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The Effect of Reflective Science Journal Writing on Students' Self-Regulated Learning Strategies

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The current study investigates the effectiveness of grade-ten students' reflective science journal writing on their self-regulated learning strategies. We used a pre-post control group quasi-experimental design. The sample consisted of 62 tenth-grade students (15 years old) in Oman, comprising 32 students in the experimental group and 30 students in the control group. Both groups studied a science text unit called 'Matter and Energy in Chemical Reactions'. Students in the experimental group were given a model for a journal, which they wrote after they finished their science lessons. They reflected on their dialogues with their teacher and classmates. They also reflected on their scientific observations, their main conclusions, their evaluation of their level of understanding of the scientific concepts presented in the lesson, their achievement of the lesson goals, and their personal feelings regarding what was taught in the lesson. The control group studied the same unit without writing reflective journals. We used a modified self-regulation strategy instrument to measure the effectiveness of treatment. The results showed that participants in the journal-writing group (experimental group) (M=3.96; SD=0.37) significantly outperformed participants in the control group (M=3.62; SD=0.28) with respect to their self-regulation strategies. The study recommends that reflective journal-writing should be encouraged by science teachers and in science textbooks.

Keywords: reflective journal writing, science learning, self-reflection, self-regulation strategies

INTRODUCTION

To learn science in a constructive way, science learners should be reflective, approach learning meaningfully, connect what they learn to previous experience, monitor their level of understanding of newly introduced concepts, and be able to express their feelings about what is being taught (Gunstone & Mitchell, 1998; Mintzes & Wandersee, 1998). However, studies have indicated that students approach the learning of science passively when they rely solely on absorbing

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scientific information and storing it in the memory (Neber, He, Liu, & Schofield, 2008) without sufficient reflection on what has been learned. Therefore, active learning strategies have been suggested by researchers as a way of overcoming the passive learning phenomenon and getting students' minds more involved in the learning process (Desta, Chalchisa, Mulat, Berihun, & Tesera, 2009; Dori & Belcher, 2005). When students are engaged in active learning activities, they are expected to take responsibility for their learning by making decisions regarding their self-learning strategies (Akinoglu & Tandogan, 2007).

Making observations, hands-on activities, dialogue with others, and self-reflection through journal writing are examples of active learning strategies (Fink, 1999). Observations might take different forms such as observing a demonstration by the science teacher, making observations when conducting a science experiment, watching a film on science activities, or observing a phenomenon as it happens in nature. Hands-on activities include all forms of activities that students conduct such as role playing, simulation, science experiments, field trips, or designing concepts or mind maps. Dialogue with others might be done through debating socio-scientific issues, brainstorming ideas to solve problems, discussing alternative designs for an experiment, and considering the best explanations for the results. Self-reflection through journal writing allows students to think back on the activities during the lesson, reveal their judgments and feelings with respect to these activities, suggest alternative methods for conducting these activities, and note down questions for further exploration.

The current study explores the effectiveness of reflective journal writing on students' self-regulation strategies. Self-regulated learning refers to being metacognitively, motivationally, and behaviorally active in the learning process (Chen, 2002; Corrigan & Taylor, 2004; Zimmerman, 1990). This study contributes to the literature on science education in Oman as the first study to investigate the self-regulation strategies for school science students. It is also one of few studies internationally in science education that study reflective journal writing in science classrooms and its impact on self-regulation strategies. Thus, the current study helps us as researchers to understand the role of students' structured reflections on the regulation of their learning.

Reflective journal writing

Studies indicate that journal writing engages students' thinking through different cognitive processes such as prediction, brainstorming, reflection, and questioning. It encourages students to express their interests, thinking and curiosity about the world around them, and discover new ideas. This in turn contributes to the enhancement of their understanding of scientific concepts (Fingon & Fingon, 2008; Glynn & Muth, 1994; Hand & Prain, 2002; Hand, Prain, Lawrence, & Yore, 1999; Keys, 2000; Towndrow, Ling, & Venthan, 2008). Journal writing facilitates the integration between prior and new knowledge, and assesses learners' understanding (Glynn & Muth, 1994; Hand, et al., 1999). It also encourages learners to be involved in cognitive processing, which facilitates the interaction between data (the content space) and reasoning (the discourse space). This mental interaction results in, for some students, the generation of new knowledge from the writing practice (Keys, 2000). It also helps them to mentally organize their thoughts by building organizational relations necessary for constructing meaningful learning (Glynn & Muth, 1994). When journal writing is associated with an inquiry-based approach to learning, it helps improve the quantity and quality of students' questions, which is the first essential step in inquiry-based learning. The students start writing about their manipulations, observations and results; they fill in knowledge and skills gaps and advance their interpretations. Journal writing also

develops students' persuasion and argumentation skills, and enhances the communication between teachers and students (Glynn & Muth, 1994; Hand & Prain, 2002; Hand, et al., 1999; Towndrow, et al., 2008). They become more aware of their vocabulary deficiencies, develop their invention skills and feel comfortable expressing their feelings and emotional reactions to real-world phenomena (Glynn & Muth, 1994; Myers, 2001).

However, past studies have indicated that writing does not produce desirable learning effects in school contexts (Hand & Prain, 2002) unless it is associated with metacognitive prompts such as asking students to reflect on their knowledge, learning processes, and comprehension difficulties (Nückles, Hübner, & Renkl, 2009). In this regard, journal writing might be directed at reporting on self-regulated strategies such as cognitive learning strategies, metacognitive or self-regulatory strategies to control cognition, and resource management strategies. If this is done, journal writing significantly enhances learners' intrinsic motivation, task value, metacognition, and time management (Arsal, 2010). Also, in order to benefit from journal writing, it should be about authentic experiences and involve an authentic audience (Glynn & Muth, 1994). Students need to keep record of the activities and conversation during the lesson, and pay attention to the accuracy of what they are writing (Hand, et al., 1999). On the other hand, there are some challenges which face science teachers when using journal writing. The main challenges are planning, setup and assessment (Hand & Prain, 2002). Thus, science teachers need to design the journal writing activities in a manner that promotes desirable outcomes (Hand, et al., 1999).

Self-regulated learning

Self-regulated learners monitor their understanding to diagnose and overcome possible comprehension obstacles (Chen, 2002; Eliam & Aharon, 2003; Nückles, et al., 2009). They monitor their progress toward the achievement of pre-determined goals, are able to judge whether they achieve these goals, and can maintain motivation regardless some learning difficulties (Eliam & Aharon, 2003). Literature links self-regulated learning to achieving success (Chen, 2002; Zimmerman, 1990). This is explained in part by self-regulated learners' involvement in planning, setting goals, organizing, self-monitoring, and self-evaluation at different times during the learning process (Zimmerman, 1990). It is also explained by their sense of self-efficacy, self-attributions, and motivational processes (Zimmerman, 1995). However, this is not always the case. For instance, in one study a self-regulated environment did not help to improve the conceptual understanding of pre-service primary teachers of science and technology (Corrigan & Taylor, 2004).

There is no doubt that the above mentioned self-regulated processes are types of active leaning strategies (Desta, et al., 2009). Reflective journal writing shares some of these processes such as self-evaluation, monitoring of self-efficacy, self-reflection on classroom activities, and judgments and feelings about these activities. In the current study, the reflective writing model encourages students to produce internal feedback on their learning process. The students' interaction with the content and their dialogue with others facilitate the making of connections with what has already been learned and the eventual internalizing of meaning. This internal feedback is believed to help them "monitor their engagement with learning activities and tasks, and assess progress towards goals" (Nicol & Macfarlane-Dick, 2006, p. 200). Also, self-regulation is considered to have cognitive and affective components where self-regulation is interrelated with both domains. One of the affective aspects is the expression of a desire to learn (İnan & Yüksel, 2010). Reflective journal writing, as used in the current study, touches on an affective aspect of learning by allowing students to reflect on their feelings about the scientific concepts they learn.

In traditional settings, students receive scientific concepts and are not provided with the opportunity to think about their feelings towards them. Previous research indicates that journal writing allows students to express their feelings comfortably (Myers, 2001). In addition, writing encourages students to self-regulate their understanding of the subject matter (Nückles, et al., 2009). In conclusion, the literature suggests that both reflective journal writing and self-regulative strategies involve active learning, and that reflective journal writing might be directed to enhance self-regulated learning (Arsal, 2010; Keys, 2000).

In addition, journal writing serves as a formative assessment. It helps teachers to monitor the development of their students' understanding of different topics within the subject and how they make connections among these topics (Towndrow, et al., 2008). Journal writing provides teachers with evidence and feedback regarding their teaching (Fingon & Fington, 2008). They might also discover some of their students' misconceptions when reading these journals.

The current study investigates whether involving students in reflective journal writing after their science lessons affects their self-regulative strategies. The interaction between reflective journal writing and self-regulative strategies, to the knowledge of the authors, has not been fully explored in science education literature at the school level. Although Arsal's (2010) study explored the effect of diaries on self-regulation strategies, his participants' diaries were geared towards reporting on the self-regulation strategies that they used for their daily learning activities. The current study differs from this in that the journal writing participants were asked to write structured reflective journals about what happened during classroom activities, which included the components shown in Table 1. The research bases for each of these components are illustrated in the same table. The journal writing model used in this study is presented in Figure 1.

Table 1. Research basis for the components included in students' reflective journals

Reflective journal element	Research basis
1. The goals which they need to achieve by the end of each lesson.	– Learners need to monitor their progress towards the achievement of pre-determined goals (Eliam & Aharon, 2003). – Literature links self-regulated learning to achieving success (e.g. through planning and setting goals) (Chen, 2002; Zimmerman, 1990). – Learners should monitor their progress towards their *learning goals* (Nicol & Macfarlane-Dick, 2006).
2. Their dialogues with the self, the teacher, and their classmates.	– Dialogues with the self, the teacher, and their classmates are an active learning strategy (Fink, 1999). – Learners should monitor their engagement with *learning activities and tasks* (Nicol & Macfarlane-Dick, 2006). – Dialogues with the self, the teacher, and their classmates are part of the *discourse space* that the journal writing provides. The interaction between this discourse space and the content space involves learners in cognitive processing, which results in the generation of new knowledge through the writing practice (Keys, 2000).
3. Their scientific observations.	– Making observations is an active learning strategy (Fink, 1999). – Learners should monitor *learning activities and tasks* (Nicol & Macfarlane-Dick, 2006).

4. Their main conclusions.	– Learners should monitor their understanding to diagnose and overcome possible comprehension obstacles. – They should monitor their progress toward the achievement of pre-determined goals (Chen, 2002; Eliam & Aharon, 2003; Nückles, et al., 2009). – Making conclusions is part of the *content space* that the journal writing provides. The interaction between this content space and the discourse space involves learners in cognitive processing, which results in the generation of new knowledge though the writing practice (Keys, 2000). – This content space provides teachers with evidence and feedback regarding their teaching (Fingon & Fingon, 2008).
5. Their assessment of the level of their understanding of the scientific concepts in the lesson.	– Asking students to assess the level of their understanding is a type of metacognitive prompting. For writing to produce desirable learning effects in school settings, it should be enhanced with metacognitive prompts such as asking students to reflect on their knowledge, learning processes, and comprehension difficulties (Arsal, 2010; Nückles, Hübner, & Renkl, 2009). – Self-regulated learners are metacognitively, motivationally, and behaviorally active in the learning process (Chen, 2002; Corrigan & Taylor, 2004; Zimmerman, 1990). – Self-regulated learning is linked to achieving success (Chen, 2002; Zimmerman, 1990). – Self-regulated learners engage in organizing, self-monitoring, and *self-evaluation* at different times during the learning process (Zimmerman, 1990). – Writing should encourage learners to self-regulate their understanding of the subject matter (Nückles, et al., 2009). – Learners should *assess* their progress towards goals (Nicol & Macfarlane-Dick, 2006, p. 200).
6. Their personal feelings about what was taught.	– Self-regulation learning should consider both cognitive and affective domains. The expression of a desire to learn is an example of the affective aspects (İnan & Yüksel, 2010). – Writing helps students express their feelings and emotional reactions to real-world phenomena (Glynn & Muth, 1994; Myers, 2001).

Purpose and design

The purpose of the study was to explore the effect of tenth grade science students' journal writing on their self-regulation strategies. More specifically, the guiding question for the study was:

Is there any significant difference between tenth graders who write reflective science journals and their counterparts who do not, in terms of their self-regulation strategies as measured by the Motivated Strategies for Learning Questionnaire (MSLQ) instrument?

METHOD

The design of the study is a pre-post quasi-experimental design. Both groups studied a science text unit called "Matter and Energy in Chemical Reactions." Students in the experimental group were instructed to write journals for each lesson. The journal writing format is illustrated in Figure 1. Both groups were taught by the same teacher (the second author) who had seven years of science teaching. The study lasted for eight weeks and there were seven lessons per week. This number of lessons per week is the normal number of

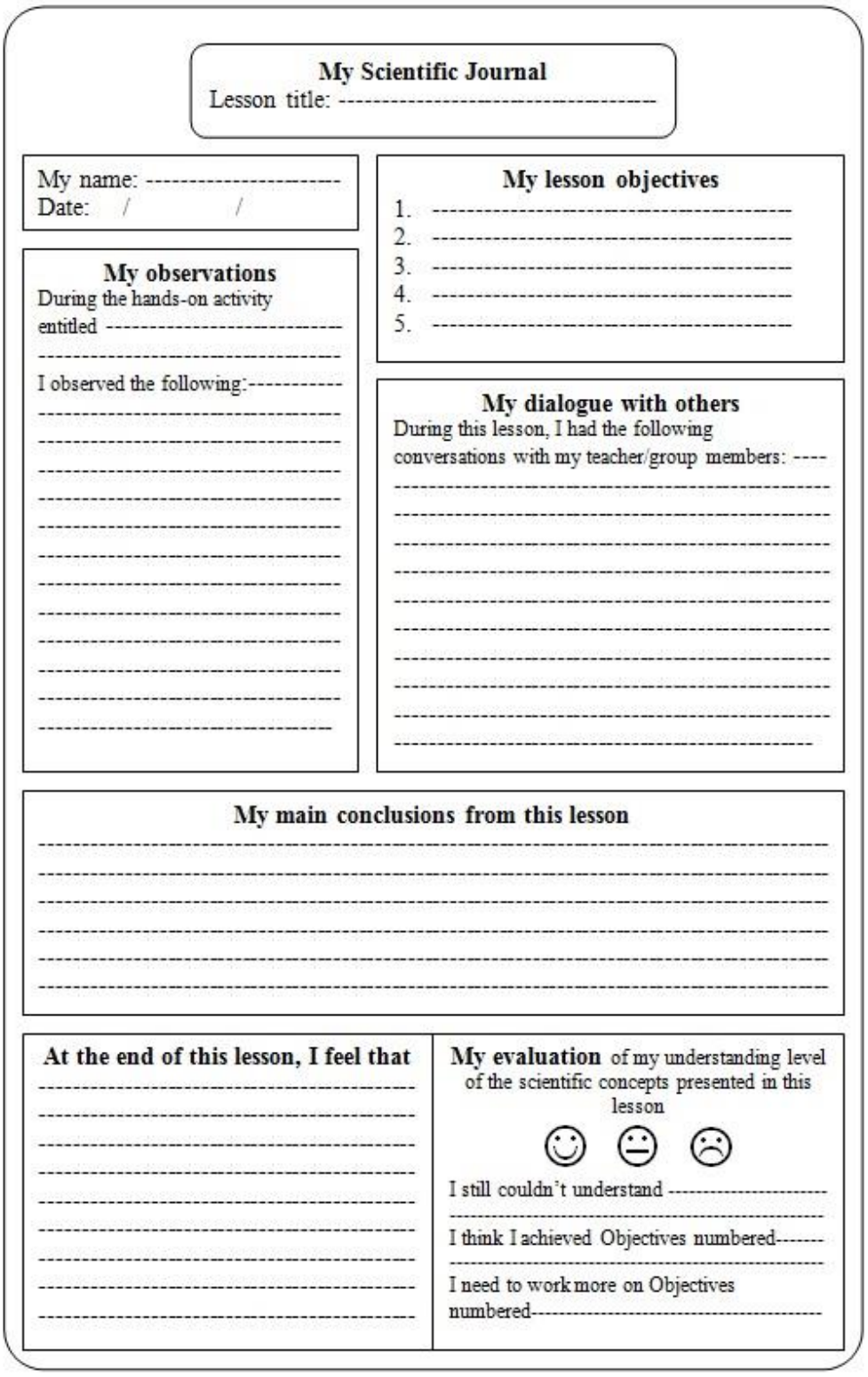

Figure 1. The reflective journal writing model

lessons devoted to science subject matter in grade ten in Omani schools. Students were given time during each lesson to start writing their journals, and then had to complete them at home. The teacher collected students' journals at the beginning of the following lesson, commented on the journals, then returned them to the students. Meanwhile, the control group studied science content in the same way as

the experimental group, except that the students did not have to write journals or express their feelings in a systematic manner.

Participants

The study was conducted on two tenth grade classes (15 years old) in a public female school in the Ad Dakhiliyah region in Oman. The two classes were assigned randomly into a control group of 30 students and an experimental group of 32 students. The total number of participants was 62. The education system in Oman is composed of three main phases: Cycle I (grades 1–4), Cycle II (grades 5–10) and Secondary Education (grades 11 and 12). Cycles I and II comprise what is called Basic Education. Cycle I schools are co-gendered; however, the teachers and administration staff are all females. Cycle II and Secondary Education schools are single-gendered schools taught by same-gender teachers. The current study was conducted in a Cycle II female school. Participants came from middle socio-economic families. Based on their previous semester achievement scores, their achievement level was middle to high. The researchers obtained the legal approval and permission to conduct the study from the Technical Office at the Ministry of Education.

The instrument

To assess participants' self-regulation strategies, the study used some items from an instrument called the Motivated Strategies for Learning Questionnaire (MSLQ). This instrument is composed of two main subscales: motivation and learning strategies. The main reason for choosing this instrument is that it has been widely used for assessing students' self-regulation strategies (Chen, 2002; Pintrich, Smith, Garcia, & McKeachie, 1993). Another reason is that this instrument has been translated into Arabic by other researchers (e.g. Al-Battashi, 2004) and has been administered to Arab participants for some time. Thus, the validity of its English-to-Arabic translation has been established by these researchers. Also, Al-Battashi standardized the MSQL to the Omani context. She piloted the instrument on an Omani sample and conducted a factor analysis. She reported that the results were satisfactory. To judge its suitability for the study and for its participants, the instrument was evaluated by a panel of six psychology and science education professors teaching at higher education institutions in Oman. The major concern of the panel was that the instrument is lengthy, so tenth graders might not complete it properly. The referees justified that, from their own experience as researchers, surveys given to students in grade ten and below were not completely filled in. Thus, they suggested that the MSLQ should be shortened. As a result, the final version of the instrument used in the current study consisted of 51 items; however, the original instrument consists of 81 items. Another reason for shortening the MSLQ was that referees did not feel that the "managing resources" subscale was directly related to the current study. Therefore, they suggested eliminating it.

A five-point Likert scale was used. The 51-item instrument was piloted on 30 tenth grade female students. The aim of the piloting process was to clarify any linguistic ambiguities, estimate the administration time, and evaluate the reliability of the instrument. The piloting process resulted in the rephrasing of some items. The estimated time was 40 minutes and Cronbach's alpha reliability coefficient was 0.88.

Data collection and analysis

The MSLQ was administered as both a pre- and a post-measure. Data were analyzed using analysis of covariance (ANCOVA). The score from the pre-

administration of MSLQ was used as a covariant. Also, the assumptions for ANCOVA were tested and found satisfactory. In addition, sample copies of students' reflections, which were recorded on their reflection sheets, were collected with the teacher's comments on them. Students' reflections and the teacher's comments were used to support the discussion of the quantitative results.

RESULTS AND DISCUSSION

The self-regulation strategies instrument was administered before and after the completion of the study. Table 2 illustrates the means and standard deviations for the administration of the instrument to both groups. Analysis of covariate (ANCOVA) was used to determine the effects on students' self-regulation strategies when the pre-test result used as a covariate. This allowed for controlling of the differences in the pre-test scores between the groups of the study, as shown in Table 2. Table 3 shows these results, and they indicate that there was a significant difference between the experimental and control groups in terms of participants' self-regulation strategies in both scales (i.e. motivation and learning strategies) and in the overall score. Participants in the journal-writing group (experimental group) significantly outperformed participants in the control group.

Table 2. Means and standard deviation (SD) of pre-post administrations of the self-regulation instrument

Sub-scale	Group	n	Pre-administration		Post-administration	
			Mean	SD	Mean	SD
Motivation	Control	30	3.90	0.27	4.08	0.25
	Experimental	32	4.05	0.36	4.32	0.31
Learning strategies	Control	30	3.05	0.50	3.27	0.39
	Experimental	32	3.36	0.47	3.70	0.52
Overall score	Control	30	3.47	0.35	3.62	0.28
	Experimental	32	3.72	0.39	3.96	0.37

Table 2. Summary of ANCOVA comparing the means of the post-administration of the self-regulation instrument in the control and experimental groups

Sub-scale	Source	df	Mean	F	P
Motivation	Method of Instruction	1	0.42	6.90	0.01*
	Pre-administration	1	1.23	20.34	0.001**
	Error	59	0.07		
Learning strategies	Method of Instruction	1	1.02	6.35	0.02*
	Pre-administration	1	3.33	20.79	0.001**
	Error	59	0.16		
Overall score	Method of Instruction	1	0.61	8.65	0.005**
	Pre-administration	1	2.36	33.33	0.001**
	Error	59	0.07		

**significant at P < 0.05 ** significant at P < 0.01*

The journal writing activity in the experimental group had different advantages, which may have helped to enhance the participants' self-regulation strategies. The model used in the current study for journal writing encourages students to report on the hands-on activities in their science lessons. Hands-on activities are believed to enhance students' self-regulation strategies such as enthusiasm, confidence, and positive attitudes (Corrigan & Taylor, 2004). Throughout the course of the study, we observed that during the inquiry, when it came to hands-on activities, students were eager to do the experiments, work with the equipment and materials, look for evidence of the occurrence of chemical reactions, and find answers to the inquiry question or their own exploratory questions. For instance, a high level of excitement was observed during an experiment of an endothermic reaction between ammonium thiocyanate (NH4SCN) and sodium chloride (NaCl). A collective surprised smile was on their faces when they felt the coldness of the beaker in which the reaction took place. They were fascinated. Students were also excited to know how some real-world reactions took place, such as when a drop of bleach reacted with a piece of cloth. Here is an example of a student's reflection on her feelings regarding what she had learnt:

> I liked the discovery titled "Is it exothermic or endothermic reaction?" I wanted to complete it because I felt that I was curious to know the results of this experiment.

The participants in the current study were encouraged to express their feelings about what had been studied and discussed during the lesson. Expression of feelings is part of the affective domain which is believed to be one important component of the self-regulation of learning (İnan & Yüksel, 2010). On the other hand, students in the traditional settings are encouraged to ignore their personal feelings while studying (Eliam & Aharon, 2003). One student from the experimental group stated in her journal as follows:

> I feel that this lesson could help me understand the difference between different types of reactions. I think I would need this information when I study chemistry in grade 12 and college later on.

The journal writing model used in the current study promotes self-reflection, an important element of self-regulated learning (Corrigan & Taylor, 2004). The participants had the opportunity to reflect on their level of understanding, their feelings, and the dialogue they had with the teachers and their classmates. This active learning process helps to involve students more in the learning process (Desta, et al., 2009; Dori & Belcher, 2005). A student from the active learning group described her excitement and involvement during the learning process, when she was moving from one station to another to find answers to the questions in the worksheet:

> I really liked this station activity. We were going from one station to another to answer the questions in the worksheet. I was eager to reach the next station because I wondered what it had.

The dialogue with the self in the journal writing model of the current study is a metacognitive process by which students think about what cognitive benefits they obtained from studying the scientific concepts in the lesson, what questions they should ask to satisfy their curiosity, and what cognitive difficulties they encountered during the lesson. The literature indicates that, when compared with traditional writing practices, writing activities that include metacognitive prompts which require students to reflect on their knowledge, report their comprehension difficulties, and describe their learning processes, have a significantly greater impact on learning (Nückles, et al., 2009). One participant in the current study expressed her feelings regarding the dialogue with self:

> This part of the reflection journal helped me not only in gaining information but also to understand, deal with and interact with myself.

> This led me to ask new questions and encouraged me to find answers to them.

Consequently, students became increasingly able to reflect on their understanding of the scientific concepts and determine the difficulties they were facing. Here are some examples of reflections that students wrote in their journals:

> When it comes to decide on the type of chemical bonding, I'm stuck! I need more practice.
>
> I feel that to determine which reaction is exothermic and which one is endothermic is difficult to understand. I don't understand how they do that.
>
> I can easily decide where some of the elements are located in the periodic table, but I couldn't decide which is more reactive than the other.
>
> I face difficulty distinguishing between two types of reactions: single displacement or double displacement.

The teacher used these reflections to address the difficulties that students face. Some of the teacher's interventions took place during the next lesson, while others were during the review session at the end of the unit.

The reflection process within journal writing in the current study is geared partly towards monitoring and evaluating the understanding of the subject matter. Monitoring the effectiveness of their learning strategies is an important self-learning mechanism that leads students to adjust the use of a learning strategy (Zimmerman, 1990). It also helps them judge whether they are achieving the learning goals (Eliam & Aharon, 2003). Additionally, this process of self-monitoring and the evaluation of understanding and learning is a metacognitive process which facilitates the self-regulation of cognition (Arsal, 2010). Eventually this metacognition improves their understanding of the subject matter (Arsal, 2010; Nückles, et al., 2009). The above examples of students' reflections show how students reflected on their comprehension of the subject matter.

The reflective writing model used in the current study generates internal feedback which students use to monitor their progress during the learning process towards the achievement of the lesson goals. This generation of internal feedback is a kind of formative assessment that helps assess performance to develop and accelerate learning (Nicol & Macfarlane-Dick, 2006).

The teacher's feedback plays an important role in this study. Students in the experimental group received regular feedback on their journals. When a student reported a negative feeling about a concept, the teacher encouraged her to consider this concept differently, for example, how studying it might help her understanding of a related real-life phenomenon; or, if a student reported a poor understanding of a concept, the teacher would suggest a learning strategy to try with that particular concept. Following are some examples of students' reflections and the teacher's feedback to them:

> Student's reflection: Studying the periodic table is difficult. I don't know what benefit we could get from it.
>
> Teacher's feedback: Studying the periodic table will help you understand how the elements behave in nature, and their properties. More examples will be discussed during the upcoming lessons.
>
> Student's reflection: Today I couldn't name the compounds which were presented by the teacher. I don't know which element to start with.
>
> Teacher's feedback: When you name the compounds in Arabic, always start with the second element.
>
> Student's reflection: I face difficulty distinguishing between two types of reactions: single displacement or double displacement.

> Teacher's feedback: Single displacement reaction is when an active element reacts with a compound, whereas double displacement reaction occurs when two compounds exchange their ions and form new compounds.

On the other hand, the teacher also praised any innovative ideas that appeared in students' journals. If an interesting learning strategy was revealed in a journal, she would mention that in the classroom and encourage students to make use of that strategy in their learning about the subject. Examples of students' learning strategies:

> I can tell what type of bond from the types of elements involved. If the compound has a metal and a non-metal, then the bond is ionic.
>
> It is easy for me to determine if the reaction is a decomposition reaction. It is when the reaction starts with one compound and ends up with two elements.
>
> When two elements react together to produce one compound, I can tell that this is a synthesis reaction.

CONCLUSIONS AND IMPLICATIONS

The current study investigates the effect of journal writing on tenth grade students' strategies for self-regulation. The results show that the experimental group significantly outperformed the control group. This result leads to the conclusion that journal writing can improve self-regulation strategies if it is structured around self-reflections in terms of learning goals, learning strategies, observations, understanding, feeling, and dialogues with oneself and others. Since both the experimental and control groups used the same textbook materials and were engaged in similar experimentation and observation activities, the authors believe that the main contributor to the experimental group participants' significant outperformance in the self-regulation strategies instrument is their journal writing activities, as well as the teacher's reflections on their journal entries for each lesson. Together with active learning strategies, journal writing should be encouraged by science teachers. Also, science textbooks could benefit from making use of the model presented in Figure 1 to encourage students' writing and reflection.

Nowadays, science teachers could take advantage of different smartphone applications to encourage students to write in their science journals. Note-taking applications such as Endnote and OneNote make journal writing in science lessons more interactive. These applications allow students to augment their writing with photos and videos. Moreover, they could design sketches in one of the painting and drawing applications and then mount it to their notes in the note-taking application. Students could share their notes with their teacher, who could then comment on them. Students could see their teacher's comments instantly, which allows for an efficient feedback approach.

The journal writing used in the current study is a type of structured writing in which students fill in spaces in response to pre-determined questions. This is a limitation of the current study. Further research might explore the effect of open or free writing in which students are encouraged to extend their writing both quantitatively and qualitatively. This would allow them to reflect on further aspects of their science lesson, extend their personal expression, and enrich their writing skills. It would be legitimate to explore the effect of this extended version of journal writing on students' self-regulation strategies.

Another limitation of the current study was the novelty effect. Students in the experimental group spent extra time doing something different or new (Ayyıldız & Tarhan, 2013; Kırık & Boz, 2012). This was not the case in the control group. To control for this novelty effect in a future study, a second experimental group might

be created. Students in this group might be given extra time to do something new in the form of writing: e.g. writing a story that summarises each lesson in a very open and general format without their being asked to reflect, express their feelings or evaluate their progress.

In addition, another effect might have undermined the generalisability of the results of the current study. That is the expectancy effect. Literature provides evidence that effective external feedback promotes learning (Nicol & Macfarlane-Dick, 2006). In the current study, students in the experimental group received regular feedback from their teacher, which did not happen in the control group. Since the teacher in the control group was giving regular feedback to students on their home assignments, however, we believe that this expectancy effect was already controlled for in the current study. Also, the current study considers teacher's feedback as an essential pillar for successful reflective journal-writing. Nevertheless, this expectancy effect might be controlled for in future study by asking the teacher to give regular feedback to students on their writing assignments. One more limitation, which might undermine the generalizability of the results of the current study, is the relatively small sample size of the study. Increasing sample size and also repeating the study in other cultures and contexts would allow for a more generalizable conclusion to be drawn.

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