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Middle School Students' Perceptions of the Instructional Value of Analogies, Summaries and Answering Questions in Life Science

The authors investigated students' perceptions of the effectiveness and utility of generating analogies, summaries, and answering questions in a middle school science classroom and elucidated their intentions to use these strategies in science classrooms and in other subject areas

Introduction

Advances in developmental psychology and cognitive research have revolutionized the way educators think about teaching and learning science. Presently, science educators realize that students' brains are not empty vessels waiting to be filled with knowledge transmitted by the teacher. Rather, they believe that most people learn best through personal experience and by relating new information to what they already know. They also understand that learners need to construct their own scientific knowledge by actively taking control of their own learning. Specifically, learners have to be able to identify and analyze problems, explore and test solutions in a variety of in- and out-of-school situations, conduct their own investigations, analyze and communicate their findings, and reflect on their learning. This requires that students develop a strong conceptual base and essential problem solving and critical thinking skills that they can apply in a variety of situations. In short, students should be able to use their prior knowledge to answer new questions, solve new problems, and relate what they have learned to everyday life; that is, they need to experience meaningful learning (Mayer, 2002). For years, however, evidence has been mounting that indicates teachers' stress on the acquisition of factual information and tests are direct assessments of memory tasks and performance skills with little emphasis on meaning or sense making (Van den Akker, 1998).

Meaningful learning, described by Ausubel (1968) as the establishment of non-arbitrary relations among concepts in the learner's mind, is the fundamental process that underlies the acquisition of useful information and the construction of new knowledge (Novak, 1998). By creating meaningful relations, learners are able to organize the information in bigger and more organized chunks of information; an organization that reduces memory overload and increases processing capacity, ultimately improving the ability to remember information and solve problems (BouJaoude, 1992). There are many strategies that can be used to help students achieve meaningful learning; three of these strategies, called generative learning strategies, are analogies, summaries, and answering questions.

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Analogies provide a bridge between what is known and what is less known, facilitate conceptual change (Dagher, 1995), assist in conceptual change learning, facilitate understanding of abstract notions, provide visualization of the abstract, provoke students' interest, and may reveal misconceptions in areas already taught (Duit, 1991). Finally, Lawson (1993) suggests that analogies

enhance concept acquisition and the development of scientific reasoning skills. Similarly, summarization has been found to enhance comprehension and recall of passage content (Wittrock & Alesandrini, 1990) and to contribute to comprehension of both content and text organization in second language learning (Kamhi-Stein, 1993). According to Vacca (1981), "questions are the tools of our trade" (p. 159). Oral and written questions stimulate thinking, improve retention of content material (Chin & Chia, 2004), and improve students' achievement (Woloshyn, Paivio, & Pressley, 1994). Engaging students in answering or generating thought-provoking questions helps them gain the knowledge and skills necessary for managing their learning (Chin, Brown, & Bruce, 2002), become more successful problem solvers, construct explanations that mediate meaningful learning (King & Rosenshine, 1993), describe and relate what they are learning to existing knowledge, and change their alternative conceptions (Roth, 1991).

In summary, generative learning strategies improve the cognitive and non-cognitive outcomes of schooling at all educational levels (Wong, 1993). Moreover, research has demonstrated that students can generate analogies (BouJaoude & Tamim, 2000). Consequently, understanding students' perceptions of the instructional value of generating analogies and summaries and answering questions, as well as their intention to use them in the classroom, are important to investigate because of the assumed link between intention and behavior (Crawley & Coe, 1990).

Educators who understand students' perceptions of teaching strategies and their readiness to use these strategies can adapt their teaching to take into account these perceptions and intentions. However, currently, there is very limited research that addresses students' perceptions and intentions, especially for students at the middle school level. Consequently, the purpose of this study was to investigate students' perceptions of the effectiveness and utility of generating analogies, summaries, and answering questions in a middle school science classroom and to elucidate their intentions to use these strategies in science classrooms and in other subject areas.

Method

Sample

The sample consisted of 51 seventh grade students (25 males and 26 females) in a private school in Beirut, Lebanon in which English is the language of instruction. The average age of the students was twelve years. Two sections of the Grade 7 class participated in the study. Both sections had the same science teacher and followed a science curriculum that included life and physical science topics.

Tasks, Materials, and Procedures

The study included three phases. During each phase, the students were divided into three groups; each group was assigned a different strategy (generation of analogies or summaries and answering questions) in such a manner that the three groups had the chance to work with the three strategies by the end of the study.

The title of the science unit during which the study took place was "Interactions of Living Things." This unit consisted of three sections: a) interactions within the environment, (b) niches and adaptations, and (c) changes and balance in the food web. All students participated in training sessions on the generation of analogies and summaries. Following the training sessions, the science teacher taught the unit using her usual teaching methods.

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At the end of each class period, students took approximately ten minutes to provide their analogies and summaries or to answer questions on the materials covered in the class period. At the end of the study, students completed the Perceptions Questionnaire, which consisted of five open-ended questions designed to investigate students' perceptions of the effectiveness and utility of analogies, summaries, and answering questions and their intentions to use them in science or in other subject areas. The questions were selected to represent students' beliefs and affective inclinations while determining the reasons for these beliefs or inclinations (feel, like … and why) and behavioral intentions (which of the strategies would you use … and why). These statements are based on the view that attitude has three components: beliefs, behavioral intentions, and affect (Fishbein & Ajzen, 1975), and behavioral intention is the factor that best predicts a person's behavior (Crawley & Coe, 1990).

This prediction is premised on the assumption that there is consistency between the level of specificity of the behavioral intention and the behavior (Crawley & Coe, 1990), which is the case in this study, since the behavioral intention is directed toward the use of the learning strategies in science and other subject areas. The five questions included in the Perceptions Questionnaire were:

1. Which one of the learning strategies did you like most? (Generating analogies, generating summaries, or answering questions), and why?
2. Do you feel that any of the strategies helped you understand the science lessons more? If yes, which one and why? If no, why not?
3. Which of the strategies would you use if the teacher did not ask you to? Why?
4. Do you feel that the three strategies can be used with subjects other than science? If yes, which strategy, with which subject and why? If no, why not?
5. Would you like to learn other similar strategies? Why?

Data Analysis

Responses were analyzed using an inductive qualitative process of review, coding, and identification of themes (Bogdan & Biklen, 1992). Each question was analyzed separately to identify categories of responses. Following this analysis, percentages of each category were calculated. Then, categories of reasons for students' responses were read several times to develop a coding scheme that was applied to all reasons provided by the students. This coding scheme consisted of two categories: functional and amusing.

Results

Results of analyzing students' responses to each of the questions on the Perceptions Questionnaire are presented below in the order they appeared on the Questionnaire.

Students' Preferences of Strategies

Results of analyzing students' responses to Question 1 are presented in Table 1, which shows that students liked answering questions the most, followed by generating analogies, and generating summaries. However, adding the percentages of students who liked answering questions and those who liked questions and other strategies resulted in approximately (53%) of the students. In addition, adding the percentages of students who said they liked analogies and those who liked analogies and other strategies resulted in (43%) of the students.

Table 1. Percentages of Students' Preferences of Strategies.

Analogies	Summaries	Answering Questions	Analogies & Questions	Summaries & Questions	Summaries & Analogies	All strategies
33.3%	11.8%	41.2%	5.9%	3.9%	2.0%	2.0%

Reasons for Students' Preferences of Strategies

Generation of analogies. The most common reason for preferring the generation of analogies was that they were interesting (6 students out of 17; 35.3%). This was followed by the fact that they helped students study by comparing different domains (4 students out of 17; 23.5), they were easy (4 students out of 17; 23.5%), they were new and interesting (2 students out of 17; 11.8%), and they made studying easy (2 students out of 17; 11.8%).

Generation of summaries. The most common reason for choosing the generation of summaries was that they included the main idea and important concepts (3 students out of 6; 50%) followed by the fact that they helped in studying and understanding (2 students out of 6; 33.3%), and aided in organizing information.

Answering questions. The most common reason for choosing answering questions was that this strategy was easy to use (15 students out of 20; 75%), not time consuming (8 students out of 21; 38.1%), and helped students to practice and select what was important to study (3 students out of 21; 14.3%).

Students' reasons for their preferences can be divided into two categories: functional and amusing. Students liked answering questions and generating summaries because they fulfilled their functions: they helped students focus on main ideas, understand science concepts, and check their understanding. Moreover, students considered these strategies easy to master and time efficient. Analogies, on the other hand, were

1. A Number of students provided more than one reason for liking a given strategy, thus the sum of the percentages for the reasons could be more than 100.

Table 2. Percentages of Students' Perceptions of the Most Helpful Strategies.

Analogies	Summaries	Answering questions	Summaries & questions	All three strategies	None
5.9%	39.2%	21.6%	3.9%	3.9%	23.5%

preferred because they were amusing (fun, interesting) but functional.

Strategies as Support for Understanding Science Lessons

Results analyzing students' responses to Question 2 are presented in Table 2, which shows that most students (76.5%) thought that all strategies were helpful.

Reasons for Students' Preferences

All students who chose generation of analogies as the most helpful said that they helped them to understand and memorize by relating different ideas (3 students out of 3; 100%). Students who thought generating summaries was the most helpful, however, had different reasons for their responses. The most common reason was that summaries included the main ideas of a lesson or paragraph (13 students out of 20; 65.0%). This was followed by the fact that they helped students to understand the entire lesson (4 students out of 20; 25.0%), were easy to write, and helped students check their understanding (1 student out of 20; 5.0%). Furthermore, the most common reason for choosing the answering questions strategy was that questions helped students to remember and check understanding before the exam (5 students out of 11; 45.5%), get good grades, and were easy and enjoyable. Finally, the reason for choosing a combination of strategies was that they helped in studying and understanding science content, helped in ignoring the unimportant ideas and relating ideas.

In summary, students considered generating summaries most helpful to understand science lessons, followed by answering questions, then generating analogies. Conversely, almost one-quarter of the students thought that none of the strategies were helpful. All students who said that the strategies were helpful used the functional argument to suggest that using these strategies helped them to understand and memorize science content, check their understanding, and focus on the main ideas. Those who said that none of the strategies were helpful suggested that they were not efficient for studying and getting high grades on tests.

Table 3. Percentages of Students' Preference of the Strategy to be used Without Teacher's Advice.

Analogies	Summaries	Answering Questions	Analogies & Questions	Summaries & Questions	Summaries & Analogies	All three Strategies	None
17.6%	27.4%	33.3%	2.0%	5.9%	5.9%	2.0%	3.9%

Using the Strategies without Teacher's Advice

Results of analyzing students' responses to Question 3 are reported in Table 3, which shows that the vast majority of students would use all the strategies, even if the teacher does not ask them to do so.

Reasons for Students' Choices

Generation of analogies. The main reason for choosing the generation of analogies was because they were interesting (4 students out of 9; 44.4%). This was followed by the fact that they were easy to create (3 students out of 9; 33.3%), quick to produce (3 students out of 9; 33.3%), helped students to understand and memorize new terms (2 students out of 9; 22.2%), and were new and interesting (2 students out of 9; 22.2%).

Generation of summaries. Students who chose to use the generation of summaries had different reasons for their choices. The first reason was that summaries helped students to spend less time studying (3 students out of 14; 21.4%). This was followed by the fact that summaries were familiar, produced better understanding (3 students out of 14; 21.4%), helped students to check their understanding (2 students out of 14; 14.3%), were easy to produce, and facilitated the understanding of difficult lessons and ideas (2 students out of 14, 14.3%).

Answering questions. Students who chose the strategy of answering questions on their own, thought that questions were easy (7 students out of 17; 41.2%). They could also be answered quickly (3 students out of 17; 17.6%), they helped students to check their understanding of the main

Table 4. Percentages of Students' Perceptions of the Applicability of the Strategies in Other Subjects.

Analogies	Summaries	Answering Questions	Summaries & Questions	All three Strategies	None
3.9%	15.7%	3.9%	35.3%	23.5%	13.7%

ideas of a lesson and review for tests (5 students out of 17; 29.4%), and they were familiar (2 students out of 17; 11.8%).

To summarize, students preferred answering questions on their own, followed by generating summaries, then generating analogies. Their preferences were premised on the fact that answering questions and generating summaries were functional because they helped students to understand content, check their understanding, and were time efficient. Analogies, on their hand were amusing with some functionality because they were interesting, fun, and helpful in understanding content.

Using the Strategies in Subjects other than Science

Analyzing responses to Question 4 (Table 4) shows that 86.3% of the students said that they would use the strategies in subject areas other than science.

Of the students who said that generating analogies was useful when studying subjects other than science, one felt they were useful when studying English and Arabic only, while another felt that they were useful with all other subjects. Moreover, of the students who thought that generating summaries was useful when studying other subjects, 37.5% (3 students out of 8) also felt that they were useful when studying social studies, 25.0% (2 students out of 8) when studying Arabic, and 87.5% (7 students out of 8) when studying English. Finally, the two students who said that answering questions was useful when studying other subjects, felt that they were useful when studying English and Arabic. Furthermore, approximately 44% of the students who said that they would use summaries and answering questions in subjects other than science said that they would use them in Arabic, English and social studies; 44.4 % in Arabic and English, and 22.2% in all subjects. Students who said that all strategies are useful in subjects other than science suggested that they would use them in English (16.7%), Arabic (16.7%), social studies (25.0 %), and in all subjects (41.7%).

Students who thought that the strategies were not useful in subjects other than science had different reasons that included the strategies were related to science only (28.6%), other subjects do not require much thinking (14.3%), and students needed to study for the test, so they need not waste their time using inefficient strategies (1 student out of 7; 14.3%).

The responses to Question 4 show that students valued generating summaries and answering questions more than generating analogies because the generation of analogies did not seem to work with subject areas other than science. Still, the three strategies were considered helpful in English, while very few students mentioned the relevance of these strategies to mathematics.

Willingness to Learn other Strategies

In response to Question 5, 66.7% of the students said they were ready to learn other strategies while 33.3% said they were not. The students who accepted to learn other strategies suggested that these strategies might help them achieve higher grades on exams (23 students out of 34, 68%) and simplify the process of studying (4 students out of 34, 12%). Each of the remaining students (20%) gave a different reason for his or her answer. One student thought that such strategies could help him if he became a teacher in the future. Another said that she was willing to do anything that helped her learn and improve her study habits. A third noted that he liked to experiment with new strategies. A fourth said that he wanted to learn new strategies because he was always curious about new things, while the fifth said that he was ready to learn new strategies because of their potential usefulness in the future. A sixth student said that, while he would like to learn new strategies, schoolwork was too time consuming to allow this to happen. The seventeen students (33.3%) who were not ready to learn other strategies said that these strategies were not helpful and a waste of time.

Discussion and Recommendations

Results of analyzing the questionnaire showed that, while students liked generating analogies for being interesting and fun to work with, they preferred answering questions and generating summaries because these strategies helped them to achieve their goals of understanding science

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concepts, checking understanding, and ultimately performing better on achievement measures along with spending as little time as possible on academic tasks. Thus, students' arguments were functional in nature even though having fun and being amused while performing academic tasks was one consideration in choosing the learning strategies, especially analogies. Furthermore, students' readiness to use the strategies without teachers' advice, beliefs about the effectiveness of the strategies in other subject areas, and willingness to learn other similar strategies, showed the same trend. Specifically, students were ready to use those strategies that, in their opinions, produced the best academic results; that is, they were functional. Students' preference for answering questions and generating summaries is understandable; students usually invest the least effort to reach their goals, and prefer whatever is easy and familiar to them. Thus, it is likely, as they indicated in their responses, that they would continue to use the generation of summaries and answering questions. Students' perceptions of the effectiveness and utility of the strategies may influence their willingness to use them in the future in science and other subject areas. When teachers' goals are focused on achieving academic goals, they should expect students to align their goals with these and use whatever strategies they perceive as efficient and effective to accomplish these goals.

However, if the aim of schools is to help students to learn meaningfully (Mayer, 2002) in order for them to be effective and efficient citizens of the scientific and technological world and be creative members of society, is it sufficient for these students to continue using the generation of summaries and answering questions and neglect using analogies? Generation of summaries and answering questions may help students achieve higher and succeed in traditional tasks required by their teachers. However, if the aim of schools is to prepare students to use their creativity in order to solve personal and societal problems, then there is a need to encourage students to use analogies and other similar strategies that promote creativity. Teachers, who are capable of helping their students benefit from the advantages of strategies that encourage creativity, need to be prepared (Kokinov, Holyoak, & Gentner, 2001).

The findings of this study have implications for teaching, professional development of teachers, and research. Teachers should realize that their goals might not be necessarily evident to students. Thus, if they choose to use innovative strategies, such as generating analogies in their science teaching, they should make sure that students discern the relevance of these strategies to their goals and to the established goals of the school. Educators, in their turn, need to find ways to incorporate training of teachers on using innovative strategies in their teaching and professional development activities. Finally, researchers should consider the importance of students' perspectives when they investigate the effectiveness of specific strategies. For while it is possible to find significant statistical results in favor of a new strategy in an experimental setting, we must face the reality that students will not use it by themselves because of their personal views about its effectiveness and utility to reach their goals.

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