The Use of Technology-Integrated Writing-to-Learn Activities in Science Classroom: The Views and Practices of Pre-Service Teachers

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ABSTRACT

The aim of this study was to explain how technology-integrated (kotobee application) and non-technology-integrated writing activities can be used in the classroom environment in Chemistry I course and to reveal students' views on two different writing activities. The participants of the study consist of 20 freshmen pre-service science teachers enrolled at a state university located in the Central Anatolia Region in Türkiye. In the study, the process of applying and evaluating writing activities for learning purposes in science classes is explained in detail. In order to get the opinions of the participants about the implementation process, open-ended questions about the activities were asked after the implementation, and the answers were coded. As a result of the research, while the majority of the students stated that they preferred technology-integrated writing activities because it gave them the opportunity to use visuals more effectively, other students stated that they preferred writing by hand because they had difficulty using kotobee, and that writing by hand was easier and more accessible. Based on these results, it has been suggested that the technology education of students for technology-integrated writing activities can be expanded and a longer time should be given for writing activities.

Keywords: Writing-to-learn activities, Kotobee application, chemistry, pre-service teachers

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INTRODUCTION

Studies conducted in recent years show that writing is used as a communication tool, as well as to teach subjects and concepts in science, to increase science literacy and to gain scientific reasoning skills (Graham et al., 2020; Hand et al., 2021; Yaman & Hand, 2024). Researchers have emphasized that writing activities should be used for the creation of knowledge by going beyond the repetition of knowledge in order to use writing for learning purposes (Graham et al., 2020; Hand, 2017). In the updated science curriculum, students are asked to express the subjects and concepts related to science in written, verbal and visual forms (Ministry of National Education, MONE, 2018; Next Generation Science Standards, NGSS 2013). In addition, it was emphasized in the curriculum that students should gain language skills (listening, speaking, reading and writing) through science lessons(MONE, 2018; NGSS, 2013). In science curricula, writing is an important tool for gaining scientific competencies. In addition, the use of writing activities for learning purposes in science classes is recommended (Graham et al., 2020; Hand, 2017).

In this study, we aim to provide detailed information on how technology and non-technology-integrated writing-to-learn activities can be used in the science classroom and to reveal pre-service science teachers' (PSTs') views on two different writing activities. The education that PSTs receive is important so that they can experience writing activities for learning purposes in the process, use them for their future students, and use writing activities as they are necessary for their own learning.

Writing-to Learn Activities in Science Classrooms

When writing activities used in science classrooms are examined, traditionally, students transfer the information they get from the book or the board in the form of notes to their notebooks, make a summary and prepare a laboratory report (McDermott & Hand, 2010; Yaman, 2021). In this case, students traditionally used writing activities to repeat or remember the information they have learned. Studies have shown that students achieve only superficial learning when they use writing activities in this way (McDermott & Hand, 2010) and it has been suggested to use non-traditional writing activities in the classroom. Non-traditional writing activities in the classroom can also be defined as writing-to-learn activities for learning. In this context, writing-to-learn activities provide opportunities for students to use and develop the language skills that are aimed to be acquired in science Education (Graham et al., 2020; McDermott & Hand, 2010).

Five components suggested by Prain and Hand (1996) are generally used in writing activities for learning purposes in science classes. The five recommended components are: topic, type, purpose, audience and the method of production (Figure 1). For the *topic*, students search for "What are the main ideas?" of the learning activities. Depending on the main ideas, it can be considered what the main concepts are, how to make connections between ideas and what examples can be given. The *purpose* component includes the question of "What is the purpose of the writing activity?" which can be the answer to the question and a clear statement of the purpose(s).

It is necessary to decide for whom the writing activity will be done in line with the subject and purpose. *Audience* component answers the question of "Who does the writing process appeal to?". The audience should be clearly stated to whom the article is addressed. Is the audience peers, younger people, textbook readers? Research shows that students should write to younger audiences. Because, when students write to the teacher or someone older than them, they use the concepts without explaining them. But when they write to their younger counterparts, they need to explain the meanings of the concepts they have used. In this context, students go through a series of language transfer processes. After filtering their understanding of science, they try to transfer the concepts in a way that the audience can understand. In this way, students reconstruct knowledge in a different way than before and engage in in-depth learning. This situation reveals the importance of the audience in writing-to-learn activities (Hand, 2017; Hand et al, 2009; McDermott & Hand, 2010; Norton-Meier et al., 2008).

The Method of text production component seeks to answer the question of how the text will be produced. In the production method, students

will decide whether they will prepare the writing text as a group or individually, and whether they will write it on the computer or with a pen. Finally, there is the *type* component, where it is decided which type of writing will be made. Here, it is expected to choose one of the writing types such as stories, articles, letters, posters, concept maps and brochures, which are discussed within the scope of writing activities for learning purposes, and to do a writing process in accordance with the rules of the genre (Hand, 2017; Yaman, 2018). Although the components in the writing model seem separate from each other, they are used in conjunction with each other. For example, if the aim is to transfer the subject to someone else at the end of the unit, it is more appropriate to write this writing activity to a different audience than the teacher, possibly to a younger audience. While doing this, a story (*type of writing*) can be written individually after the class discussion (*text production method*) (Hand, 2017).

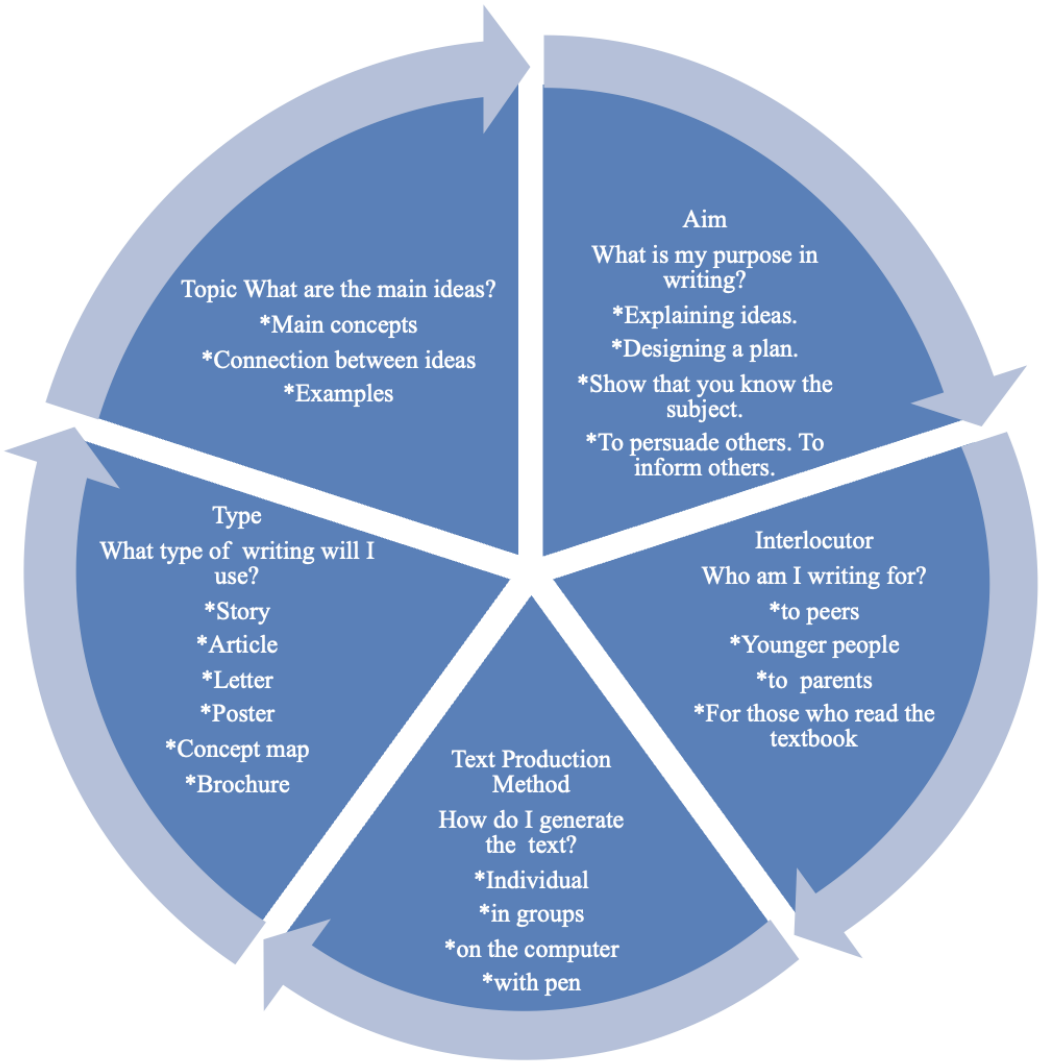

Figure 1. Writing template to be used in writing-to-learn activities (Prain & Hand, 1996)

The use of Writing-to-Learn strategies in Science Classrooms

Five stages are suggested for using writing –to-learn activities in science classes (Hand et al., 2018; Hand et al., 2009; Hohenshell et al., 2004; Yaman, 2018; Yaman, 2021). These stages are: big ideas, small group discussions, class discussions, preparing the first draft and preparing the final draft. In the context of big ideas, students are expected to focus on ideas within the context of the topic. Small group discussions allow students to discuss and defend their ideas in groups. Class discussions, on the other hand, allow students to present ideas that they have discussed in small groups to the class, and allow other peers to criticize the ideas presented. Students are expected to create their first drafts individually, taking into account the feedback they received from their teachers and peers as a result of classroom discussions. The first drafts prepared individually by the students can be given to their real audience for feedback or evaluated by the teacher. Students are expected to prepare their first drafts and create their final drafts, taking into account the feedback received from the audience. The final drafts created can be evaluated in two ways. One of them is the evaluation of the teacher and the other is the evaluation of the real audience. The teacher and the audience can evaluate the final drafts by considering the evaluation criteria with the help of the rubric (given in Figure 4). In this context, the final draft can be evaluated by looking at the clear indication and clarify of explanation of big ideas, the suitability of the text to the audience, the writing in the desired format, and the use of representations (graphics, diagrams, pictures, figures, etc.) (Hand et al., 2009; Hohenshell et al., 2004).

When the themes and purposes of the studies of writing-to-learn activities are examined, research has shown that certain factors such as academic achievement, science attitude, scientific process-metacognitive skills and scientific literacy, writing-supported argumentation practices, laboratory success and laboratory attitude are studied. Moreover, the studies are repeated on different topics (Arslan & Benzer, 2022; İspir &Yıldız, 2021). There are recent studies on students' conceptual learning, but the number of studies on technology integrated writing-to-learn activities is very limited. In addition, as a writing type, scientific story is used very limitedly in science education (Arslan & Benzer, 2022; İspir & Yıldız, 2021). Research highlights that writing-to-learn activities should be carried out in science classrooms and the current study attempts to eliminate this deficiency in the literature.

Standards

In this study, the PSTs wrote scientific stories for two different concepts: acid and bases, and physical and chemical changes. The PSTs who wrote acids and bases with hand writing wrote physical and chemical changes with Kotobee. In a similar way, the PSTs who wrote physical and chemical changes by hand wrote acid and bases with Kotobee. However, this paper only focused PSTs' writing on physical and chemical changes to explain the process in detail. The subject of the writing activity for learning is the subject of "Physical and Chemical Changes." This subject is associated with the subject of "F.8.4.2 Physical and Chemical Changes" in the 8th grade "F.8.4.Matter and Industry/Matter and Nature" unit in Turkish Science Education Program (MONE, 2018). A scientific story writing activity within the scope of Physical and Chemical Changes was prepared in accordance with the standards of "F.8.4.3.1. Explains the differences between physical and chemical changes by observing various events." In this context, 8th grade students were determined as the audience in the writing activities. This Turkish science standard is aligned with the Next Generation Science Standards associated with middle school (6-8 grade) "MS-PS1-2 matter and its interactions," explained as "analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred" (NGSS, 2013). Moreover, it is aligned with common core state standards connections literacy "RST.6-8,7 "Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)" (MS-PS1-2).

ACTIVITY IMPLEMENTATION

This section aims to explain the components of the writing for learning activities mentioned in the previous section and how the assessment criteria are used in the classroom environment.

In this study, the following materials were used for technology and non-technology integrated writing activities:

- Computer,
- Kotobee application,
- Paper,
- Pencil.

Table 1

The sequence of planning activities for technology and non-technology integrated writing tasks

Timeline	Students' experiences for technology integrated writing task	Students' experiences for non-technology integrated writing task
Lesson 1	Challenged with the writing task using a call text (Figure 2). Encouraging PSTs' discussion (Figure 4)	Challenged with the writing task using a call text (Figure3). Encouraging PSTs' discussion (Figure 5)
Lesson 2	Whole group discussion-identifying big ideas and creating a draft.	
Lesson 3	Researched in small groups. Presenting drafts in class discussions and evaluating classmates' drafts. (Table 2)	Researched in small groups. Presenting drafts in class discussions and evaluating classmates' drafts. (Table 2). Writing a revised draft.
Lesson 4-5	Trained by an expert for Kotobee use. Wrote a revised draft.	Wrote a final draft
Lesson 6	Evaluation of final drafts. Reviewed assessment from teachers	

The First Lesson Activities:

In the first lesson activities, the call texts given in Figure 2 and Figure 3 were read to the pre-service science teachers. The purpose of giving the call texts is to create a fun environment in the classroom, and to enable pre-service science teachers to be aware of and discuss the five components suggested by Prain and Hand (1996) in writing activities for learning purposes (Hohenshall et al., 2004). This activity covers approximately 50 minutes (1 class hour).

As seen in Figure 2, the PSTs were asked to prepare a technology-integrated (using Kotobee) scientific story on Physical and Chemical Changes with 1000 words or less, using a language level that 8th grade students can understand. In order for PSTs to better convey the subject to 8th grade students, various representations (picture, diagram, graphic, chemical equation and drawing, etc.) and multimedia (link, sound, visual component, video, picture, 3D, gallery, animation, simulation, etc.) have been emphasized to the point that students can benefit from their applications. Different applications can be used optionally for the technology-integrated writing activity (padlet, storyjumper, powtoon, moovly, etc.). In this study, Kotobee, an e-book application, was preferred.

Dear pre-service science teachers and future science teachers,

I am writing this call to you as the CEO of the scientific book publishing house. Recently, we received a request from the Ministry of National Education to write a story book for secondary school students. In this context, we want to hire you as a writer as a publishing house, and we want you to write a "scientific story book" for 8th grade students on "Physical and Chemical Change", which you will prepare with technology support. The number of words you will use in the story should be 1000 or less. If you think it will help your future students to understand the subject better, you can use various representations such as pictures, diagrams, graphs, chemical equations and drawings and multimedia applications (link, synchronized sound insertion, widget, video, 3D, gallery, animation, simulation links, questions).

The storybook needs to be written so that your future students can better understand the topic and concepts you want to explain. Therefore, please design and write your storybook using age-appropriate language. Your storybook will be reviewed by the editors of our publishing house and your future middle school students. We will seek feedback from them to see if the topics and concepts in your book are helping your future students to understand.

Sincerely,
Chemistry SCIENTIFIC
Scientific Publishing House CEO

Figure 2. Call text presented to the class for a technology-integrated (Kotobee application) writing-to-learn activity

As seen in Figure 3, in the handwriting activity, pre-service teachers were asked to write a scientific story on Physical and Chemical Changes by hand with 1000 words or less for 8th grade students, as mentioned in Figure 2. In addition, as stated for the technology-integrated activity, it was emphasized that 8th grade students could benefit from various representations (figures, drawings, graphics, tables, etc.) in order to better convey the subject.

Dear pre-service science teachers and future science teachers,

I am writing this call to you as the CEO of the scientific book publishing house. Recently, we received a request from the Ministry of National Education to write a story book for secondary school students. In this context, we want to keep you as a writer as a publishing house and we want you to write a "scientific storybook" on "Physical and Chemical Change" for 8th grade students. The number of words you will use in the story should be 1000 or less. You can use a variety of notations such as pictures, diagrams, graphs, chemical equations, and drawings if you think they will help your future students better understand the subject. The storybook needs to be written so that your future students can better understand the topic and concepts you want to explain. Therefore, please design and write your storybook using age-appropriate language.

Your storybook will be reviewed by the editors of our publishing house and your future middle school students. We will seek feedback from them to see if the topics and concepts in your book are helping your future students to understand.

Sincerely,
Chemistry SCIENTIFIC
Scientific Publishing House CEO

Figure 3. Call text presented to the class for a non-technology-integrated (handwriting) writing-to-learn activity

After the call text was read to the class, the PSTs were asked to examine the texts given in Figure 1. In this context, pre-formed groups of five and four PSTs were asked to discuss and determine what the purpose, audience, production method, type and topic were in the template given in Figure 1, taking into account the two call texts. The PSTs were asked, "*Examine the call texts. How can you use the elements in the writing template (topic-purpose-type-audience-production method) that are technology-integrated (Kotobee) and non-technology-integrated (while preparing manually)? Discuss.*" Small group discussions were initiated by directing the question. The aim here is to enable PSTs to discuss the elements of learning writing activities and to be aware of the necessities of writing activities. In this context, it was stated to the pre-service teachers that they should carefully examine the template given in Figure 1 with their groups and that they had 5-6 minutes for small group discussions. After the small group discussions were completed, the groups in the class were given the right to speak separately and asked, "*How do you use the items in the template for two separate writing activities?*" The opinions of the groups were taken by asking the question. After the answers received from each group, the question "*What do you think about what your classmates said*?" was asked to the other students in the class, and other students outside the group were encouraged to participate in the discussion. Next the group was asked "*How do you use the elements in the template for two separate writing activities?*" directed to the groups. General answers to the question were like this:

"*In the text of the call, we were asked to consider physical and chemical changes as the subject, the 8th grade students as the audience, and to inform these students about the given topics as the aim. Our use of scientific stories as a type of writing; As a production method, we were asked to write individually and write one of the subjects by hand and the other using an e-book (Kotobee).*"

If desired, Figures in 4 and 5 can be brought in the classroom environment to encourage students' discussion and the expectations from students in writing-to-learn activities can be discussed.

In this context, it is stated that the quality of writing is important to the students, the purpose of the writing activity is to inform the 8th grade students about the topic, the achievements should be taken into account and a language suitable for the audience should be used. The main characters and topics should be determined, and an introduction-development-result structure of writing is better for the audience. In addition to using various representations (pictures, diagrams, figures, graphics, drawings, etc.) for information transfer, it can be emphasized that multimedia applications should be used for the writing-to-learn activity to be prepared with Kotobee.

Figure 4. Template about the main components of the scientific story writing activity for Kotobee

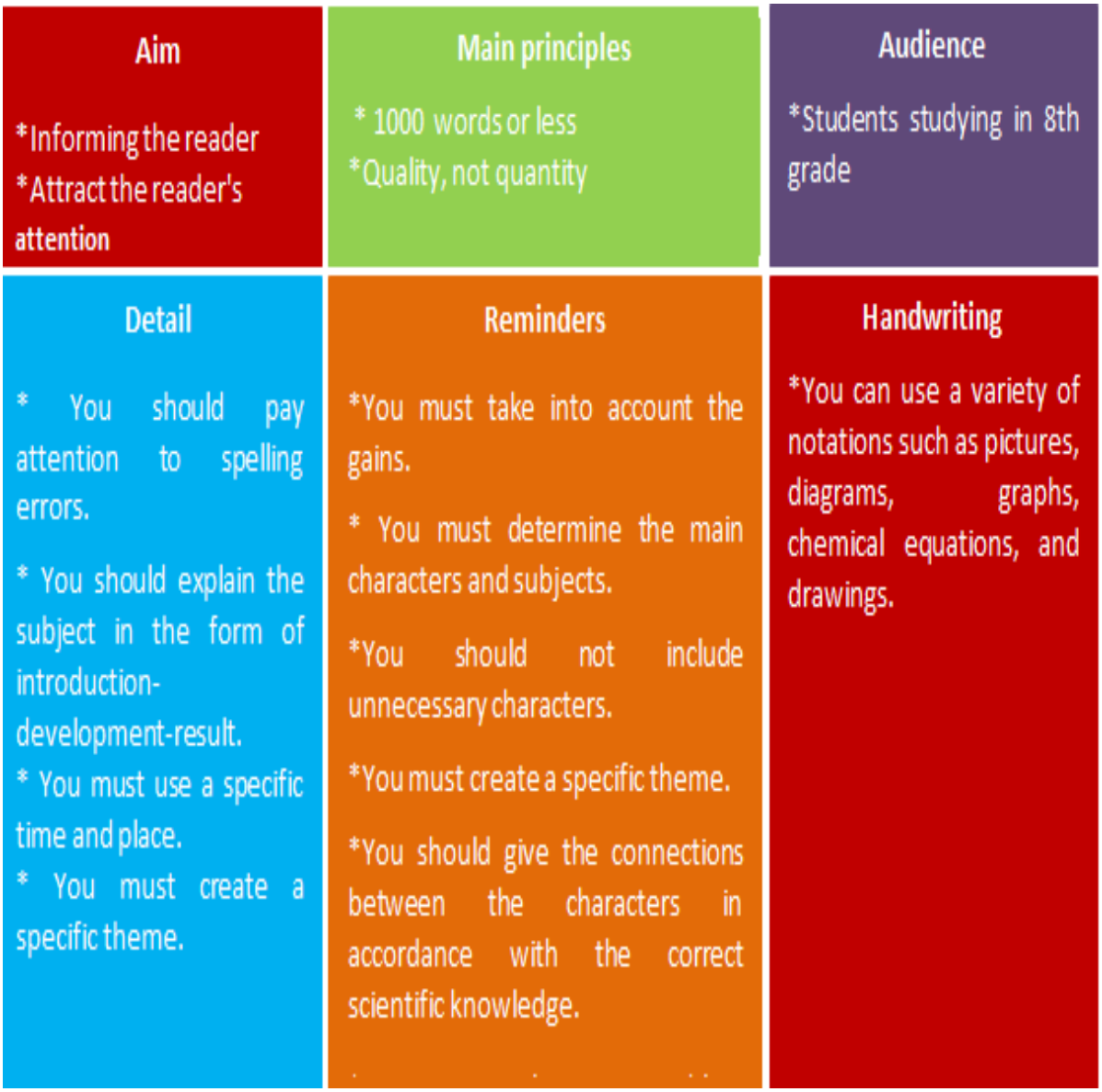

Figure 5. Template about the main components of the scientific story writing activity for handwritten

The Second Lesson Activities:

The second lesson hour focused on the "identifying big ideas" stage of writing-to-learn activities in science classes. The recommended time for this activity is 40-50 minutes. As indicated previously, "Physical and Chemical Changes" in the 8th Grade Science Curriculum have been determined by considering their standards. In this context, the big ideas for the subject of physical and chemical changes are expressed as "*the situations in which the internal structure of the substance does not change, only the shape and appearance changes are psychical change, and the situations in which both the internal structure and the external structure of the substance change are chemical changes*". The PSTs were asked either how they would shape their e-book or how they would write it by hand around this big idea. The answers from the groups were generally as follows:

"*For e-book (Kotobee), events such as state change events (melting, freezing, evaporation, condensation, sublimation, frosting), cutting (cutting of paper), dissolution (dissolving salt in water); For chemical change, I find videos or gifs of events such as burning (burning wood), rusting, molding, photosynthesis, respiration, or I shoot videos of them myself. In the story we*

write by hand, I wrote/draw photographs or figures."

It was also discussed with PSTs what should be considered when writing a scientific story. First of all, while writing a scientific story, the opinions of the PSTs were taken by asking students what should be considered when writing a scientific story. Information was given about the need to determine the main characters and subjects, not to have unnecessary characters other than the main characters, to have a certain time and place, to create a certain theme, to take into account the achievements, to pay attention to spelling errors, and to use plain and understandable language. It was also mentioned that the subject should be explained as introduction-development-result, the connections between the characters should be given in accordance with the correct scientific knowledge, and the main idea should be determined. In addition, a resource on the website was shared (Hay, 2025) for students to get detailed information on how to write stories. At this stage, the expert teacher can be invited to the class at the point of how the story can be written, and the students can be informed by the field expert.

Finally, in this lesson, the PSTs were asked to create a draft by considering their big ideas about physical and chemical changes and the points to be considered while writing a scientific story until the next lesson.

The Third Lesson Activities:

In this lesson, the PSTs were asked to present their scientific story drafts, which they prepared in small groups, to other groups by making a class discussion. For this activity 50 minutes are allocated.

In this course, guiding questions for PSTs about what to discuss with their groups were asked; "*What do you think the writing activity should include? How can you write in an appropriate way? What should you pay attention to when you consider the type of writing?"*For small group discussions 5-6 minutes are allowed. At the end of the time allocated for small group discussions, the PSTs were asked to share their group ideas with the class. While the groups were sharing their drafts, they asked the other PSTs in the class, "*What do you think about the draft that your classmates have prepared? Do you think it is suitable for the audience? Does it have a suitable scenario in terms of science? Explain why you think this way.*" The opinions of other PSTs in the class were taken by asking questions. PSTs were encouraged to ask questions to their presenters.

Table 2

Rubric to evaluate groups' presentations

Criteria	Weak (1 p)	Medium (2 p)	Good (3 p)
Big ideas Are big ideas understandable?			
Writing Type Have the 8th grade students been written in the desired format (scientific story)?			
Audience Is the scientific story suitable for the addressee (8th grade students)?			
Flow Is the scientific story flowing? Are all concepts clearly written for the addressee?			
Science content Are the concepts in the scientific story understandable?			

At this stage, the rubric in Table 2 can be given to students to evaluate their peers' presentations. The rubric consists of a three-point Likert type: poor (1 point)-moderate (2 points)-good (3 points). The five assessment criteria used in the rubric are examining major ideas, writing genre, audience, flow, and science content. The clarity of the big ideas is evaluated by looking at the writing in the desired format (scientific story) for the 8th grade students, the suitability of the scientific story for the audience, the fluency of the scientific story - the concepts are written clearly for the audience, and the comprehensibility of the concepts used in the scientific story. Class discussions at this stage are very important as they encourage students to think about what they should pay attention to in writing activities and what will make them successful while doing the writing activity. In this course, pre-service teachers were asked to

submit a handwritten scientific story revised draft within a week.

The Fourth and Fifth Lesson Activities

These lessons include the preparation of the revised draft of the scientific story to be written with technology support. In these courses, the PSTs were given a training that includes 2 lesson hours (2x50) about the application by the field expert so that they can learn how to use Kotobee effectively. This training is given in the computer laboratory so that the PSTs can try what is explained simultaneously. In this training, information about what Kotobee is and what it is used for is given, and after the examples are shown, its interfaces are introduced. It is explained how students can add video, picture, sound, 3D animation, simulation representations to their content, apart from the writing process. While explanations were made about the application and examples were shown, the PSTs were asked to participate in the process and try what was done simultaneously.

After this stage was completed, the students were asked to transfer the scientific stories they prepared in draft form into practice, taking into account what they had learned, and to submit the final drafts they prepared using Kotobee next week. The PSTs were given one week to submit the final draft they will prepare with Kotobee and handwriting. In addition, the drafts requested to be prepared can be sent to their real audience (to 8th grade students), and PSTs can be asked to create a final draft by taking into account the feedback they have received from their audience.

The Sixth Lesson Activities

This course includes the evaluation of the final drafts prepared by the PSTs considering the feedback they received from their audience. The final drafts produced by the PSTs in both activities can be evaluated in two different ways. One of these forms of evaluation is the evaluation of the final drafts by the teacher, and the other is the evaluation by sharing them with their real audience, that is, with the 8th grade students. Within the scope of this study, the drafts prepared by the PSTs taking into account the group and class discussions and the feedback they received from the teacher and classmates, were evaluated by the teacher with the rubric given in Table 2. The drafts prepared by the PSTs are given in the examples below and explanations are given about the evaluation of the drafts.

Figure 6 shows the first page of the scientific story prepared by the student coded PST3 (The PST wrote 4 pages in total) (See Appendix 1 for original Turkish version). When the scientific story sample written by the PST was examined, PST 3 got a total of 14 points. In this context, he clearly expressed the big ideas (3 points); wrote in the desired format together with the visuals supporting the flow of writing (3 points); that the draft written as the audience was suitable for 8th grade students (3 points). When the flow was examined, the sentences showing the time flow cannot fully form the whole and need to be developed (2 points), and the science content is good (3 points).

In Figure 7, a page of the scientific story sample prepared by the student coded PST7 using Kotobee is shown (the student wrote 8 pages in total) ((See Appendix 1 for original Turkish version). The PST7 received 14 points in total: 3 points for expressing big ideas prominently, with visuals that support the writing genre such as gifs, photos, videos, etc. 3 points for using and writing in the desired format; 3 points for the appropriateness of the 8th grade students of the draft written as the audience; 2 points for improving the flow of the writing in response to feedback and 3 points for the correctness of the examples and good explanations within the scope of physical and chemical changes when the science content was examined.

A Mysterious Museum Story

Alex is a 15-year-old teenager living in a big city with his family. He loves climbing mountains, riding his bike, doing extreme sports, and visiting places where mysterious events have occurred. This Saturday, Alex decides to secretly enter a museum that had been shut down a long time ago. When evening comes, he grabs the necessary equipment and sneaks out of the house. He climbs onto the roof of the museum, lowers himself down with a rope, and finally gets inside. Since it's completely dark, he can't see anything, but he feels something moving and has the sense that someone is watching him. Suddenly, he hears something fall to the ground, and at that moment, he becomes certain that he's not alone in the museum. Confused and scared about the sounds coming from a museum that's been closed for so long, Alex turns on the lights. All of a sudden, whispers begin to echo, and he sees things scattering in every direction. As Alex carefully looks around the museum, he sees miniature soldier armies, Native Americans in their habitats, and a pharaoh commanding his slaves. What catches Alex's attention the most is the miniature army of soldiers. They looked amazing, though they seemed a bit worn out. He begins watching them. One soldier says, "Commander, I don't understand why our armor has turned brown and become unusable." The commander replies, "They should have kept us in an oxygen-free environment. When our iron armor came into contact with oxygen, a substance called rust formed, and the internal particle structure of our iron armor changed." Then the rusted iron armor speaks: "I used to be strong and durable. Everything changed when I reacted with oxygen ($4Fe + 3O_2 \rightarrow 2Fe_2O_3$)" The soldier says, "Then let's go somewhere without oxygen!" The captain responds, "It's too late for that now. The rusting of iron is a chemical reaction. Since the particle structure of the iron has changed, it cannot return to its original state." Realizing that they won't be able to use their armor in battle, the soldiers return sadly to their castle.

The soldiers' armor before reacting with

The iron armor that reacted with oxygen

Figure 6. An example of a handwritten scientific story on Physical and Chemical Change

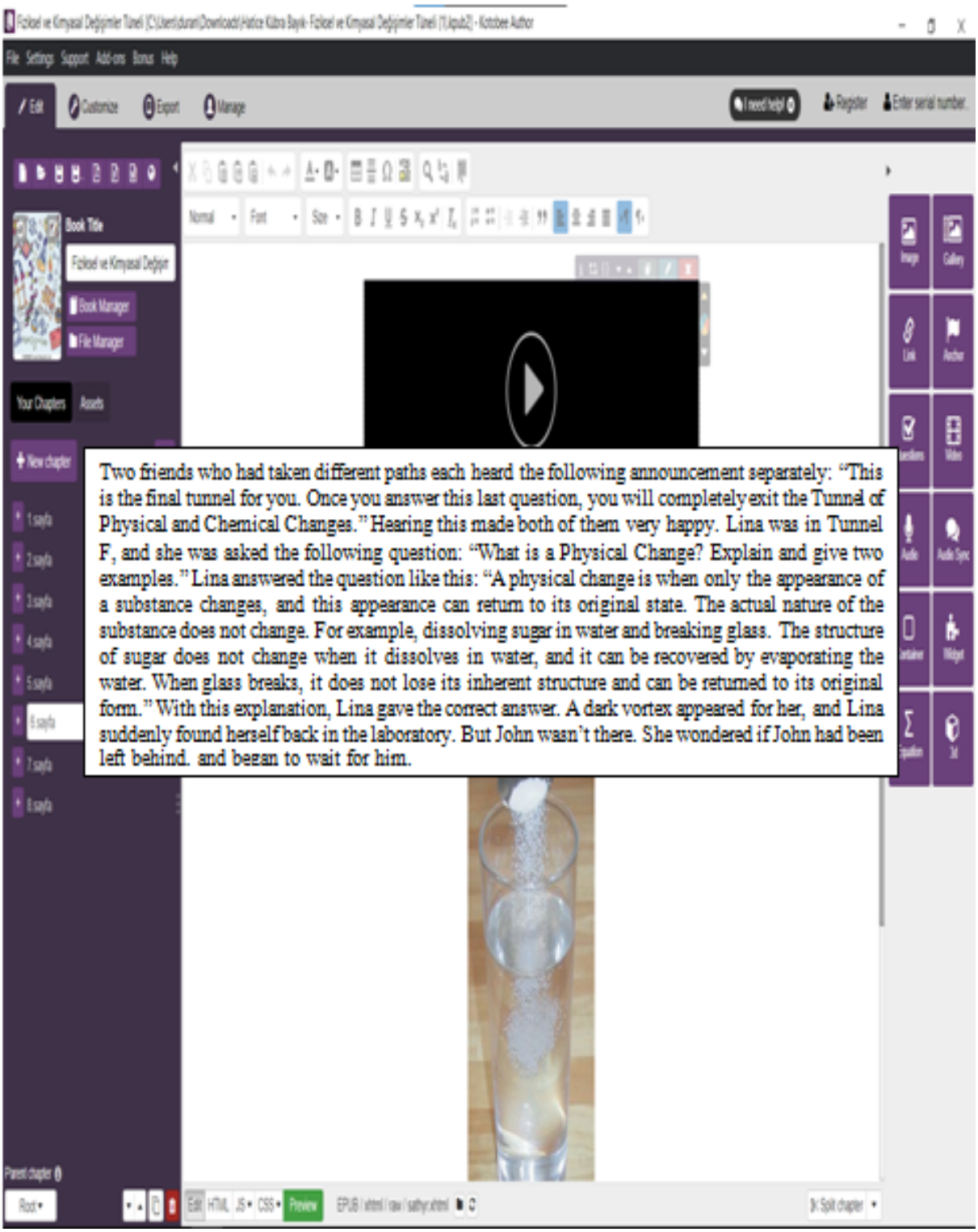

Figure 7. Example of a scientific story prepared with Kotobee on Physical and Chemical Change

EVALUATION OF THE LEARNING ACTIVITY

In this study, a case study design, which is one of the qualitative research methods, was used. Case studies are used to provide in-depth understanding of a situation (Merriam, 2015). In this context, the research starts with the determination of a special situation, and this situation can be an individual, a small group, a community or a project. The main point here is that the situation can be limited or defined by certain variables such as a specific time and place (Creswell, 2021). This study was carried out with 20 freshman pre-service science teachers (PSTs) enrolled at a state university located in the Central Anatolia Region of Türkiye. In this study, writing-to-learn activities were implemented as technology-supported (Kotobee application) and non-technology-supported (handwriting). At the end of the application, the PSTs' views on these two applications were revealed through open-ended questions, and then the obtained qualitative data were coded. Interrater reliability was tested by asking another researcher in science education to analyze four transcripts (PSTs' answers to open ended questions) and this was found to be 0.86.

In this section, information was given by examining the opinions of the PSTs about the writing-to–learn activities that they created using Kotobee and by hand. After both applications, open-ended questions about writing-to-learn activities were asked to the PSTs and the answers were examined. “During the semester, you wrote two different scientific stories. You typed one of them manually and the other using Kotobee. Which of these writing activities (manual and Kotobee) do you prefer? Why?" The question was asked and the written answers from the PSTs were examined. The analyzed statements were coded with their justifications.

The majority of PSTs preferred to prepare their writing activities with Kotobee, with a percentage of 53.4% (n=8). Among the reasons why PSTs prefer to use Kotobee were, they can use the features of Kotobee (n=6) (picture, video, simulation, sound, 3D animation, etc.). The effectiveness of the Kotobee application (n=2), the faster and easier work with technology (n=1) and the effective learning (n=1) are among the reasons why the Kotobee application is preferred in writing activities. When the expressions of the PSTs are examined, they generally prefer the Kotobee application because it is comfortable in terms of visual use and because they can use images in different shapes effectively. The PSTs' opinions are that the application is more useful in terms of the use of demonstrations (pictures, videos, gifts, animations, etc.). Examples of statements that include reasons for students to prefer Kotobee are given below.

“Kotobee. The reason is that many different things and related animated gifts, videos, pictures, links can be added. We can only add images manually. For students, it is both effective and plays the contents of the subject while they are reading (PST12).”

“I would prefer the Kotobee app. Because I think that being able to use both visuals and many different aspects of it allows us to write a more gripping story (PST13).”

When the answers of the PSTs were examined, 46.6% (n=7) of them preferred to write by hand. The PSTs preferred handwriting because they had difficulty using Kotobee (n=4) and because it was easier to write by hand (n=4). In addition, not having a computer (n=2), being easily accessible (n=1), and providing effective learning (n=1) were listed as the reasons for preferring writing by hand. When the expressions of students who prefer to write by hand are examined in general, handwriting is preferred because it is easy to access and they have difficulties while using Kotobee. Some students prefer to write by hand due to reasons such as not having a computer and having difficulties in using the application. Below are some examples of the statements in which the PSTs prefer to write by hand.

“I would prefer manual activity because I wrote it in an easier way than the Kotobee application. But I would prefer the Kotobee application in terms of visuals and for us to learn the subject better (PST7).”

“I would prefer to write by hand. Because I had problems logging into the Kotobee application, that's why. Also, since some of us do not have computers, I prefer to write by hand (PST8).”

The PSTs were asked the question “Do you think these writing activities were effective in your learning? Why?" All of the PSTs who participated in the activity stated that both

writing activities (writing by hand and writing with Kotobee) contributed to learning. While most of the PSTs (n=9) stated that writing-to-learn activities were effective in their learning, some of them stated that they were effective in the learning of the audience, that is, their future students. There are also opinions that think that it contributes to both himself and the student's learning (n=2). In this context, the reasons why PSTs' writing activities affect learning were examined and these statements were coded. When the expressions of the PSTs were examined, the effect of writing activities for learning purposes on their own learning was mostly due to the effectiveness of writing activities (n=3). In addition, doing research (n=1), enjoyability(n=1), reinforcements (n=1), visualizations (n=1), repeating what they know (n=1), helping to understand the subject better (n=1), the contribution of telling something to someone (the audience) (n=1), understanding the directions to be followed (n=1) and transferring information (n=1) were seen to indicate that writing-to-learn activities contribute to their own learning. Some of the PSTs (n=3) explained the reasons why writing activities contributed to students' learning; they expressed that writing activities require students to state complex ideas in a simple way and experience with different methods to convey information. Finally, PSTs stated that doing research (n=2) and telling something to someone (n=1) contributed to the contribution of learning-oriented writing activities to both their and students' learning.

CONCLUSION AND IMPLICATIONS

The aim of this study was to give detailed information on how technology-integrated and non-technology-integrated writing-to-learn activities can be used in the classroom environment in the Chemistry I course and to reveal the views of PSTs about the practice. The PSTs indicated that writing-to-learn activities are effective in their learning regardless of whether they are technology-integrated or hand-written. When the studies are examined, writing-to-learn activities have positive effects on PSTs' academic achievement, attitudes towards the course, detecting misconceptions, learning concepts and ensuring permanence (Akçay et al., 2014; Daşdemir, 2018; Öztürk et al., 2022; Tarıkdaroğlu & Akar, 2022; Yaman, 2018; Yıldız & Büyükkasap, 2011; Yıldız & Koçak, 2021). The results of this study support the results of the previous studies.

The suggestions made within the scope of the study to the teachers who want to implement the activity or to the researchers who want to examine it in different dimensions are as follows;

- If writing-to-learn activities will be prepared in a technology-integrated, that is, in a digital environment, the education period can be extended in order for students to use the application more effectively.
- When the statements of the students are examined, it is seen that the majority of the reasons for their tendency to write by hand is due to the fact that they are easily accessible. In the activity planned to be implemented in this direction, an application that students can reach over the phone and that they can use online or offline can be selected.
- If the application intended to be used in the activity is only computer supported (such as Kotobee), the application can be taught before starting the writing activities. After the application is taught, the computer laboratory can be used for students, who do not have access to a computer during certain hours each week, or science lessons can be taught there, so that students can easily transfer the drafts they have prepared.
- The attached evaluation rubric can be used so that students can evaluate each other during the process or at the end of the process (class discussions).
- The drafts prepared by the pre-service teachers can be sent to their real addressees (8th grade students) so that they can receive feedback from the addressee.
- In this study, for the scientific story type determined for the learning-oriented writing activity, a resource determined on the internet was given to the students and it was discussed what should be considered while writing a scientific story in the classroom. However, it can be ensured that students get help from field experts for the writing type determined in writing activities for learning purposes. For example, in order to obtain information about the writing type, the Turkish teacher can be invited to the class and be asked to provide information on how to use the writing type.

- The same application can be used in different courses and for different grade levels.

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REFERENCES

Akçay, H., Özyurt, B. B., & Akçay, B. B. (2014). The impacts of multimodal writing opportunities on science and technology teaching concerning student achievement and concept learning. *Journal of Bayburt Education Faculty, 9*(2), 15–31.

Arslan, K., & Benzer, E. (2022).A synthesis study of national and international graduate theses on writing for learning in science education. *Education and Science, 47*(210).

Creswell, J. W. (2021). *Qualitative research methods, qualitative research and research design according to five approaches* (M. Bütün & B. D. Demir, Trans. Eds.) (3rd ed.). Ankara: Political Bookstore.

Daşdemir, İ. (2018). The effect of cooperative learning and letter-writing activities for learning purpose on teacher candidates' academic achievement and attitudes to the force and movement topic. *Sakarya University Journal of Education, 8*(3), 205–221.

Graham, S., Kiuhara, S. A., & MacKay, M. (2020). The effects of writing on learning in science, social studies, and mathematics: A meta-analysis. *Review of Educational Research, 90*(2), 179–226.

Hand, B. (2017). Exploring the role of writing in science: A 25-year journey. *Literacy Learning: The Middle Years, 25*(3), 16–23.

Hand, B., Chen, Y. C., & Suh, J. K. (2021). Does a knowledge generation approach to learning benefit students? A systematic review of research on the science writing heuristic approach. *Educational Psychology Review, 33*(2), 535-577.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating science: The critical role of argument in student inquiry.* Heinemann Publishing.

Hand, B., Shelley, M. C., Laugerman, M., Fostvedt, L., & Therrien, W. (2018). Improving critical thinking growth for disadvantaged groups within elementary school science: A randomized controlled trial using the science writing heuristic approach. *Science Education, 102*(4), 693–710.

Hay, L., V. (2025, March 17). *How to write a short story. WikiHow.* https://www.wikihow.com/Write-a-Short-Story

Hohenshell, L., Hand, B., & Staker, J. (2004). Promoting conceptual understanding of biotechnology: Writing to a younger audience. *The American Biology Teacher,* 333–338.

İspir, B., & Yıldız, A. (2021). An analysis of the researches on writing to learn in Turkey: A meta-synthesis study. *OPUS International Journal of Society Researches, 18*(41).

McDermott, M. A., & Hand, B. (2010). A secondary reanalysis of student perceptions of non-traditional writing tasks over a ten-year period. *Journal of Research in Science Teaching, 47*(5), 518–539.

Merriam, S. B. (2015). Qualitative research: Designing, implementing, and publishing a study. In Handbook of research on scholarly publishing and research methods (pp. 125-140). IGI Global Scientific Publishing.

Ministry of National Education, MONE, (2018). *Science curriculum middle (school 8th grade)*. Ankara: Milli Eğitim Bakanlığı.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. The National Academies Press. https://doi.org/10.17226/18290

Norton-Meier, L., Hand, B., Hockenberry, L., & Wise, K. (2008). *Questions, claims, & evidence: The important place of argument in children's science writing*. Heinemann.

Öztürk, B., Kaymakoğlu, H., & Demiroğlu-Çiçek, S. (2022). The effect of writing to learn activities on the academic achievement of 8th grade students on periodic system. *Journal of Science Teaching*, *10*(1), 115-138.

Prain, V., & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. *Teaching and Teacher Education, 12*(6), 609–626.

Tarıkdaroğlu, M., & Akar, M. S. (2022). The effect of learning writing on primary students' academic achievement and attitudes to writing. *International Journal of Education Science and Technology, 8*(2), 111–122.

Yaman, F. (2018).The effect of writing-to-learn strategies on 6th grade students' conceptual understanding of matter and heat unit. *Sakarya University Journal of Education, 8*(4), 89–108.

Yaman, F. (2021). Examining students' quality and perceptions of argumentative and summary writing within a knowledge generation approach to learning in an analytical chemistry course. *Chemistry Education Research and Practice, 22*(4), 985–1002.

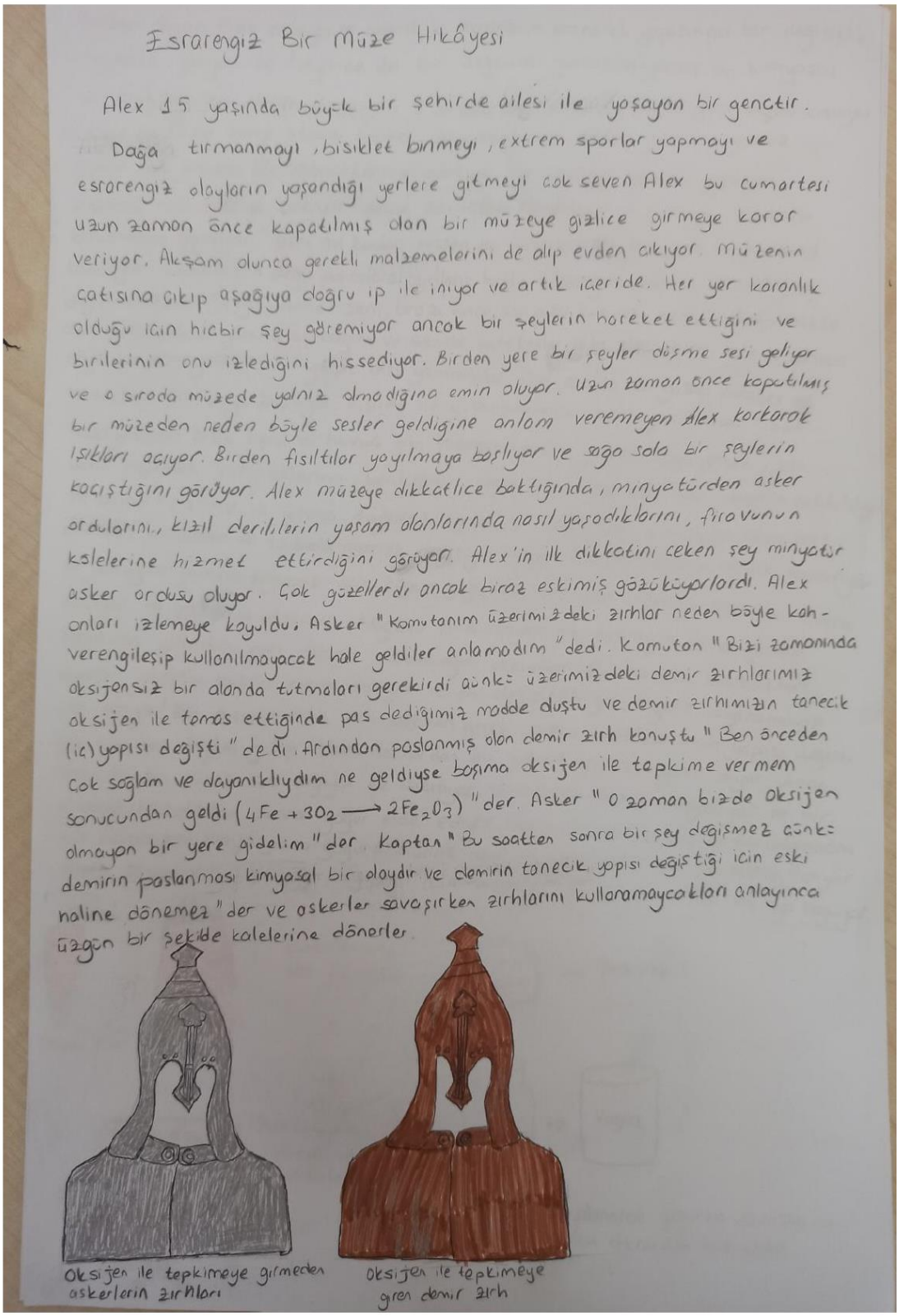
Yaman, F., & Hand, B. (2024). Examining the link between oral and written reasoning within a generative learning environment: the impact of the Science Writing Heuristic approach. *International Journal of Science Education*, *46*(8), 750-772.

Yıldız, A., & Büyükkasap, E. (2011). Pre-service teachers' understanding levels of the photoelectric effect and the impact of writing-to-learn activities on academic achievement. *Educational Sciences: Theory & Practice, 11*(4), 2259–2274.

Yıldız, E., & Koçak, G. (2021). Investigation of the effect of writing to learn activities on academic and laboratory achievement of preservice science teachers. *OPUS International Journal of Society Researches, 18*(39), 1–1.

APPENDIX

Appendix 1- Turkish version of an example of a handwritten scientific story on Physical and Chemical Change



Esrarengiz Bir Müze Hikâyesi

Alex 15 yaşında büyük bir şehirde ailesi ile yaşayan bir gençtir. Dağa tırmanmayı, bisiklet binmeyi, extrem sporlar yapmayı ve esrarengiz olayların yaşandığı yerlere gitmeyi çok seven Alex bu cumartesi uzun zaman önce kapatılmış olan bir müzeye gizlice girmeye karar veriyor. Akşam olunca gerekli malzemelerini de alıp evden çıkıyor. Müzenin çatısına çıkıp aşağıya doğru ip ile iniyor ve artık içeride. Her yer karanlık olduğu için hiçbir şey göremiyor ancak bir şeylerin hareket ettiğini ve birilerinin onu izlediğini hissediyor. Birden yere bir şeyler düşme sesi geliyor ve o sırada müzede yalnız olmadığına emin oluyor. Uzun zaman önce kapatılmış bir müzeden neden böyle sesler geldiğine anlam veremeyen Alex korkarak ışıkları açıyor. Birden fısıltılar yayılmaya başlıyor ve sağa sola bir şeylerin koştuğunu görüyor. Alex müzeye dikkatlice baktığında, minyatürden asker ordularını, kızıl derililerin yaşam alanlarında nasıl yaşadıklarını, firavunun kölelerine hizmet ettirdiğini görüyor. Alex'in ilk dikkatini çeken şey minyatür asker ordusu oluyor. Çok güzellerdi ancak biraz eskimiş gözüküyorlardı. Alex onları izlemeye koyuldu. Asker "Komutanım üzerimizdeki zırhlar neden böyle kahverengileşip kullanılmayacak hale geldiler anlamadım" dedi. Komutan "Bizi zamanında oksijensiz bir alanda tutmaları gerekirdi çünkü üzerimizdeki demir zırhlarımız oksijen ile temas ettiğinde pas dediğimiz madde oluştu ve demir zırhımızın tanecik (iç) yapısı değişti" dedi. Ardından paslanmış olan demir zırh konuştu "Ben önceden çok sağlam ve dayanıklıydım ne geldiyse başıma oksijen ile tepkime vermem sonucundan geldi ($4Fe + 3O_2 \longrightarrow 2Fe_2O_3$)" der. Asker "O zaman bizde oksijen olmayan bir yere gidelim" der. Kaptan "Bu saatten sonra bir şey değişmez çünkü demirin paslanması kimyasal bir olaydır ve demirin tanecik yapısı değiştiği için eski haline dönemez" der ve askerler savaşırken zırhlarını kullanamayacakları anlayınca üzgün bir şekilde kalelerine dönerler.

Oksijen ile tepkimeye girmeden askerlerin zırhları

Oksijen ile tepkimeye giren demir zırh

Appendix 2- Turkish version of an example of a scientific story prepared with Kotobee on Physical and Chemical Change