (SW)  <b>Code for source factor:</b> SW2.close meaning  <b>Indicator of the code:</b> Writing the word translated with a close meaning (tool, related to a tool).</p> <p><b>Data Source:</b> Students’ reflective notes  <b>Source of the factor:</b> Academic background (AB)  <b>Code for source factor:</b> AB3.Academic frameworks knowledge  <b>Indicator of the code:</b> Student sentences concerning an influence of their academic background on their translations.</p>
<b>Expression Not Translated Adequately: Instrument</b>	
<p><b>Data Source:</b> Researchers’ notes  <b>Key Factor identified:</b> Personal  <b>Category for the key factor:</b> Translation Tools  <b>Source of the factors:</b> Internet search engines (SE)  <b>Code for source factor:</b> SE2.Google Scholar  <b>Related Source of the factor:</b> Similar words in languages (SW)  <b>Related Code for source factor:</b> SW3.different meaning</p>	<p><b>Data Source:</b> Researchers’ notes  <b>Key Factor identified:</b> Personal  <b>Category for the key factor:</b> Translation Tools  <b>Source of the factors:</b> Online dictionary (OD) + Machine translator (MT)  <b>Related source factor:</b> Similar words in languages (SW)  <b>Related Code for source factor:</b> SW2.close meaning</p>

and/or a will to modify the direct translation because of the loss of meaning in the sentence (e.g. “retired”). Researchers’ notes were essentially used to code different translation tools such as online dictionaries, machine translators, or Google/Google Scholar that PSTs preferred. We completed the analysis of PSTs’ individual translations by gathering the codes in the factor categories as linguistic and cultural factors.

Another example of analyses is the translation of the concept related to the word “instrument” concerning the DAD approach. An excerpt of the table of analyses is given in Fig. 4, where we gathered the data from four different data sources in order to analyze the factors that affect the difficulties of translation.

Hence, the content analysis allowed us to explore the themes influencing the PSTs’ translation process and the difficulties while translating. Then, we re-analyzed PSTs’ personal information forms in order to define personal factors so as to understand whether there was a relationship between the personal differences and the coded factors and difficulties. Table 2 presents the themes emerging from the analyses of the individual translation sessions and influencing the PST’s translation process, and the difficulties in translations related to these themes.

In the second phase, we analyzed the semi-structured collective sessions with respect to the themes and categories revealed in the analysis of the individual translations.

We transcribed the video recordings of collective sessions and we read these transcriptions several times. We identified each different discussion of themes. We categorized every block of conversation belonging to different themes in Table 2; then we analyzed the block of conversations according to these themes. These analyses were conducted in two axes; first to support the codes formed in the analysis of individual sessions and second to reveal how PSTs share their translation experiences in a collective work.

Hence, for the collective sessions, we furthermore analyzed the video recordings of the collective sessions according to the researchers’ observation notes, using the themes from the analyses of the individual translation sessions. These analyses allowed us to explore how PSTs discussed the difficulties they had and how they managed those difficulties, and the factors influencing the translation process in collaborative work. We analyzed the recordings of the collective sessions together and reached a consensus on the themes and categories.

## 4 Findings

The findings resulting from the analyses of the data are presented in three sections. In the first section, we first present the findings related to the influence of linguistic factors on the translation difficulties (Sect. 4.1), then we present the

findings on the influence of the cultural factors on the translation difficulties (Sect. 4.2), and lastly, we present the findings on the influence of the PSTs’ personal factors on the translation difficulties (Sect. 4.3).

### 4.1 Influence of the linguistic factors on the translation difficulties

Turkish and English belong to different language families: English belongs to the Indo-European language family while Turkish is in the Ural-Altai language family. This difference in the language families has strong consequences. In this section we present the findings related to each category revealed by content analyses concerning the main differences between the SL (English) and the TL (Turkish) that influenced the translation processes, namely “syntactic differences” and “lexical/semantic equivalences” (cf. Table 2).

#### 4.1.1 Factors related to syntactic differences

Sentence structure differences and tense accordance problems were revealed as main sources for difficulties related to syntactic differences between SL and TL. The structural form of the English sentence compared with that of Turkish shows that the basic order of the declarative sentence elements in the two languages is quite different from each other. In Turkish, the main elements of a sentence are organized as “subject + object + verb” and in English the elements are organized as “subject + verb + object.” An example of a sentence to illustrate this structural difference is given below:

Carlos	developed	documents.	English Sentence
Subject + Verb	(past simple)	+ Object(plural)	
Carlos	dokümanlar	geliştirdi.	Turkish Sentence
Subject + Object(plural)	+ Verb	(past simple)	

The order of the elements of the sentence appears to have a major influence on the difficulties of translation. According to the content analyses, reorganizing the order of the words in sentence structure was a real difficulty for the PST. Indeed, during the individual translation sessions, almost all of the PST used a machine translator. In fact, however, the machine translator does not function correctly in reversing the order of the sentence elements for long sentences. This difficulty was discussed during the collective sessions. Most of the PSTs, especially master’s students, expressed their inability to reorganize the sentences. Indeed, the great difference between SL and TL in the sentence structure obligated the PST to fully understand the SL sentences’ main idea and interpret it in order to be able to reorganize words leading to a logical and comprehensible sentence in the TL.

Because of the syntactic differences between SL and TL, the use of parentheses and the place of examples in a sentence were also a syntactic factor for the translation process. Indeed, in the TT, in-sentence parentheses were present to give extra information about the object of the sentence, but in Turkish this is not an ordinary use of parentheses, as the

object of the sentence is never at the end of the sentence. Therefore, in the translated text it was necessary to remove the parentheses and insert the information in the sentence.

Student M1's translation, its correctly ordered form, and the original English sentence are given below as an example.

onun dokümantasyon çalışmasına erişimi vardır (araştırmacının doğrudan gözlemini ötesinde),.

“Onun dokümantasyon çalışmasına erişimi vardır (araştırmacının doğrudan gözlemini ötesinde)”

**The sentence correctly ordered in Turkish:**

“Araştırmacının doğrudan gözleminin ötesinde, onun kendi dokümantasyon çalışmasına erişimi vardır.”

**The original English sentence:**

“...s/he is the one having access to his/her documentation work (beyond the direct observation of the researcher).”

The findings also showed that the difference between tenses in English and Turkish in terms of their timing influenced the translation process. Firstly, the present perfect and past perfect tenses in English do not have equivalents in Turkish, which caused differences between translations. There were also problems with long sentences. In

the individual translations, it seemed that PSTs translated long sentences with different tenses: they started with a past tense, and they continued with a present tense. An example of translation concerning the tense accordance problem (TAP) is given below.

The original English sentence:

“Hence, the study of resources and mathematics teachers' interaction/work with those resources **has become** a prominent field of research, not least because curriculum reforms in many countries support the provision of reform-oriented curriculum materials that **are seen** to help teachers enact the new curriculum.”

The sentence translated by PST:

“Bu yüzden bu kaynakların incelenmesi ve matematik öğretmenlerinin bu kaynaklar ile etkileşim halinde olması önemli bir alan haline **geldi**. Birçok ülkedeki müfredat reformları reform odaklı müfredatın öğretmenlere materyallerle yardımcı olması **sağlıyor**.”

The English version of PST's translation:

“Hence, it **became** an important area to examine these resources and for mathematics teachers to interact with these resources. Curriculum reforms in many countries **are enabling** a reform-oriented curriculum to assist teachers with materials.”

In her translation, the student has divided the two sentences; in the first sentence she used past tense, as the present perfect tense does not exist in Turkish (coded as TAP1. nonexistence of tenses), and in the second sentence she used the present continuous tense, as the student converted the passive sentence into an active sentence without respecting the tense continuity of the paragraph (coded as TAP2.

incoherence of tenses). The tense accordance problem in this example is interpreted as resulting in the loss of lexical/semantic equivalence of the translation.

In the collective session, students discussed this situation and explained that they translated the sentences in machine translators after dividing them. For example, the master's student M4 expressed her difficulty as follows:

M4: “The sentence is too long, I guess that’s the problem. I’m translating in Translate, it doesn’t make sense. Then, I say that I will organize the sentence myself, this time I forget the beginning while translating the end of the sentence. It challenged me a lot.” ... “I translated long sentences by splitting them.”

#### 4.1.2 Factors related to lexical/semantic equivalences

Content analyses showed that lexical/semantic equivalences had an influence on the PSTs’ translation work. The

great majority of the PSTs produced verbatim translations of idioms and of the specific terminology of the theoretical framework. For example, the term *documentational* was translated as *belgesel* (documentary). Indeed, most of the PSTs (8 master’s and 8 PhD) tended to translate *document* as *belge*, which is the exact Turkish translated word; but the word *doküman* also exists in Turkish with the same meaning. The example below shows these differences in the translations.

The **documentational approach to didactics** → Student notes on DAD paper  
*dokümantasyon yaklaşım*

Didaktiğe Dokümantasyon Yaklaşımı → Student translation  
 (Documentation approach to didactics)

**Resources + scheme of usage = document** → Student notes on DAD paper  
*kaynaklar + kullanım şeması = belge*

*kaynaklar + kullanım şeması = belge* → Student translation  
 (resources + usage scheme = document)

In their individual translation, students had translated the word group *document, documentation, documentational* as *belge, dokümantasyon, belgesel*, respectively, but during the collective sessions, the discussion resulted in the translation *doküman, dokümantasyon, dokümantal*, respectively. The first reason for this change in the translations was to obtain a continuity in the usage of these terms inside the framework; the other reason, which was more commonly accepted, was that the word *belgesel* referred mainly to a kind of movie. Therefore, the PST decided to use the word *dokümantal*, even though the word *dokümantal* sounds Turkish but does not exist in Turkish dictionaries. Students’ dialog below is an example of the discussions on these group of words:

P3: I think we should use the word *belge*. It is clear and appropriate.

P4: But what about documentation and documentational. How can you translate that connectedly?

P3: *Belgeleme* (Certification), *Belgesel* (Documentary) ?

Another element regarding the lexical/semantic equivalences factor influencing the translation process was the

presence of similar words in SL and TL. Indeed, in the ST there were words existent in the TL with same meanings, close meanings or different meanings. The analyses showed that words that have shifted from their meaning in the SL and are used with close or even different meanings had some negative influences on student translations during the translation process.

For example, although the word *instrument* exists in Turkish as a loanword, it was borrowed to be used only in the field of music, which corresponds to its first meaning in English. However, according to the Cambridge Dictionary (2022), the word *instrument* has four different meanings. It can be thought that mastering all of these meanings directly affects the conceptual understanding behind the word *instrument*. The example below illustrates the translation of the word *instrument* into Turkish and the problem of the use of the same word in the translated document because of the nonexistence of one-to-one translation, confronted by the PST and resulting in the loss of meaning of the word.

temel dayanak      araçsal yaklaşım  
 the central underpinning for DAD was the *instrumental approach*. → Student notes on DAD paper

DAD'ın temel dayanağı araçsal yaklaşımdı. → Student translation

I said tool (araç) for instrument, related to the tool (araçsal) for instrumental. But that didn't quite fit me. Because I had to say tool for artifact as well. I think instrument and artifact are different things, but I translated them with the same word. → Student reflective notes

Another example of a word that was transferred to the Turkish language from European languages and has experienced shifts in terms of meaning is the word document, and this word was also determined to have a negative influence on the PSTs' translations. When the word document was transferred into Turkish, the noun meaning in English (a paper or set of papers with written or printed information, especially of an official type) was borrowed; however, its verb meaning (to record information about something important by writing about it or photographing it) is not found in Turkish. When considered in the context of the documentational approach, there is also the verb "se documenter" (to document oneself, to learn about, to do research on) in the language (French) from which the approach originated. This situation reveals the loss of meaning of the word document during its translation journey into Turkish, and thus gives an idea about the reasons for the negative influence of words entering Turkish from European languages on student translations.

## 4.2 Influence of the cultural factors on the translation difficulties

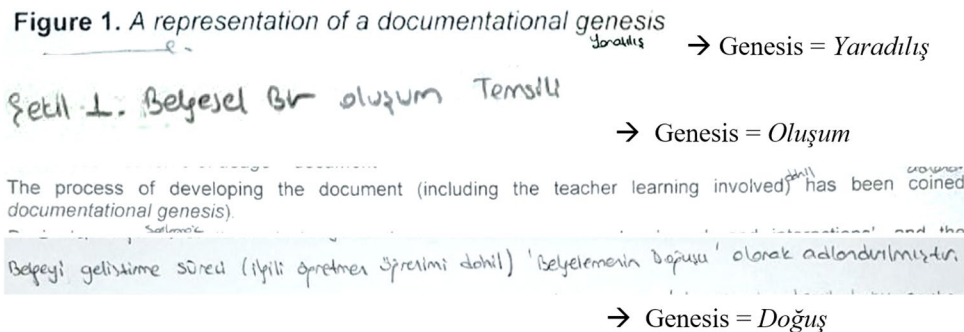
As every language is shaped in a cultural context, we analyzed the influences of socioculturally related words as part of the differences between SL and TL. Two examples that we can give resulting from the analyses are the words create and genesis. Both in their individual and in their collective translations, PSTs preferred to replace words with more appropriate ones for Turkish culture. In Turkish culture it is said that "only God can create." Hence, the word create (*yaratmak* in Turkish) was replaced systematically with *oluşturmak* (construct, form), *yapmak* (do, make, effectuate), and *gerçekleştirmek* (realize, bring about) by both master's and PhD students.

work;  
 \* The principle of long-term follow-up. Geneses are ongoing processes and schemes develop over long periods of time;      \* Genesis = oluşum  
 Sığan ilköğretim;      \* "Oluşum" dönem eden süreçlerdir ve programlar uzun süre boyunca gelişir;      ayrıntılı...

The same translation process occurred for the expression genesis, and for the same reason that people prefer not to use words related to creation for things that are created by humans. Even though the exact translation of the word genesis is *yaratılış* (creation), PSTs wanted to translate this word differently, and this subject was discussed during the collective sessions. They discussed translating the expression *documentational genesis* in a way that would be welcomed by the Turkish audience. They therefore decided to

use the word *oluşum* (formation) for genesis and to translate documentational genesis as *dokümantal oluşum* (meaning documental formation).

The example below shows the hesitation on the part of a PST when translating the word genesis. Indeed, the PST used three different words with close meanings in different parts of the translation. These three different words were "yaradılış" (genesis), "oluşum" (formation), and "doğuş" (birth).



### 4.3 Influence of the PSTs' personal factors on the translation difficulties

In this section, we present the findings related to each category revealed by content analyses concerning the personal factors that influenced the translation processes, namely “teaching experience,” “use of translation tools,” and “conceptual academic culture and knowledge” (cf. Table 2).

#### 4.3.1 Teaching experience

The analyses showed that factors related to the teaching experience of PSTs influenced their translation process. The translation of the part concerning the Chinese abacus was difficult for the PSTs as there is no such a tool in Turkish educational culture. Although there is an explanation in the DAD paper about the Chinese abacus, all of the PSTs mentioned that they had a very hard time understanding the usage of the abacus. Analyses of individual translations showed that PSTs with low professional experience as a teacher preferred to omit this part of the DAD paper and did not translate it, and in their reflective notes they mentioned that they could not translate this part because they could not understand it well. However, PSTs with high professional experience tried to make sense of the functioning of this tool and also searched on Google; hence, they translated the part concerning the Chinese abacus. Since this finding was similar for master's and PhD students, it suggested that the facility of translating—and thus understanding and interpreting—the use of a tool not encountered before was related to professional experience.

P1: “I understood the Chinese abacus system at first, with the one-unit beads. I could figure out how to represent the numbers in the abacus. But, when I read more, with five-unit beads, I got lost completely. Then I couldn't concentrate on the text because I tried to understand how to use the abacus.”

The PSTs evaluated the example of the abacus as a cause of serious and unnecessary trouble, because they had to try

to learn how this tool works, which they had never encountered before and had no idea about classroom practices and concept teaching practices using this tool.

#### 4.3.2 Use of translation tools

During the individual translations, almost all of the PSTs used machine translators such as Google Translate or Yandex Translate. PhD students used different translation tools simultaneously, which resulted in a more adequate translated final text. On the other hand, master's students mostly used only one translation tool, i.e., machine translators. All of the PhD students used at least two different translation tools simultaneously, and four of them used three tools simultaneously; however, fewer than half of the master's students used at least two different translation tools and none of them used three tools at the same time. This can be understood by the fact that using different translation tools simultaneously and writing the translations resulting from these tools as a Turkish sentence requires interpretation of the text. We think that as the master's students did not have a sufficiently elaborate academic culture and knowledge, they had more difficulty in restructuring academic sentences.

#### 4.3.3 Conceptual academic culture and knowledge

The conceptual academic culture and knowledge related to the PSTs' educational level was revealed as having an influence on the difficulties encountered during translations. An example of this is the translation of the concept *artifact* related to the DAD translated differently by PSTs. Some PSTs translated it as *alet* (material, tool), and others left the word as *artefakt* (the Turkish spelling of the English word). The discussions on this concept during the collective sessions revealed that some PhD students already had some knowledge of the instrumental approach and remembered the concepts *instrument* and *artifact*. Hence, they mentioned

using the Turkish spelling versions of the words. We interpreted this result as being the influence of conceptual academic culture on the translations, because the PhD students, unlike most of the master's students, were used to encountering academic terms that do not exist in everyday language, and also because they had academic knowledge that they had acquired by reading academic literature.

#### 4.3.4 Internet search methodologies

The analysis showed that the difference in the educational level induced different internet search methodologies, which influenced the translation processes. Indeed, PST used online machine translators and dictionaries for translation but they also used Google and Google Scholar.

For example, for the expression *operational invariant*, PSTs had difficulty in individual translations. Master's students translated this expression with machine translators, except one master's student (M2) who also used Google to search for the existence of the expression on the internet. However, some of the PhD students searched on Google Scholar and found that it was already translated into Turkish as *işlevsel sabit* (functional constant). It can be said that the search methodology used by PhD students permitted them to encounter the difficulties related to the translation of an academic expression. Indeed, a translation with specialized objectives required different strategies in the use of tools for the translations.

## 5 Discussion and conclusion

The research question in this study focused on the factors influencing difficulties encountered by PSTs when translating the DAD from English into Turkish. The study focused on the influence of (i) the linguistic differences between the SL (English) and TL (Turkish), (ii) cultural aspects of the language, and (iii) personal factors of the PSTs on the difficulties encountered during translations.

The results of this study showed that linguistic differences between the SL and TL led to difficulties in translation. For instance, the PSTs had a great difficulty in translating the sentence in the right order. This difficulty related to syntactic difference was also evident in reorganization of a sentence structure. Another difficulty that PSTs experienced while translating was about the numerous examples given in brackets. Although examples in brackets in the original DAD paper did not seem inconvenient for the PSTs, after translating into Turkish, they considered such use of brackets as inappropriate in terms of readability of a sentence. Hence, the results of this study revealed that the syntactic difference between SL and TL has a strong influence on the

readability of the translated documents. Like syntactic differences, lexical/semantic differences are also addressed in this study. For instance, PSTs had difficulty in translating some concepts of DAD, such as *documentational*. Turkish being an agglutinative language, while English is a fusional one, could cause such difficulties. However, in this specific example, there is a problem that arises from the fact that two suffixes that are not used consecutively in Turkish are used in this way. Therefore, the PSTs omitted one of the suffixes and translated the word as *dokümantal*.

This study indicated also that cultural aspects result in difficulties for PSTs during translation. This was evident particularly in their choice of terms in the TL. For instance, in their translations, the PSTs preferred to modify the meaning of certain terms rooted in the target culture even though semantic equivalence was obtained. In fact, almost all of the PSTs systematically replaced the terms derived from the verb to create (e.g., creation, creativity, creator, create) with another term that was semantically close but not equivalent. A similar result was reported by Pym (2014) that "cultural translation moves beyond translations as restricted texts; its concern is with general cultural processes rather than finite linguistic products" (p. 144). One of the examples about the difficulties resulting from cultural aspects in this study stem from the fact that Chinese abacus does not belong to the educational system of TL. Originally, it serves as an example to clarify the concepts, however in TL it appeared to be an obstacle to understanding the concepts of DAD. Such result indicates that the comprehensibility of the DAD paper could be improved if PSTs were familiar with the artifacts used in the example embedded into their education system. In trying to overcome such difficulty based on cultural aspects, it became apparent that the PSTs' personal factors played a key role. Although all PSTs had difficulties in translating Chinese abacus and related concepts, the professionally experienced PSTs did research about the usage of the abacus and managed to overcome this difficulty. Hence, professional experience can be considered as affecting flexibility in the instrumentation process by facilitating the adaptation of utilization schemes to new artifacts; it would therefore be interesting to carry out research to define the conditions and limits of this flexibility with a documentational point of view.

In addition to different factors influencing the PSTs translations, this study indicated that how PSTs used the translation tools might affect their translations. It became apparent that the PSTs who used different translation tools simultaneously (i.e., Google Translate and online dictionary) produced better translations. Similarly, it is reported in the literature that the meaning given to concepts and the richness of the language are related (Clarke, 2006; Mesiti et al., 2021). To be able to interpret the meanings of the concepts, a holistic overview with the help of different translation tools might

be useful. This need for different tools can be expected even more in translating theoretical frameworks whose language is more academic than everyday language (Thompson & Watkins, 2021). Therefore, understanding the academic language requires academic culture and knowledge. In this perspective, some of the PSTs in our study also used academic articles (such as those indexed in databases like Google Scholar) as a tool for their academic translations. We believe this formation of PSTs on the internet search methodologies concerning academic translation might be a key to PSTs' academic development. Further research on the strategies and methodologies for translation of theoretical frameworks in mathematics education would contribute to the literature and to the development of PG education.

According to the results of this study, we suggest that reworking of the DAD-ML considering the factors influencing the translations, might be beneficial for better understanding the DAD paper, since this study showed that the term multilingual also implicates the term multicultural, including social, educational, and academic aspects. The Chinese abacus and the certain concepts from the French didactics culture highlighted in this paper are important examples to show the need to rework and re-discuss the DAD-ML.

To address the limitations of the study, we must state that even though the translated papers, reflective notes, and discussions in collective sessions of PSTs gave some answers about their understanding of DAD concepts, it would be useful to study with fewer PSTs and do clinical interviews with each PST to deepen the analysis. Also, the results from 21 PSTs might not be representative of all PSTs in Turkey. However, we believe that this study serves an important role in identifying the interrelations of the factors affecting the translation process. It would be interesting to conduct studies to investigate these interrelations and their place in the translation and hence in the interpretation process. Consideration of the factors influencing the PSTs' translations might be beneficial for a better organization of cross-cultural and cross-linguistic higher education. Further research can also be done in the Turkish context comparing the PSTs and teachers who are not doing postgraduate studies using the DAD and its main concepts for analyzing their documentation work and their usage of the concepts.

**Data availability** The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Conflict of interest** The authors did not receive any funding for conducting this study. The authors have no competing interests to declare that are relevant to the content of this article.

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