African Journal of Physics Vol. 1 (4), 13 pages, December, 2013. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Significance of understanding and writing in studying physics in secondary classrooms

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Accepted 19 May, 2013

The aim of this study was to understand physics teachers' and secondary students' perceptions of reading and writing to learn activities in physics and to determine students' strategies in performing reading and writing tasks. A case study strategy was employed in this study, involving 42 10th grade secondary students and two physics teachers in a secondary school in the spring term of 2007 - 2008 academic year. Student questionnaires consisting of 28 Likert- type items and 5 open-ended questions, observational field notes and a semi-structured interview protocol for teachers were used as data gathering tools. Findings revealed that both teachers and secondary students found the reading and writing to learn activities very useful and effective in conceptual understanding of physics and failed to develop students' procedural or computational skills. Using the Internet as authentic read text, visual representations and unfamiliar activities aroused students' situational interest, leading to improvement in personal interest through active engagement, conceptual understanding and control over their learning. The university entrance exam, which requires more computational skills or understanding and dominates thinking, was seen as a big challenge for teachers to use reading and writing activities in secondary physics classrooms.

Key words: Reading to learn physics, writing to learn physics, secondary students, teaching physics.

INTRODUCTION

Angell et al. (2004) declared that unlike many other disciplines, physics is more conceptually demanding subject. Concepts as units of knowledge in science have a unique role to explain natural phenomena. Studies about the value of reading and writing-to-learn in school science revealed that those linguistic activities enhance both conceptual understanding and scientific usage of language (Hand and Prain, 2002; Roth and Duit, 2003; Florence and Yore, 2004; Fang, 2004; Gunel et al., 2007; Günel et al., 2009; Günel, 2009). The researcher's concern in this paper is about the use of scientific reading and writing in physics lessons and the participants' perceptions of these linguistic activities.

Language has a constitutive role in doing, communicating and learning science rather than simply being as a medium (Lemke, 1990). Fang (2004) also stressed that as the language in school science is distinct from the ordinary everyday language of students, science teachers need to pay more attention to improve their students' use of scientific language. This shows the necessity of language in doing science, or learning to do science (Osborne, 1996). The ability to read and write in science is a prerequisite of scientific literacy. Scientific texts should be used in science teaching and learning to deepen students' understanding of science topics. Otherwise, students become very limited to construct their science knowledge (Norris and Phillips, 2003).

Contemporary theories of teaching and learning in science demand mentally and physically active learners. What is expected from learners is to put bits and pieces of information they obtained from different sources together, question and analyze it, generate summaries and synthesize or draw conclusions. Reading and writing in science can serve for this purpose, making students mentally active, through which they can ask questions, take notes while reading, summarize, find goal relevant information, generate meanings, evaluate, construct personal knowledge and communicate to others.

As Osborne (1996) asserted, learning science is more akin to the learning of language rather than learning

some historical facts. Many researchers stressed that teachers of science should have the responsibility of teaching the new language of science; that is, they have to be sure about that the language used in science lessons is understood and used correctly and efficiently by their students (Henderson and Wellington, 1998; Prain and Hand, 1999; Koch, 2001; Hand and Prain, 2002; Norris and Phillips, 2003). Henderson and Wellington (1998) stressed that the language in science remains as a barrier and thus an obstacle to the learning of students. Writing has the potential to foster the generation of knowledge by actively translating new meanings into verbal symbols since it facilitates active information processing (Keys, 1999b) . It is commonly believed that you will understand a topic better after writing about it (Grabe and Grabe, 1998). In the last two decades, there has been considerable interest in studies about writing to learn in science, and these studies proposed writing-to-learn as an instructional technique in science teaching and learning even though science teachers have been reluctant to use them as an integral part of their teaching.

Writing can promote learning in science through; expansion of scientific ideas and the generation of meaningful inference (Keys et al. 1999; Keys 1999b), interpreting, learning and using the language of science in speaking, writing and reading (Henderson and Wellington, 1998; Fang, 2004), conceptual understanding (Hand et al., 2004; Gunel et al., 2007), promoting reflection and the production of new knowledge (Keys, 1999a), imaginative writing (Hildebrand, 1998), developing metacognitive skills focusing on issues of purpose, audience, topic, method of text production and writing type (Prian and Hand, 1999), employing writing to learn strategies as a mode of learning (Hand and Prain, 2002), collaboration (Rivard, 2004), analytical writing (Rivard and Straw, 2000), and writing experiment manuals (Rijlaarsdam et al., 2006). In all these studies it is commonly revealed that writing to learn activities would make students reprocess, question, analyze and synthesize the topic or ideas. As Yore et al. (2002) discussed, writing promotes learning since it provides students with the opportunity to reflect, consolidate, elaborate, and reprocess concepts and ideas, resulting in a deeper understanding of the concepts being taught.

On the other hand, Koch (2001) made an emphasis on developing students' communicative skills, notifying that reading is one aspect of communicating in physics beside other verbal communications. Wade (2001: 254) asserted that reading foster conceptual learning that can be defined as 'an in-depth knowledge of major concepts and theories - those unifying networks of ideas and beliefs that we hold about physical world and social relations'. As writing, scholars stressed the negligence of writing, reading to learn activities also have been neglected in science classrooms (Koch, 2001). Beck and McKeown (2001) asserted that coherence of the read texts and forms of students' engagement with the text directly affect students' comprehension. Guthrie and Cox (2001: 284) defined the engaged readers as 'students who are intrinsically motivated to read for the knowledge and enjoyment it provides'. This leads us to question students' metacognitive knowledge, which is defined as 'a construct that provides insights into the awareness and executive control of knowledge construction' and 'a hidden level of behaviour that involves focusing on conscious knowledge about knowledge and its relation to intellectual performance' (Koch 2001: 760).

Metacognitive knowledge of reading comprehension also necessitates active reading that facilitates conceptual learning as opposed to traditional passive reading that generally results in rote-memorization. However, as Hirsch (2003) pointed out, metacognitive knowledge of reading comprehension facilitate learning but excessive instruction in metacognitive skills can prevent us from considering other factors greatly influencing comprehension. One of them is the knowledge of words or concepts the read text includes; that is, the unique language demand of scientific texts (Fang, 2004). The other one is interest, personal (activated internally) or situational (activated environmentally). As Guthrie et al. (2006) emphasized, situational interest can be triggered by providing students with stimulating tasks in reading.

Schraw et al. (2001: 220) suggested six ways to increase students' interest: 'Offer meaningful choices to students, use well-organized texts, select texts that are vivid, use texts that students know about, encourage students to be active learners, provide relevance cues for students'. Text genre, discourse of the read text, is also a crucial factor affecting reading comprehension. Genres of science textbooks can be classified into two categories: Narrative genre provides information about a sequence of events, mainly employing an understandable language as used in popular science magazines, expository genre, on the other hand, provides explanations about something (explanations about laws or theories in textbooks, for instance). Baram-Tsabari and Yarden (2005) found out that text genre affects students' performance. Their study revealed that students' comprehension was enhanced and they demonstrated less negative attitudes with a more narrative text genre, comparing with an expository text genre in the same topic.

As Koch (2001) indicated, although reading comprehension is a crucial form of physics teaching and learning, physics texts contain no unnecessary information and include new concepts and vocabulary for students who make the text hard to comprehend. Students in the secondary level come across with expository texts, including scientific language that is distinct from the ordinary language, which are less familiar and more alienating to them (Fang, 2004). Students' understanding of the content vocabulary is crucial and thus a predictor of their level of understanding of the read text (Young, 2005). If Osborne (1996)'s view is accepted, that is, learning science is more akin to the learning of language

rather than learning some historical facts, then physics teachers, all subject teachers indeed, need to pay special attention to the language issues in the classrooms as an integral part of their teaching.

The context of the study

In the spring term of 2006 - 2007 academic year, the materials designed by the researcher in a multi-national European Commission supported project were implemented as a pilot study. The overall aims of the project are to develop Initial (Pre-Service) Science Teacher Education and innovative activities emphasising reading and writing in science.

The researcher designed activities about the unit "impulse and momentum", which is a problematic topic for students (Sekercioglu and Kocakulah, 2008). Two CDs were formed, one for teachers/student teachers and one for secondary students. As the CD for teachers includes activities, theoretical background information about reading and writing activities in science learning, goals of each activity and suggestions for teachers/ student teachers in order to effectively implement the activities, the CD for student only includes the activities developed. Before both pilot study and real study, all science teachers (physics, chemistry and biology) working in a school were informed about the CDs. All science teachers were invited to this course since the CDs include activities related to a unit in physics, impulse and momentum, a unit in chemistry, radioactivity, and a unit in biology, circulation and transportation systems. This study, however, focuses on only physics lesson and thus reading and writing activities related to impulse and momentum. All activities are designed as Directed Activities to Reading Text (DART). Therefore, students can follow what their tasks are, with directives written in the beginning of each activity, and they can link the Internet via the links provided for them through the directives in the CD.

After the pilot study, the actual implementation of this current study, based on the reading and writing to learn activities was carried out in the spring term of the 2008 - 2009 academic year. Writing and reading to learn activities have been neglected and have not been well accepted by teachers as forms of learning in science in Turkey. Recent initiatives, however, curricular changes in primary education since 2005 and in secondary education initiated in the 2008 - 09 academic year, aimed to change the theoretical bases of teaching and learning in formal education. New programmes are based on some contemporary theories of learning such as, multiple-intelligence theory, context-based learning theory, and different models within constructivist theory. In a general term, new syllabuses for subject areas are more student-centred, requiring knowledge construction through multi-forms of teaching and learning, multi-channels and multi-feedbacks. New syllabus of Physics (MEB, 2007) for secondary schools redefines the expectations from secondary students, including data processing and communication skills. It made emphasis on reading comprehension; that is, reading and understanding articles and other written texts related to concepts, terms and laws of physics. It also stresses that students use suitable terminology in their communications related to physics (that is, verbal, written, visual etc.), explain complicated information clearly, in an understandable and a genuine way.

As Alev and Uzun (2007) point out activities related to writing and reading are mainly in copy paste format, using computers or copying information from the books, journals, encyclopaedia, the internet etc. without any or relatively less mental engagement which could be defined as passive reading and writing in Turkish secondary schools. There have been very few studies in writing to learn in science (Gunel et al., 2006; Gunel et al., 2007; Günel et al., 2009; Günel 2009) in Turkey, especially in secondary schools, reading to learn activi-ties in science classrooms are either passive reading format, or do not exist (Alev and Uzun, 2007).

As Koch (2001: 759) asserts, "extensive reliance on numerical and graphical forms of communication in traditional physics teaching comes at the expense of verbal communication". Verbal communication involves reading, writing, speaking and listening. These verbal communications requires classroom activities related to the skills in these domains, and at the end leading to improvement in conceptual understanding. Current classroom activities in physics lessons are mainly in talk and chalk format, which result in improving students' procedural understanding or computational skills rather than conceptual understanding (Sekercioglu and Kocakulah, 2008). As Hand and Prain (2002) concluded, there is still a need to study the effects of different reading and writing activities on students' learning.

However, as they also suggests, there is also a need to grasp how the practitioners, teachers and students, perceive these reading and writing activities in science lessons. Studies on practitioners' perception of and examining the process of the implementation of reading and writing activities would make a contribution to pedagogical utility of those activities for learning, and also utility of those activities in transition from teacher-centred to student-centred classroom practices, especially for the countries where traditional classroom teaching dominate physics lessons.

The aim of this study is to explore physics teachers and secondary students' perception of reading and writing to learn activities in physics and the emerging issues during the intervention. For this main purpose, the researcher seeks to understand: (1) How physics teachers and secondary students perceive reading and writing activities in learning physics, (2) Which issues are arisen from the implementation of these reading and writing activities, and (3) Students' styles or strategies to read and write to learn in physics lessons.

Table 1. The implemented reading and writing activities.

Type of activities	Nature
Direct questions (2*)	Reading comprehension and writing
Guessing unknown words (5*)	Reading comprehension and vocabulary reinforcement
Transferring verbal language to non-verbal language (2*)	Reading comprehension and completing diagrams
Transferring diagrams to verbal language (written text)	Reading comprehension and writing
Matching questions with their answers	Reading comprehension
True/False questions (2*)	Reading comprehension
Solving problems (3*)	Understanding and
Comparing different scientific procedures (2*)	application Writing
Drawing conclusion (5*)	Writing
*the number of activities in that type	

METHOD

Research design

Case study strategy was employed since the aim of the study is to gather data about an ongoing project implementation. The intervention of reading and writing to learn impulse and momentum topics was carried out in two 10th grade classrooms throughout four weeks. Case study is a strategy in which a researcher investigates a single phenomenon within its 'real context', restrained by 'time and activity', and collects 'detailed information by using multiple methods' of evidence or data collection in a sustained 'period of time' (Yin, 1989; Robson, 1993; Gillham, 2000). In this study, the focus of the case was to investigate teachers' and students' perceptions of the reading and writing activities to learn impulse and momentum topics in secondary physics classrooms. Data for the study were collected through semi-structured interviews, observational field notes and student questionnaires including likert -type items and open-ended questions. In this current study the researcher try to understand and discover how the implementation process proceeded in a classroom environment and how participants (teachers and students) perceive the use of reading and writing activities in physics lessons.

Participants

The participants of the study are two physics teachers; Teacher A, a male with 15 years of experience in teaching Physics, Teacher B, a male with 17 years of experience in teaching Physics. Both teachers had worked as physics teachers in different parts of Turkey before they both came to this particular school four years ago, in which this study was carried out.

The school is an Anatolian High School located in the city centre. The number of the participating 10th grade secondary students are 42 in total, in two different classrooms; 19 students in classroom A (taught by Teacher A) and 23 students in classroom B (taught by Teacher B).

Data gathering and research instruments

Questionnaire

A Likert type (absolutely not agree to absolutely agree) questionnaire was developed by the researcher, including 28 items. The questionnaire also includes five open-ended questions to collect in-depth data from the students. The questionnaire consists of four parts; students' perceptions (the reliability coefficient = 0.82), reading comprehension skills (the reliability coefficient = 0.77), writing strategies (the reliability coefficient = 0.89), and open-ended questions about the impacts of the implemented activities.

Semi structured interviews

Semi structured interviews were performed with two participating teachers after the implementation. The semi-structured interviews focused on teachers' thoughts about the activities and the use of the Internet as authentic text source, advantages and inconveniences that they have found on the implementation of the CDs, the interesting and stimulating things that they experienced during performing the activities, difficulties to understand how to perform the activities, suggestions about how teachers should use these activities in their lessons, bearing their experience in mind.

Field notes

The researcher took field notes throughout the intervention to collect data about students' and teachers' roles and interaction and communication inside the classrooms during the intervention. To do this, the researcher sat down in a corner of the computer room, the intervention took place and took notes of the observed roles and interaction.

Directed activities to reading texts (DARTs) and writing activities

Henderson and Wellington (1998) declare that DARTs can be used for active reading which "involves reading for specific purposes, and the sharing of ideas and small group work" (p.44). They also mention that DARTs make students focus on important parts of the text, and involve them in discussion, communicating ideas and scrutinizing their interpretation of the read text. DARTs' can be classified in two broad categories; 'Reconstruction (or completion) DARTs that students need to fill in the missing parts (words, phrases, labels, names, objects etc.) of the modified text, while 'Analysis DARTs' is that students need to find, locate and categorize targeted information in the unmodified read text, followed by small group or whole class discussions (Henderson and Wellington, 1998).

In this study both types of DARTs were used. The two Internet based texts including visual representations were written in expository genre which the language of the text is very formal and scientific. Writing activities were integrated into DARTs. The following Table 1 illustrates the activities implemented in the classrooms.

Data analysis

The questionnaire contained a mixture of open and closed questions. Quantitative data collected through closed-ended questions with a Likert scale, from absolutely not agree (0) to strongly agree (4), were analyzed by taking mean into consideration. Interpretive analysis was adopted for the qualitative data derived from semi-structured interviews and open-ended questions in the questionnaire. Transcripted interviews, field notes and students' responses to the open-ended questions were coded as first level code, and then the related first level codes were grouped as themes and coded again regarding the research questions (Miles and Huberman, 1994) . Using both sets of codes a conceptually clustered matrix was formed (Miles and Huberman, 1994). Field notes, on the other hand, were analyzed descriptively in order to draw a picture of the learning environments and to link the data with the context of the studied.

RESULTS

The first part reports on the observational field notes to provide the reader with an understanding of how the reading and writing activities were implemented and the roles and interactions of the participants.

The process of the implementation

To understand how reading and writing to learn activities were implemented in real classroom settings, the researcher took field notes about the organization of the classroom, roles of the teachers, students and classroom interaction during performing the tasks. The school in which this study was carried out has a computer laboratory with a projector and 11 available terminals; that is, terminals that are working properly and have an internet connection. Thus throughout the implementation the teachers needed to relocate physics lessons from normal timetabled classrooms to the computer laboratory. Seven computers were ranged around the perimeter of the laboratory and four computer terminals in the middle of the laboratory. Majority of students in both observed classrooms were in pairs in front of a computer.

From the field notes, the two participating teachers' roles could be explained under three main themes. The first one is the role of classroom organizer: The teachers organized the classroom, formed the pairs, taking students' decisions into consideration, and asked them to study all through the way in computer laboratory till the end of the impulse and momentum unit. Then they explained the objective of each activity and tasks at the beginning of each activity, directing them to the CD and activity books provided beforehand for each student.

Second, the teachers guided students while they were working on their assigned tasks during lesson time. In both classrooms, the teachers stood back and just walked around the classroom, observing what students do and responding to them when they asked about something or have a problem. After settling down, in the first week, especially in the first lesson, students have some technical problems with the computers, solved by the computer and instructional technology teacher, and some questions from a couple of students about the activities how to proceed, explained by the teachers, stressing that "when read the directives carefully, you will understand what you are asked to do" (Teacher, Class B).

The teachers directed small discussions among nearby pairs, and sometimes whole class discussions. In both classrooms, the teacher was listening and directing position during these discussions. The teacher employed whole class discussions especially if something important or problematic question has been raised by students. During these discussions the teachers usually let pupils discuss, probing their understanding. Teachers used probes such as, "any other idea?", "is he right?", "what else?", "who else?", "let's think it this way", "why?". Generally these whole class discussions ended up with the teachers' final comments about the topic under discussions to make it clear for pupils.

Third, the teachers had the opportunity to provide support and feedback for each student, and thus one-on-one interaction was available. The teachers had the opportunity to check students' works. At the end of each lesson, the teacher asked students what they have learnt from the tasks they performed, eliciting students' ideas and summarizing the topic.

Students, on the other hand, unlike traditional classroom practices that is teacher-sensitive, all took parts in the assigned tasks. Through reading and learning activities, all students were encouraged to mentally engage in the classroom activities individually. Except some complaints and technical problems in the first lesson, students enjoyed doing the activities. The organization of the classroom and works required students to communicate with their friends and teachers all through the activities, discussing, learning from each other, learning from the teachers' feedback and communicating through talking and writing.

Students' strategies related to reading and writing to learn in physics

In this section, findings from the questionnaire data are presented, providing mean for each questionnaire item.

Table 2 shows students' styles or strategies during their reading tasks, that is, metacognitive skills of reading comprehension. As seen from Table 2, during reading, students mainly used tactics such as writing important points (M = 3.47), imagining scenes or drawing pictures (M = 3.28), focusing on visual presentations (M = 3.23), re-read (M = 3.26), and skimming (M = 3.02). The least used tactic is to look up words in the dictionary (M = 0.97).

Table 3 shows students' tactics used during their writing tasks. As seen from the Table 3, that students

Table 2. Students' reading strategies.

	Mean (M)
I focused on pictures, graphs, simulations to understand the topic	3.23
I thought of key words to determine the main idea of text	2.76
I compared what I read with what I already know while reading.	2.80
I skimmed when reading to look only for specific information.	3.02
While reading, I asked someone else if I did not understand a point in the text	2.78
I imagined scenes or drew pictures of what I am reading.	3.28
I re-read parts that I didn't understand.	3.26
I wrote important information presented in the text that I read.	3.47
I looked up words that are new to me in the dictionary.	.97
I skipped the words that I didn't know its meaning	2.38
I guessed the meanings of new words in context while reading.	2.54
I grouped words that were related in some way.	2.26

Table 3. Students' writing strategies.

	Mean (M)
I consulted the read text for facts and information while writing.	3.28
I wrote down ideas first and then wrote what we asked to do	3.50
I made plans before I started writings.	3.50
I revised and edited my writings.	3.47

consulted the read texts for facts and information (M = 3.28), made a plan (M = 3.50), wrote down ideas first, and then wrote down what they asked (M = 3.50), revised and edited their writings (M = 3.47).

In both reading and writing activities, students, being agree and/or strongly agree with the ideas in the items that are valuable for reading to understand and writing to learn, made comments on the role of directed activities, claiming that they were clear enough to do the tasks. Therein using DARTs as an outlet of the reading comprehension tasks, directed students how to pursue their tasks. The directives at the beginning of each task might have an effect on students' metacognitive skills, as an indirect training on metacognition. Similarly, the integrated writing tasks also included directives which accommodate implications of how to perform writing tasks. This illustrates that in both set of activities, reading or writing tasks, students are responding to the prompts, provided by the directives of each activity, to take up these strategies.

Participants' perceptions of reading and writing activities in teaching and learning physics

The participating teachers and students' perceptions were grouped into four categories; effectiveness of the reading and writing activities, usefulness of the reading and writing activities, students' interest and challenges.

Effectiveness and usefulness of the reading and writing activities

The participating teachers stressed on the effect of the reading and writing activities on students' learning and their effectiveness and usefulness in learning process and communication skills. They both mentioned that these activities promoted knowledge construction, allowing students to learn with their own efforts. T1, for instance, pointed out that:

> "These types of activities are very useful since they reinforce students' knowledge, allow individual and group studies, and promote knowledge construction... expand students' knowledge… they critically question the topic they were studying on."

T2, on the other hand, mentioned that:

> "… With these activities I witnessed that students tried to understand through reading and discussing with their friends and construct their own knowledge, being mentally active."

He also mentioned that he has never used these types of activities in his teaching so far, stressing that:

> "I like the availability of different types of activities which make students active throughout their learning

Table 4. Students' perceptions of reading and writing activities.

	Mean
Internet-based content and directed activities helped me understand the topic	2.95
Linguistic activities improve scientific thinking	3.09
Linguistic activities improve the use of language correctly in science	2.97
I prefer teacher explaining the topic rather than these type of activities	2.30
Reading and writing were good forms of learning Physics.	3.02
The reading and writing activities were useful	2.92
I felt that I was in Turkish lesson rather than physics lesson	1.23
I enjoyed reading and writing in Physics lessons	2.61
The writing and reading activities kept me engage in class	3.40
During my writings I realized how much I learned.	2.57
After writing I understood the topic more clearly.	3.64
These activities were vast of time in physics lesson	1.16

process."

Both teachers made an emphasis on the process of learning during the implementation. They found the reading and writing activities very useful, which made students active, allowing student-centred teaching:

> "… The CD requires students to be active and there is a real attempt here to teach the topic employing different activities…reading, writing, discussing, sharing etc..... This leads meaningful and in-depth learning" (T1).

While T2 stressed that "reading and writing activities improve scientific thinking and writing", T1 commented that:

> "The concept maps and information maps are interesting to me… Having been filled them in; students were asked to write a paragraph explaining the concepts and relationships between concepts in the concept maps. This also makes contribution to scientific use of language… language and the correct use of language in physics are very crucial regarding effective teaching and learning of physics..."

T1 also commented that during the implementation he had the opportunity to assess students' performance on each activity and gave feedback, which is a kind of formative assessment, pointing out that 'the activities helped me determine which topics were not learned'.

During the implementation of the activities both teachers checked students' works after each activity and gave guiding feedbacks. The teachers stood back and just walked around the classroom, observing what students do and responding to them when they asked about something or have a problem. The teachers directed small discussions among near-by pairs, and sometimes whole class discussions. In both classrooms the teacher was listening and directing position during these discussions. The teacher employed whole class discussions especially if something important or problematic question has been raised by students. During these discussions the teachers usually let pupils discuss, probing their understanding. Generally these whole class discussions ended up with the teachers' final comments about the topic under discussions to make it clear for pupils.

Students' perceptions, derived from questionnaire, of reading and writing activities were presented in Table 4.

As it can be seen from Table 4, students were very positive about the use of the reading and writing activities in physics lessons. The most astonishing result was about the role of these types of activities in student engagement (M = 3.40). They agreed that reading and writing are good forms of learning Physics (M = 3.03). They believed that reading and writing activities improve scientific thinking and correct use of language in science (M = 3.09, M = 2.97, respectively) . However, it was surprising that students did not enjoy reading and writing in Physics lesson (M = 2.69) as much as they valued the reading and writing activities in learning Physics. They strongly agreed that they understood the topic after writing about it (M = 3.64).

Data from students' answers to the open- ended questions revealed that all participating students made positive comments on visual support of the CD (n = 42). Majority of students commented that the activities helped them better comprehend the topic (n = 30), made them engage in the activities (n = 27), promoted improvement in thinking and reasoning (n = 22), were clear and helpful (n = 22). The participating students stressed that the reading and writing activities ended monotonous lessons (n = 18), made them learn on their own (n = 16), resulted in permanent knowledge (n = 13). Eighteen (18) students found the reading and writing activities in physics lesson

very useful. Seventeen (17) students commented that these types of applications must be used in every lesson. Some students mentioned that the activities were effective since they require search for information (n = 15), to draw and write conclusions (n = 11), to solve questions that require reasoning (n = 5). Twelve (12) students stressed that they enjoyed working in groups. Seven students commented that it is easy and quick to reach information. Following quotes from students' answers, summarized their perceptions of effectiveness and usefulness of the reading and writing activities in physics.

> "... As a science student, it was more effective to learn by struggling rather than getting information without effort. Besides, simulation and visualization in the CD made abstract concept more concrete" (S6.1). "This is a good idea since it gave me an opportunity to learn on my own with my effort rather than only listening from the teacher" (S2.1). "This was a good method since it requires stu-dents' own research about the topic...I can interpret any events in impulse and momentum topic without difficulty since the activities helped me comprehend the core of the topic, progressing by digesting" (S21.1).

As understood from the students' comments, students' participation in the activities helped them understand the topic better. According to their reflective remarks, the value of the reading and writing activities was about being mentally active in the classroom. They expressed themselves using words such as, searching, learning by struggling, learning on my own, performing the activities, progressing by digesting, observing and drawing conclusion. A valuable comment or recommendation was made by a student, as follows:

> "Students' learning styles differ from each other. Some prefer to listen, some prefer to read and write. Students should group in respect of their learning styles. This would make this method more effective and students would be more successful" (S11.2).

Only one student stressed that it was not easy to understand the topic from the read text.

> "It is not easy to understand physics by reading from the text. In my view, you need to write, scrabble and solve problems in physics. However, visual properties help me understand the topic" (S9.1).

Twelve (12) students were in some way sceptical; three of them mentioned that reading and writing activities were useful for those who wanted to learn, three of them stressed that it could be more useful if the topic was explained by the teacher first, one student stressed that these activities might not be suitable for every topics, one pointed out that the reading and writing activities are most useful for verbal lessons rather than numerical lesson. Following quotes illustrated students' scepticism about the reading and writing activities:

> "It is very good to understand the topic...However, this productive method could be more productive if some more exemplary questions related to university entrance exam and practical ways to solve these problems were provided for us." (S7.1)
> "It is a good way to learn... We tend to interpret the physical events rather than focusing on numerical data, and this help us find answer for many questions that we would not understand in other ways. However, as long as OSS is there, I do not believe it will help us in this exam. This method requires more class hours. But more importantly, to use this method for learning, university entrance system requires a fundamental change" (S1.2).

Some students made comments on traditional habits of teachers and learners in physics lessons:

> "This method helped me fully comprehend the topic, actively engaging in the activities. However, as long as teachers have a tendency to give everything... I would like to make clear that this type of learning activities would hardly be seen in classrooms" (S3.2). "More teacher involvement requires. After all we have learned by listening to the teacher for so many years" (S13.2).

The effects of the reading and writing activities on students' interest

As seen from Table 5, the participating teachers commented that reading and writing activities were unusual in their classrooms. These unusual classroom activities attracted students' attention and aroused their interest as both teachers stressed:

> "These types of activities attract students' attention, they are very effective for students to comprehend the topic... reading and writing activities and use of the Internet motivate students. Visualization is very crucial in physics. There are different simulations in the web site we provided for students. I witnessed that they enjoyed working on-line...This is a good alternative approach to be taken into consideration" (T1). "Students enjoy themselves doing these activities... they tried to put forward their ideas… The CD arouses students' interest since the activities are unusual in our classrooms… especially for those who are ignorant…Having said this, students who are successful are taking more advantage of the activities" (T2).

Both teachers commented that majority of the students enjoyed doing the reading and writing activities and found

Table 5. The participants' perceptions of reading and writing activities in physics lesson.

	Effectiveness	Usefulness	Interest	Challenges
Teachers	-visualization -expands students' knowledge -effective in the early years - improve scientific thinking and writing, scientific use of language - active learning -they critically question the topic -promote knowledge construction -improve reading comprehension -writing with their own words - concreteness -allows student-centred teaching	- up-to-date information -positive impact on teaching and learning science -home becomes school by means of the internet -learning by students own pace - acts. are very useful in the early years -the CD is easy to use - a good alternative approach to teaching and learning physics - support traditional teaching methods -allow individual and group studies -formative assessment	- motivate students -arouse students' interest, especially for those who are ignorant - arouse students' interest since the acts. are unusual in our classrooms. -students enjoy themselves doing these activities - activities are stimulating and interesting. - students' interest to research is very limited -attract students' attention	-time - suitable text or web-pages - university entrance exam - students' technical skills on ICT are well-developed -infrastructure and the Internet service breakdown. - activities are well-arranged - teachers should prepare acts. -the availability of these types of acts. -our students' prefer to be passive and they do not like to do research leading us to teach in a teacher-centred approach
Student	-visualization (42*) -better comprehension (30*) -engagement (27*) -improve thinking and reasoning (22*) -ended monotonous lessons (18*) - learn on my own (16*) -effective since activities require search (15*) -not effective for problem solving (14*) -permanent knowledge (13*) -drawing and writing conclusion (11*) -effective to solve questions that require reasoning (5*) -not easy to understand from text (1*)	- directed activities are clear and helpful (22*) -very useful approach (18*) -must be used in every lessons (17*) -group work (12*) -easy and quick to reach info. (7*) -useful for students wanted to learn (3*) -more useful after explained by teacher (3*) -gain time (3*) -may not be suitable for every topics (1*) -most useful for verbal rather than numerical lessons (1*) -more whole class discussion (1*)	-learned by enjoying (22*) -arouse interest (21*) -stimulating (9*) -motivating (8*) -develop responsibility (8*) -Arouse my curiosity (6*) -encouraging (4*) -not so interesting (3*) -Increase my self-confidence (3*) -disperse attention (1*)	- university entrance exam or more problem solving (42*) -time (9*) -not easy to abandon habits (6*) -infrastructure and the Internet service breakdown (6*)

*the number of students who emphasized this point.

them stimulating and interesting. They both also commented that students' active involvement in the classroom activities motivate them to read and write to learn the topic. Data from students' answers to the open-ended questions revealed that the participating students enjoyed doing the activities (n = 22). Half of the participating students mentioned that the reading and writing activities aroused their interest in lessons. They found the activities stimulating (n = 9), motivating (n = 8), encouraging (n = 4). The participating students commented that the activities developed

a sense of responsibility (n = 8), and aroused their curiosity (n = 6), increased their self-confidence (n = 3). Three students found the activities not so interesting, and only one student commented on the use of the internet-based text dispersed attention. Following quotes from students' answers summarized their perceptions of the impact of the reading and writing activities on their interest in physics.

> "I learned better by performing the activities, reading and writing. I enjoyed doing this and learning. This was very encouraging and increased my self-confidence." (S8.2) "This method was a creative one, and the activities were stimulating and interesting" (S18.2). "Reading and writing helped me think and draw conclusions. So, these types of applications arouse our interest since they were very interesting. What I expect from our teacher is to use these types of activities in physics lessons from now on" (S13.1).

Direct quotations from students' responses illustrated that the reading and writing activities made a great contribution to improving students' situational and personal interest through active engagement in the classroom activities, unusual or unfamiliar activities, understanding the topic and developed self-confidence.

Challenges

Both teachers declared that they are not faced with any difficulties to implement the reading and writing activities except some technical problems with the internet and software required for simulations. These infrastructure problems were solved by the ICT teacher in the first lessons in both classrooms, and then the ICT teacher explained the teachers and students how to solve these problems if occurs again. In the following lessons the problems were solved by the students, as they commented "students' technical skills on ICT are well-developed" (T1) . They both mentioned that the activities were organized in a clear way, and so they did not face any problems how to implement the reading and writing activities.

Both participating teachers commented that reading and writing activities in physics were very useful and effective, but they mentioned that "all materials must be ready to use" and "preparing these types of activities takes real time" (T2). Their main concern was about time required for the preparation of reading and writing activities in both preparation phase and implementation process. T1 also commented on quality of the read text, stating that "entering to suitable web-pages is crucial. It must be at suitable level and the language must be clear for students".

One of the most crucial findings from the study is about students and teachers' expectations from classroom activities. Both teachers made a great emphasis on conceptual and meaningful learning, commenting that reading and writing activities have a merit on fulfilling this purpose. However, both teachers commented that there is a reality in assessment system in Turkey which they cannot keep away from.

> "In our school, teaching and learning activities mainly focus on university entrance exam. So, the CD should include some activities for students' preparation for the exam" (T1). "The activities are very useful and effective at the beginning level [early years in secondary level], but for students from Anatolian high schools more problem -based tests and questions must be in place… This is because of the fact that students prepare themselves for university entrance exam, and in this exam multiple choices tests are used" (T2).

T1 indicated that reading and writing activities should be propped up by solving problems and examples related to the topic being taught as much as possible. T2, on the other hand, stressed that reading and writing activities could be very useful in the early years of secondary level, in the following years students need to prepared for the university entrance exam, requiring more and more multiple choice tests solving.

Data from students' answers to the open-ended questions revealed that the participating students were very anxious about university entrance exam. Thus, all participating students commented that they need to practise for the university entrance exam. To do so, teacher should solve more and more examples for each topic in the classroom. Five students added that they could solve problems that require reasoning. Nine students stressed that reading and writing activities take time, leaving them less time to solve more problems. Six students commented that it is not easy to abandon habits (their habits in learning style) even though they highly value the reading and writing activities regarding learning conceptually, in-depth and meaningfully. Six students complained about the infrastructure and the internet service in the school. Following quotes from students' answers summarize their perceptions about the emerging issues because of implementation of the reading and writing activities in physics:

> "It is really an effective method in the event of establishing the required infrastructure and making required changes in education system. But, I have a difficult exam which will deeply affect my future. This method is not preparing me to this exam. I learned a lot but I did not learn how to solve problems" (S8.2). "What I learned myself is more permanent. But, more questions related to impulse and momentum needs to be solved in the class-rooms (S5.1). Since we have not got used to this type of learning for 11 years, we have struggled to adapt our-selves at the beginning. Because, in the current system the teacher is in the centre. This type of student-centred

system made me like a fish just got out of water. However, as I have got used to, I realized that it is a very good approach. I want these types of activities to be used in the classroom. However, I think that it would be better if more exemplary questions were solved" (S6.1). "These types of activities should be used in other courses as well. However, more places should be given to the examples and multiple choice tests" (S15.1).

As both participating groups commenting, the big challenge is the university entrance exam. Nationwide exams dominate both teachers and students' thinking about classroom practices. What students expect from teachers is to solve as much problems as possible for university entrance exam. Data show that this expectation will not fade away until some changes in the university entrance system occur. It is clear from the data that this creates a big dilemma for physics teachers in secondary schools. Either they prepare students to the university entrance exam, which requires solving as much problems, mainly multiple choice tests, as possible, or they prepare new learning environments for their students to learn in-depth, meaningfully and conceptually. Is it possible to do both? Teachers' main concern then is to manage to cover all topics in the physics syllabus, time barrier, as the data revealed in this study.

DISCUSSIONS AND CONCLUSIONS

In this study, the researcher sought to understand how physics teachers and secondary students perceived reading and writing activities in learning physics, what kinds of issues emerged from the implementation of the reading and writing activities, and to determine students' styles or strategies to read and write to learn in physics lessons during the implementation.

Findings revealed that reading and writing activities made students active in learning process in the class-room. Students expressed their active participation using words such as, searching for information, reading, learning by struggling and on their own, performing the activities, progressing by digesting, discussing, drawing and writing conclusions. Henderson and Wellington (1998) points out that "directed reading activities make pupils focus on important parts of the text, and involve them in reflecting on its content" (p.44) . Unlike current traditional teacher-centred applications in physics lessons in Turkey, these activities promote student-sensitive classroom activities, leading to improvement in the quality of teaching and learning process. In traditional science classrooms which dominate current practice in teaching physics in secondary schools, students are just listener or passive information receiver. The data showed that the reading and writing activities promoted students active involvement in constructing their own knowledge through questioning, reprocessing, reflecting, analyzing the ideas about the impulse and momentum and drawing conclusions and communicating their own ideas with peers and the teacher. This positive impact of reading and writing activities implies that they could be used in science teaching and learning, either as a separate mode or as an integral part of other modes, such as practical work or field trips. As Roth and Duit (2003) discuss, language must not be viewed as a medium between the individual and reality or a passive representation of reality. Rather, they comment that, cited from Clancey (1997), "it must be viewed as a deep feature of the processes that guide behaviour and respond to perceptions" (p. 870). Thus, students construct their own knowledge through interactions with the text, the teacher and their peers, acquiring the concepts or new scientific terms. Their understanding and interpretation of the topic might differ, but in this study the teacher was a guide and provided feedback on students' works. This promotes a common understanding of the topic through generally teacher -led within groups or whole class discussions, and writing. The participating teachers were very positive in this respect. The pedagogic value of reading and writing activities in physics lessons lie in the fact that students ground their understanding and learning the topic in their interactions with the activities, group members, whole classroom and the teacher.

Finding revealed that teachers and students found the reading and writing activities very effective and useful to teach and learn in physics lessons. Their main focus was on in-depth, conceptual understanding and knowledge construction through meaningful learning, which the reading and writing activities would provide opportunities for. This supports findings from the literature (Baram-Tsabari and Yarden, 2005; Gunel et al., 2006; Gunel et al., 2007; Günel et al., 2009; Günel, 2009; Hand et al., 2007; Hsu and Yang, 2007; Keys, 1999b; Prain, 2006; Rivard and Straw, 2000; Rivard, 2004). The participating teachers and majority of students commented that physics topics can be understood better with the reading and writing activities comparing with traditional teaching and learning. The participants' emphasis is on better comprehension, improvement in scientific thinking and reasoning, permanent knowledge construction, scientific and correct use of language. As Brown and Ryoo (2008, p. 550) points out, "science teaching must reflect the way science learning occurs, which is both conceptual and discursive". The reading and writing activities in this study included such discursive activities as reading, discussing and writing for an audience, the teacher in this case, which both facilitate conceptual understanding and science language.

However, it is surprising that from the quantitative data students do not enjoy reading and writing in physics lesson as much as they value the reading and writing activities in learning physics. It is believed that this is because of their habits of learning, as some students and teachers commented, mainly dominated by teacher-

centered activities, and their pragmatic thinking in preparation process of university entrance exam. As Farrell (2001) puts it, conceptual understanding should be supported by an effective communicative ability unlike traditional procedural or computational knowledge which has little effect on students' communication skills. The reading and writing activities in this sense promote students' communication skills, talking and discussing about the topic, writing and reading about it. With the point raised by Grabe and Grabe (1998), the evidence for understanding a topic is hidden in being able to making discussions, talking and writing about it, using the language existed and emerged.

The findings revealed that these unusual reading and writing activities for the participating students attracted their' attention and aroused their interest - situational and personal interest. Students found the reading and writing activities stimulating and interesting, resulting in increase in situational interest. Almost half of the participating students commented that these activities ended monotonous lessons. It is worth to mention here that delivering the activities and reading materials in the internet linked CDs also made a great contribution to increase situational interest as both participating group commented. As Guthrie et al. (2006) mentioned, environmental conditions could evoke situational interest. Schraw et al. (2001) stress that "situational interest plays an important role in learning" (p.221) . For the personal or individual interest issue, from the findings it is revealed that students enjoyed doing the reading and writing activities, 23 reading and writing activities altogether throughout four weeks. All students finished the activities and majority of them stressed that these types of activities should be used in physics and other lessons even though they do not see it enough to fulfil their needs for the university entrance exam. Teachers made an emphasis on motivation side of the activities through students' active involvement in the classroom activities unlike their previous experiences in physics lessons, that is, passive listener. Students, on the other hand, made comments on enjoyment, interest in physics lessons, stimulation, motivation, encouragement, sense of responsibility, curiosity, self-confidence, which the reading and writing activities promoted. It is believed that this new learning environment (that is, various types of reading and writing activities and computerized environment, which are unusual for the students in the case) has sustained students' situational interest, leading to personal interest. This raised a question of Hawthorne effect, whether this positive attitude towards the reading and writing activities in physics is a result of novel of the method. The answer is not a simple 'yes' or 'no'. From the findings of the study, the learning environment, computerized class-room, and the learning process, active participation of the students, were novel in this case leading to increase in situational interest, which might be viewed as a result of Hawthorne effect that promote students' motivation. However, students' motivation was also promoted by the outcome of this processes; that is, meaningful and in- depth learning, as both participating groups, students and teachers, stressed on.

Any innovations in secondary education would face a barrier and so a resistance from the related parts, teachers and students in this case, unless the assessment format in university entrance exam is not changed. This study illustrated that the university entrance exam is the big challenge. What participating students expect from teachers is procedural knowledge that they need in the university entrance exam, which is defined by Wolfer and Lederman (2000) as an understanding of how concepts are applied, primarily in mathematical models, to solve problems. To do so, physics teachers need to solve as much problem as possible after a through explanation of the topic being taught, which defines the situation in physics classrooms. Thus, this present study has an implication for policy makers, which is the participating students' scream, which might be put "without any change in the university entrance exam these types of activities will not fulfil secondary students' needs". Findings, however, from the teachers' perspective, revealed that teachers have found the reading and writing activities very useful to assess students' performance-formative assessment. They can provide feedback during activity and/or after students perform each activity, leading to tracking students' performance. Doing so, teachers had the opportunity to direct, correct or guide the students to reach the purpose of each activity. In traditional physics classrooms the teacher can mainly assess students' performance on exams through several questions require procedural knowledge, and feedback almost non-exist.

During reading activities, students mainly used tactics such as writing important points, imagining scenes or drawing pictures, focusing on visual presentations, re-read, and skimming. The least used tactic is to look up words in the dictionary. During writing activities, on the other hand, students consulted the read texts for facts and information, made a plan for their writing tasks, wrote down ideas first then performed their writing tasks, after writing they revised and edited their writings. The findings also revealed that students were strongly agreed that they understood the topic after writing about it. As Koch (2001) points out, metacognition in science reading comprehension is crucial since the learners' metacognitive knowledge directs them how to learn from a read text. It is worth noting here that without any metacognitive training about reading comprehension and writing process in this study, the DARTs and other directive comments helped the students how to proceed in doing the tasks.

This study suggests more research on the teachers' and students' perceptions of reading and writing activities in physics lessons and learning processes and environment required for successful interventions, and on the

effects of those activities on the learners' communication skills. The study also shed light on students' perception of the insufficiency of the reading and writing activities used as a separate mode of teaching and learning physics, especially in cases exams (procedural or computational knowledge) dominates thinking. Thus, more research should be done about how pedagogically teachers exploit full potential of reading and writing activities regarding conceptual and meaningful under-standing, and about how these activities should be integrated into the physics syllabus together with the other forms of teaching and learning such as practical works, field trips, and modes that focus on procedural, computational understanding.

ACKNOWLEDGMENT

This study has been financially supported by the European Commission and Karadeniz Technical University through a multi-national project, 226641-CP-1-2005-1-ES-COMENIUS-C21.

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