The Effect of Thinking Aloud Pair Problem Solving (TAPPS) Strategy on Developing Scientific Concepts and Habits of Mind among Middle School Students

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Abstract

The aimof this study was to investigate the effect of Thinking Aloud Pair Problem Solving (TAPPS) strategy on developing scientific concepts and habits of mind among middle school students. The sample consisted of 64 male Saudi students. We applied a quasi-experimental design with an experimental and a control group and a pretest–posttest.We examined the correlation between the two dependent variables.The data-collection instrumentswere a scientific-concepts test and habits-of-mind questionnaire. The results revealed a statistically significant difference between the mean scores of both instruments in favor of the experimental group. Additionally, there was a positive relationship between developing scientific concepts and habits of mind among the students for the experimental group.

Keywords: Thinking Aloud Pair Problem Solving, scientific concepts, habits of mind, middle school students.

Humanity is facing many challenges, including the ability to operate in an ever-changing worldthat faces increasing instability. This rapid rate of change has made people continuouslytry to keep pace with the vagaries of a VUCA world—Volatile, Uncertain, Complex, and Ambiguous(Asmolov, 2018;Stein, 2021; Waller et al., 2019). In a *volatile*world, it isdifficult to determine the behavior of individuals in specific circumstances.The information associated with a particular event is often incomplete or unknown, that is, *uncertain*.That information may be *complex* because the interaction among events or factors influencing those events may be nonlinear. In addition,the meaning of information may be *ambiguous*, or lacking in claritydespite the presence of an appropriate amount of information.

The future of education is linked to preparing students for the VUCA world and equipping them with an appropriate set of skills. The goal of education is no longer only acquiring knowledge but rather building and refining students' personalities by providing them with certain skills and intellectual behaviors to be able to discover, develop, and produce knowledge, to use that knowledgeto solve problems they may face, and to engage their communities with confidence and determination. Among those skills and behaviors are *habits of mind* (Costa &Kallick, 2018; Prensky, 2014). Habits of mind can be defined as patterns of intelligent behavior that manage the organization of mental processes. Through a person's responses to a specific pattern of problems that require thinking, those responses are transformed into habits by means of continuous training (Hajjat, 2010). The theory of habits of mind is based on a number of other theories: social learning, emotional intelligence, constructivism, brain research, the nature of intelligence, and cognitive learning (Campbell, 2006).

In the context of education, many researchers have emphasized the need to introduce habits of mind in the classroom.Qatami and Amr (2005) argued that introducing students to habits of mind can help them take appropriate measures in the classroom; it can encourage them to respect time and trust themselves, teach them how to think, prepare them to face problems, and search for solutions to problems in innovative ways.Ritchhart and Perkins (2008) made a similar point and expanded the benefits of habits of mind outside the classroom, noting the importance of developing students' habits of mind to develop patterns of thinking and behaving in different ways when facing problems in the real world. Habits of mind can increase students' sensitivity and lead them to choose the most intelligent actions to solve a problem.Other researchers have proposed that when educational activities are based on habits of mind, a leap can be made in deepening students' thinking and encouraging them to be creative in solving problems (Sousa, 2016; Sullivan, 2014).

Along with habits of mind, developing scientific concepts can enable students to deal flexibly with scientific challenges and debates in the current era (Adwan& Daoud, 2016; Al-Falah, 2013;Zeitoun, 2010). Scientific concepts do not arise completely and clearly at once, and they do not come to a stop in the developmental process in astudent's mind at a certain point, but rather they develop as the student is exposed to different scientific approaches (Lorsey, 2012). Furthermore, Badir (2014) explained that scientific concepts are mental perceptions that result from the student's awareness of existing relationships among events related to science. Badir further stated that scientific concepts can be described in abstract formulations that combine common characteristics and scientific facts, such as names, symbols, or terms that have clear meanings and specific definitions. Collectively, the studies we review here suggest the significance of developing productive scientific thinkers as outcomes education, and the need to inform teachers' efforts in fostering productive mental habits among their students to be well prepared for today's changing society.

Previous research has established the importance of developing scientific concepts while teaching at all levels of education, and of the need for students to obtainmental habits and thinking skills to improve the life of the individual and society (Abdel Meguid, 2017; Abu Zaid, 2018; Assaf, 2017). Accordingly, the need is clear for teachers to adopt instructional strategies that ensure that students properly form scientific concepts and develop sustainable habits of minds. In this respect,TAPPS (Lochhead &Whimbey, 1987)isa collaborative problem-solving instructional strategythat help students learn how to approach problems, identify right paths to a solution, avoid false starts, and create a natural dynamic environment for students to learn. TAPPS involves students working in pairs; one student is the problem solver and the other is the listener. The pair are given a series of problems and take turns explaining the thinking processes they used to reach their solution or conclusion.Several attempts have been made to examine the effect of TAPPS in developing systematic thinking, critical thinking, problem-solving skill, and mathematics education (Abdel Meguid, 2017; Anggraeni et al., 2019; Kani&Shahrill, 2015). However, relatively little research has been carried out on scientific concepts and habits of mind, collectively. Therefore, the purpose of this study is to examine the effect of TAPPS on developing scientific concepts and habits of mind among male middle-school students.

Research Questions

1. How effective is TAPPS in the development of scientific concepts among male middle-school students?
2. How effective is TAPPS in the development of habits of mind among male middle-school students?
3. What is the connection between scientific concepts and habits of mind among malemiddle- school students?

Background

Thinking Aloud Pair Problem Solving (TAPPS) Strategy

In TAPPS, students are divided into groups of two and given a series of problems. The pair are given specific roles that switch with each problem: problem solver and listener (Al-Shammari, 2011). The problem solver thinks out loud and speaks throughout their solving of the problem. The listener observes the problem-solving process and works on understanding the underlying reasons for the problem solver’s actions, as well as encourages the other to vocalize their thoughts (e.g., what are you thinking? or what are you doing?). Similarly, Barkley et al. (2014)pointed out that in TAPPS the problem solverexpressesaloud their thoughtsand the logical steps that will solve the problem. The listener is not passive but rather has roles to play, such as encouraging expression ofthoughts, checking accuracy, and clarifying the process provided verbally by the problem solver.

Moreover, TAPPSemphasizes the mental processes of problemsolving instead of the end product. This leads to discovering logical errors, as it also helps raise the students’ awareness of successful and unsuccessful inputs in problemsolving(Abdel Meguid, 2017).

Furthermore, TAAPS improves students' analytical reasoning (Lochhead &Whimbey,1987) by helping them reformulate their thoughts, repeat concepts, understand the progression of the steps underlying their thoughts, and recognize the logical errors of their peers.Overall, the goal of TAPPSis to engage students in the deep mental processing they use to solve problems and to help them acquire higher order thinking during the problem-solving process.

Scientific Concepts

Ascientific concept can be viewed from two sides (Al-Khazraji, 2011; Sbeitan, 2010). The first is in terms of being a mental process through which a set of common facts is abstracted. The other is as a product of the that mental process—the name, concept, or symbol assigned to a group of common characteristics, such as light, digestion, reaction rate, chromosomes, electrons, or symbols such as Na and DNA. Al-Falah (2013) stated that what distinguishes scientific concepts is that they are more stable than scientific facts because they link facts and clarify the connections between them, and they have more to do with students' lives. Indeed, learning scientific concepts is a demanding and lengthy process, in which the students' initial and personal concepts gradually change toward more scientific concepts in that they become part of a coherent knowledge system (Koponen&Kokkonen, 2014). Al-Samarrai (2014) stressed that science teachers need to adopt instructional strategies that do not depend on direct indoctrination but rather on students' participation and thatmotivate them to link new scientific concepts with their previous experiences and everyday lives. Scientific concepts have become a prerequisite that must be acquired and developed for students, and this is confirmed by recent trends in the field of scientific education (Muhammad, 2017; SirajSaadawi,2020).

Habits of Mind

The term *habits of mind*isoften equated with successful people's problem-solving skills.Previous studies mostly defined habits of mind as a set of dispositions that describe an effective thinker, a set that includes the skills and strategies that individuals might use when they are confronted with difficult problems (Costa &Kallick, 2008). Similarly, Anderson (2013) described habits of mind as the actions that are applied skillfully and rationally by the most successful people in society when they strive to achieve goals that require effort.Collectively, habits of mind can be described as an internal compass that guides an individual's decisions as they are solving problems.Furthermore, many classifications of habits of mind have emerged. Al-Hwaiti(2018) referred to the most prominent of them as follows:

- The American Association for the Advancement of Science has presented in the Project 2061 for Science, Math, and Technology a classification of habits of mind into integration, effort, curiosity, openness to new ideas, educational suspicion, critical response skills, justice, perseverance, arithmetic skills, guessing, observation, and connection.

- The British National Curriculum classified habits of mind into curiosity, respect for evidence, the will to forgive, critical thinking, perseverance, innovative thinking, open-mindedness, sound environmental sense, and cooperation with others.

Additionally, Marzano et.al. (1993) classified habits of mind into five dimensions: open-mindedness, intellectual justice, inquiry or critical tendency, productive mind habits. Moreover, Costa andKallick (2008) proposed 16 habits of mind:(1) persisting; (2) managing impulsivity;(3) listening with understanding and empathy; (4) thinking flexibly; (5) thinking about thinking (metacognition); (6) striving for accuracy; (7) questioning and posing problems; (8) applying past knowledge to new situations; (9) thinking and communicating with clarity and precision; (10) gathering data through all senses; (11)creating, imagining, and innovating; (12) responding with wonderment and awe; (13) taking responsible risks; (14) finding humor; (15) thinking interdependently;and (16) remaining open to continuous learning.

The classification by Costa &Kallick (2008) is the most commonlyused; it is the most comprehensive, integrated, and overlapping. In this study, we adopt six of those habits of mind:listening with understanding and empathy, thinking flexibly, striving for accuracy, applying past knowledge to new situations, thinking and communicating with clarity and precision, and metacognition.

Methodology

Population and Sample

We carried out our study in a Saudi Arabian public middle school. General education in Saudi Arabia consists of three stages: six years in elementary school, three years in middle school, and three years in high school. The population in this study were first-year middle-school male students who studied in the in all eight public middle schools inthe city of Jubail, Saudi Arabia, as reported by the Department of Planning and Development at the Ministry of Education (Eastern Province Branch). Random sampling was not possible as selection of the school had to be disclosed so that we could obtain ethical approval. Therefore, wepurposefully selected one middle school to participate in this study.

Research Design

We investigated our research questions using a quasi-experimental design with an experimental and a control group and a pretest–posttest.The chosen middle school consisted of sixfirst-year classes. We randomly selected two classes. Both the experimental group and the control group comprised 32 students each. The experimental group received the pretest, the treatment (TAPPS), and the posttest. The control group received a pretest followed by the control condition and a posttest.There were no differences between the two groups in terms of the following extraneous variables: chronological age, gender, educational content, and previous academic achievement. Furthermore, we chose the following two units from a science textbook,Meteorology and Astronomy.

Research Tools

The Development of the Scientific Concepts Test

The scientific concepts testwas developed to measure students' level of scientific- concept understanding related to the Meteorology and Astronomy units (see Appendix).Together with an expert teacher from the middle school,we examined several resources when drafting the test, which included the learning objectives of each lesson, the scientific concepts in each unit, previous achievement tests carried out in the school, and samples of achievement tests supplied by the Saudi Education and Training Evaluation Commission. The achievement test included 22 questions that were designed in a multiple-choice format at different cognitive levels—remembering, understanding, applying, and analyzing (Anderson & Krathwohl, 2001).

We worked to establish the validity and reliability of the test. Content validity was established by having the test reviewed by two science-education professors. They were asked to review the test's degree of representation in the content, the clarity of the questions, the suitability of the alternatives for each of the questions, the suitability of the questionsfor the corresponding cognitive level, and any other necessary feedback. Based on the reviewers' feedback, we made minor changes to the test. Then we piloted the test on 34 second-year male middle-school students who were not participants in the research. The internal consistency was assessed by calculating Pearson correlation coefficients between each question and the total mark for the cognitive level under which the question falls, as shown in the following table:

Table 1
Pearson Correlation Coefficients for the ScientificConcepts Test

Remember		Understand		Apply		Analyze	
Pearson Correlation	Question	Pearson Correlation	Question	Pearson Correlation	Question	Pearson Correlation	Question
0.614**	1	0.659**	6	0.610**	13	0.506**	18
0.469**	2	0.559**	7	0.713**	14	0.482**	19
0.537**	3	0.640**	8	0.556**	15	0.610**	20
0.580**	4	0.404*	9	0.619**	16	0.447**	21
0.461**	5	0.373*	10	0.619**	17	0.759**	22
		0.518**	11				
		0.595**	12				

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 1 shows that all correlation coefficients between each question and the total mark for a cognitive level under which the question falls are statistically significant at 0.01–0.05. This means that the scientificconcepts test has internal consistency. Additionally, the internal consistency was calculated for each cognitive level individually with overall test scores. The value of coefficients for remembering, understanding, applying, and analyzing were 0.809, 0.851, 0.710, and 0.761, respectively. All coefficients were statistically significant correlations at 0.01, indicating an existing strong internal consistency of the test. Furthermore, the reliability of the test was verified through two methods, Alpha Cronbach coefficient and split-half reliability (Spearman–Brown). We calculated the results of both methods to be 0.802and 0.853, respectively. This indicates high reliability and thus confirms the appropriateness of the test for application.

Moreover, we examined the difficulty and discrimination coefficients for each question.The difficulty coefficients ranged from 0.29 to0.65, an average of 0.47; and the discrimination coefficients ranged from 0.22 to 0.78, an average of 0.5. Accordingly, the achievement-test questions have appropriate difficulty and discrimination coefficients, and thus they are considered suitable. Finally, the scientificconcepts test took approximately 30 minutes to complete.

Development of the Habits-of-Mind Questionnaire

The habits-of-mind questionnaire consisted of six characteristics:listening with understanding and empathy, thinking flexibly, striving for accuracy, applying past knowledge to new situations, metacognition, and thinking and communicating with clarity and precision (see Appendix).We chose these specific habits of mind because of their suitability for the abilities of the study participants, and we derived the items from the literature in the context of middleschool education (e.g., Abu Seif, 2015; Al-Shakhs et al., 2015). The questionnaire consisted of 36 statements distributed over six habits of mind. Because each habit has sixstatements, we considered forming positive and negative phrases. The negative statements are items 5, 10, 11, 16, 17, 18, 22, 23, 24, 29, 30, 34, 35, and 36. The questionnaire had a three-point Likert scale, which are rarely (score 1), sometimes (score 2), and always (score 3).The questionnaire was reviewed by two experts in educational psychology to establish content validity. They were asked to evaluate each item for clarity, readability, and relevance. We made all necessary changes recommended by the reviewers, which mostly involved wording to avoid misinterpretation and minor grammatical changes to make statements more understandable. Then we pilot-tested the questionnaire on 34 middle-school students who were not participants in the research. The internal consistency was assessed by calculating Pearson correlation coefficients as shown intable below.

Table 2
Pearson Correlation Coefficients for the Habits-of-Mind Questionnaire

Thinking flexibly		Listening with understanding and empathy		Metacognition	
No.	Pearson Correlation	No.	Pearson Correlation	No.	Pearson Correlation
1	0.463**	7	0.377*	13	0.771**
2	0.643**	8	0.399*	14	0.526**
3	0.391*	9	0.423*	15	0.477**
4	0.713**	10	0.392*	16	0.489**
5	0.666**	11	0.634**	17	0.392*
6	0.439**	12	0.505**	18	0.389*
Striving for accuracy		**Applying past knowledge to new situations**		**Thinking and communicating with clarity and precision**	
No.	Pearson Correlation	No.	Pearson Correlation	No.	Pearson Correlation
19	0.369*	25	0.398*	31	0.413*
20	0.565**	26	0.526**	32	0.603**
21	0.450**	27	0.527**	33	0.449**
22	0.432*	28	0.389*	34	0.418*
23	0.455**	29	0.664**	35	0.445**
24	0.449**	30	0.484**	36	0.433*

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 2 shows that all correlation coefficients between each statement and the total mark for the habit of mind under which the statementsfall are statistically significant at0.01 and 0.05. This means that the questionnaire is internally consistent. Additionally, we calculated the internal consistency of each habit with overall questionnaire scores. The value of coefficients for thinking flexibly, listening with understanding and empathy, metacognition, striving for accuracy, applying past knowledge to new situations, and thinking and communicating with clarity and precision were 0.747, 0.737, 0.725, 0.768, 0.755, and 0.721, respectively.We tested the reliability of the questionnaire by using Cronbach's Alpha, which we calculated to be 0.809, and we determined that split-half reliability (Spearman–Brown) was 0.835,both of which are acceptable degrees of reliability. Finally, the questionnaire took approximately 25 minutes to complete.

Teachers' Guide to TAPPS

We developed a teachers' guide to TAPPSfor the two units: meteorology and astronomy.In Saudi middle schools, science is taught four times per week; each class is 45 minutes long. The guide includes an introduction to TAPPS, learning objectives and scientific concepts of the units, lesson plans according to TAPPS, and

TAPPSworksheets. The teachers' guide was reviewed by a science-education professor and by an expert middle-school teacher. We made necessary changes after receiving their feedback and verbal comments.

Procedures

Before collecting data, we sought approval from the Ministry of Education (Eastern Province Office), which issued a letter to the targeted school allowing us to conduct the study with first-year male middle-school students. All students, parents, and teachers agreed to participate voluntarily in the study. Then we administered the pretest using both instruments on the chosen experimental and control group to verifytheir equivalence. We examined the equivalence of the two groups by using an independent samples *t*-test. Table 3 illustrates the results.

Table 3

T-test Results for the Pretest Scientific Concepts Test

Group	N	Mean	SD	df	T value	Significance level
Experimental	32	6.81	2.67	62	0.815	0.418
Control	32	6.31	2.22			

Table 4

T-test Results for the Pretest Habits-of-Mind Questionnaire

Group	N	Mean	SD	df	T value	Significance level
Experimental	32	58.16	4.52	62	1.391	0.169
Control	32	56.88	2.6			

Tables3 and 4 show that the test significance level is above 0.05, which indicates that there are no statistically significant differences between the experimental and control groups. Therefore, there is equivalence between both groups. Finally, after the treatment was completed (4 weeks), we conducted the posttest by using both instruments for the experimental and control groups.

Results

In order to analyze the posttest data of this study, we used descriptive statistics that included calculating the mean, standard deviation (SD), and degrees of freedom (*df*)values for both the scientific concepts test and habits-of-mind questionnaire. We used Pearson correlation coefficients to examine the connection between the two dependent variables. Initially, we calculated the normality in each group by using Shapiro–Wilk's test, the results of which showed that each had nonsignificant readings and followed a normal distribution. Thus we used inferential statistics, which include a*t*test for independent samples to identify differences between the experimental and control groups in developing the scientificconcepts test and habits-of-mind questionnaire, and the eta-squared (η^2) coefficient to calculate the effect size of TAPPS on scientific concepts and habits of mind.

To answer the three research question, we tested three hypotheses.

First Research Question

The hypothesis states as follows: "There are no statistically significant differences at ($\alpha \leq 0.05$) between the posttest mean scores of the experimental and control groups in the scientific concepts test." Table 5 shows the summary statistics for testing this hypothesis, which corresponds to the first research question.

Table 5

Posttest Summary Statistics for the Scientific Concepts Test

Group	N	Mean	SD	*df*	*T*-test	η^2	Significance level
Experimental	32	17.1	3.2	62	7.082	0.45	0.000
Control	32	11.1	3.5				

Table 5 reveals that the significance level is less than 0.05. Therefore, the null hypothesis is rejected, which states that there are no statistically significant differences between both groups onthe posttest scientific concepts test. This means that the use of TAPPS made a difference in the posttestin favor of the experimental group. Additionally, eta squared (η2) is calculated at 0.45, which is a large effect size. This indicates that TAPPS had a significant and effective impact on the development of students' scientific concepts.

Second Research Question

The hypothesis states as follows: "There are no statistically significant differences at ($\alpha \leq 0.05$) between the posttest mean scores of the experimental and control groups in the habits-of- mind questionnaire." Table 6 shows the summary statistics for testing this hypothesis, which corresponds to the second research question.

Table 6

Posttest Summary Statistics for the Habits-of-Mind Questionnaire

Group	N	Mean	SD	*df*	*T*-test	η^2	Significance level
Experimental	32	86.97	3.16	62	7.650	0.49	0.000
Control	32	74.72	8.49				

Table 6shows that the significance level is less than 0.05. Therefore, the null hypothesis is rejected, which states there are no statistically significant differences between both groups on the posttest in the habits-of-mind questionnaire. This means that the use of TAPPS made a difference on the questionnaire in favor of the experimental group. Additionally, eta squared (η2) is calculated at 0.49, which is a large effect size. This indicates that TAPPS had a significant and effective impact on the development of students' habits of mind.

Third Research Question

The hypothesis states: "There are no statistically significant correlations at ($\alpha \leq 0.05$) between scientific concepts and habits of mind among middle-school students." Table 7 shows the summary statistics for testing the third hypothesis, which corresponds to the third research question.

Table7

Pearson's Correlation Coefficients between the Scientific Concepts Test andehtHabits-of-Mind Questionnaire

Group	N	Pearson Correlation	Significance level
Experimental	32	0.632	0.000
Control	32	0.067	0.714

Table 7 shows that the correlation coefficient in the case of the experimental group reached 0.632, greater than that of the control group, 0.067. The significance level for the experimental group is less than 0.05; therefore, the null hypothesis is rejected. Additionally, there is a positive correlation for the experimental group between students' achievement on the scientificconcepts test and their development of habits of minds when using TAAPS.

Discussion

In regards to TAPPS making a difference in the post scientific-concepts testin favor of the experimental group,TAPPSconsists of several elements: thinking aloud, peer teaching, and problem-solving. Thus TAPPS can be linked to one suggestion by Kojk (2000) to help students develop concepts, that is, provide them with opportunities to think about solving a problem or to listen to the experiences of others and express what they perceive through communication. Additionally, Kalman (2007) indicated that students need to develop a deeper understanding of a topic when they are asked to explain their thoughts (*thinking aloud*) about the topic to other students who are less informed. For example, if a student were asked to explain the concept of global warming to a less informed peer, the student would have the necessary motivation to immerse themselves in the information and then to effectively explain the concept to the peer.Another link between TAAPS and students' acquisition of scientific concepts is the need for an active classroom environment (Attia, 2014). TAPPS creates an active environment that allows students to think with their peers, build upon others' ideas, and share their previous information and knowledge on the subject. In that way students are active in the educational process, working toward attaining the meaning of the concepts, rather than memorizing facts.

TAPPS allows students to practice thinking and display their mental operations in a stimulating atmosphere for thinking and for noticing patterns and relationships that can be transferred to new situations. As a result, in taking the scientificconcepts test, students in our study were able transfer their deep understandings of the problem and underling scientific concepts to new situations. In the context of science education, Ambusaidi and Al-Balushi (2013) stressed that a key goal of a problem-solving instructional strategy is developing students' ability to transfer what they learned, including problem-solving skills and scientific concepts, to new situations.

TAPPS requires all students to engage in a cooperative learning context with their peers. In contrast, other teaching strategies may fail to ensure students' active participation and may allow them to complete a cooperative learning activity without contributing to the group effort. Students need an active classroom environment in order to acquire and develop concepts (Attia, 2014). Hence, by taking turns as problem solver and listener, both members of the pair become obligated to verbalize their thoughts on each problem that underlie the scientific concepts of the lesson. As students exchange roles, they become more aware of their thinking process.Therefore, students will have the chance to build scientific knowledge, ideas, and new scientific concepts based on their previous experiences and knowledge through the problems presented to them.The results of this study further support the idea that TAPPS provides a cooperative learning environment that allows students to exchange scientific views in a stress-free atmosphere, which helpsthemmore easily master new concepts (Qatami, 2005).

With respect to TAPPS making a difference in the post habits-of-mind questionnaire in favor of the experimental group,apossible explanation is that TAPPS created a cooperative social context for solving problems and fostering the development of students' habits of mind. This context made the students accept the views of others, even if they conflicted with their own, so that they had the ability to generate diverse thoughts and extract many alternatives to apply totheir existing knowledge in reaching a solution to the new problem. Furthermore, one of the common points between TAPPS and habits of mind is metacognition, which Costa and Kallick (2008) described as thinking about cognition, which only induces more thinking. When students describe the mental processes they use, the plans they implement to solve a problem, or the language they consciously use, their underlying thought processes will be revealed so that other students can evaluate their ideas, which is what Lochhead and Whimbey (1987) called peer thinking out loud in solving problems.

TAPPS requires the problem solver to express their thoughts whenever they appear in their mind, applying previous knowledge to new situations and articulating all ideas as they occur. Mokhtar (2017) indicated that involving students in instructional strategies that allow them to practice certain roles that foster positive behaviors can help reveal and develop their habits of mind. Therefore, the problem solver will have a high potential of adopting the habits of thinking flexibly, applying past knowledge to new situations, and thinking and communicating with clarity and precision. Moreover, the listener in TAPPS encounters a unique experience. The listener attends to the problem solver's thinking by listening carefully, asking for clarification, checking for accuracy, and responding in an appropriate manner. At the same time the listener should not give hints, solve the problem, or tell the problem solver how to correct an error. Additionally, the listener devotes their attention, moment by moment, toward accurately understanding the problem solver's solution, which is what Lochhead and Whimbey (1987) called verification of accuracy. All of these behaviors are associated with the habits of mind of listening with understanding and empathy, striving for accuracy, and thinking and communicating with clarity and precision.

TAPPS is able to make a link (positive correlation) between the development of scientific concepts and habits of mind. TAPPS provides an opportunity for students to discuss and actively participate in a scientific discourse.Thus, in order for students to communicate the ideas involved in solving a problem, they will use a set of words that have certain connotations; these words are scientificconcepts. Therefore, as students engage in scientific discourse and continuously exchange the roles of problem solver and listener, they will intuitively embrace certain habits of mind to reach a solution to the problem.

Conclusion

The purpose of this research was to examine the effect of TAPPSon developing scientific concepts and habits of mind among male middle-school students. The implication of the study offers a suggestion for middle school science teachers to useTAPPS in their instruction. Making students think aloud is a valuable way of revealing their thinking, which makes it observable for the teacher, who then can assess how well the students understand the problem, their approach to solving the problem, and the ideas they formed about the underlying scientific concept. Additionally, our findings also suggest that teacher preparation programs should incorporate TAAPSinto their methods courses. TAAPSis a useful instructional strategy for preservice and beginner teachers because it enables them to quickly observe and assess their students' patterns of thinking and to help them develop and strengthen habits of mind.

Our purposeful sampling may be seen as a limitation of the study.However, because the Saudi educational system is centralized, it is highly likely that there would be little variation in the findings were similar studies to be conducted in the region. Moreover, further researchcould explore the role of using TAAPS during preservice teachers' practicum courses. Additionally, research regarding the relationship betweenTAAPS and beginner teachers' self-efficacy in teaching would be worthwhile.

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Appendix
Scientific Concepts Test

1. The prevailing condition in the atmosphere for a short period is called:
   a. Wind.
   b. Climate.
   c. Weather.
   d. Air currents.
2. Mountainous regions on the Moon's surface are called:
   a. Moon peaks.
   b. Moon highlands.
   c. Mountain ranges.
   d. Moon craters.
3. The amount of water vapor in the atmosphere is called:
   a. Humidity.
   b. Dew point.
   c. Relative humidity.
   d. Precipitation.
4. These different types of rays, Gamma rays, X-rays, Ultraviolet, and Infrared, are called:
   a. Visible spectrum.
   b. Electromagnetic spectrum.
   c. Spectral colors.
   d. Radio spectrum.
5. Astronomical telescopes are placed in special buildings that contain a dome called:
   a. Observatory.
   b. Space agency.
   c. Spaceships.
   d. International station.
6. An astronomical telescope with convex lensesis known as:
   a. Optical astronomical telescope.
   b. Reflecting astronomical telescope.
   c. Refracting astronomical telescope.
   d. Radio astronomical telescope.
7. The term "atmosphere"refers to the following:
   a. The layer of gases surrounding the Earth.
   b. The prevailing weather conditions.
   c. The water vapor, dust, and salts in the atmosphere.
   d. The nitrogen and oxygen in the atmosphere.

8. The water cycle means the following:
    a. Evaporation, condensation, and precipitation processes.
    b. Rain, rivers, and seas.
    c. The three states of water: vapor, liquid, and ice.
    d. Continuous movement between the Earth's water and the atmosphere.
9. What is meant by air mass?
    a. Low pressure center.
    b. The boundary separating two zones.
    c. High pressure center.
    d. A huge amount of air is formed over a specific area.
10. What is meant by a meteoroid?
    a. Pieces of rocks and minerals falling to the Earth.
    b. A large body made of ice and rocks.
    c. Huge gas planet.
    d. A celestial body following a planet in the Solar System.
11. What is meant by aerosol?
    a. Oxygen.
    b. Gases.
    c. Dust and salt.
    d. Water vapor.
12. Stars and other celestial bodies transmit electromagnetic radiation and are observed by which type of telescopes:
    a. Refracting.
    b. Optical.
    c. Radio.
    d. Reflecting.
13. Early in the morning, while you were on your way to school, you noticed drops of water on the windows of cars and trees near your house. What does that mean?
    a. Humidity.
    b. Dew Point.
    c. Relative humidity.
    d. Precipitation.
14. A star is 4.5 light years away from Earth.If a light year is 9.5 trillion km,how many kilometers is the star away from Earth?
    a. 24.75 trillion km.
    b. 42.75 trillion km.
    c. 2.5 trillion km.
    d. 2 trillion km.

15. What would happen to relative humidity in the following situation: “When the air temperature decreased and the amount of water vapor in it did not change”?
    a. No effect.
    b. Decrease.
    c. Remain constant.
    d. Increase.
16. Predict what will happen when a giant star’s core collapses?
    a. Black hole.
    b. New giant star.
    c. Neutron star.
    d. Supernova star.
17. On a documentary TV channel, you watched a science program about tornadoes. Which of the following statements applies?
    a. Strong winds and heavy rains occur.
    b. Air expands due to a sudden increase in temperature.
    c. Rising air currents begin to rotate.
    d. Two air masses wrap around each other.
18. Which one of the following information regarding the troposphere layer is false?
    a. Closest to Earth.
    b. Contains the ozone layer.
    c. 10 km thick.
    d. Contains three quarters of the atmosphere.
19. Which one of the following can cause floods, destruction of agricultural crops,and injury to humans and animals and can continue for weeks and travel thousands of kilometers?
    a. Sea hurricane.
    b. Tornado.
    c. Thunderstorm.
    d. Cold front.
20. Which one of the following does not contribute to a comet forming a long tail?
    a. Solar wind.
    b. Cometsare made of ice and rocks.
    c. Ice melting when approaching the sun.
    d. Comet’s volcanic craters that emit smoke.
21. All of the following apply to a spiral galaxy, except:
    a. Stars are compact and old.
    b. Milky Way.
    c. Flat disk of gas.
    d. Arms extending from the center in a spiral
22. Which of the following factors is plausible for the solar system to remain coherent?

a. Sun's massive gravity.
b. Dark matter.
c. Unique force of the universe.
d. Charged solar wind.

Habits of Mind questionnaire

1. I accept other people's explanations on a topic.
2. I thinkabout all the solutions available to solve the problem I encounter.
3. I change my mind when I am convinced of the other point of view.
4. I come up with many alternatives to solve any problem that I encounter.
5. I can solve my problems without accepting other people's views.
6. I have a desire to search for new ideas.
7. I listen carefully to other people's views on a topic.
8. I focus well on the speaker's facial expressions.
9. I use phrases such as "I understand you" when speaking.
10. I find it difficult to respond to the opinions of my colleagues.
11. I interrupt my friend when they disagree with me on an idea.
12. I listen to my friends' ideas.
13. I think out loud when I have a problem.
14. I reflect on my thoughts before completing any task.
15. I plan what I want to learn.
16. I avoid reconsidering my thinking.
17. I have unique thoughts, and there is no need to rethink them.
18. I rarely ask myself questions before completing a task.
19. I take into account accuracy in the performance of my various works.
20. I make sure of the work I do in more ways than one.
21. I avoid submitting any disordered work.
22. I avoid proficiency in my work.
23. I get my homework done regardless of accuracy.
24. I prefer rapidlyfinishingmy work without reviewing it.
25. I use scientific information in new situations.
26. I connect new information with what I already have.
27. I learn from my mistakes in future situations.
28. I use my solved examples to solve new problems.
29. I make the same mistake more than once.
30. I avoid making use of my past experiences.
31. I can influence my friends with my right opinions.
32. I express my thoughts to others using subtle language techniques.
33. I use proofs to convince my friends of my ideas.

34. I keep my success to myself and not show it to my colleagues.
35. I find it difficult to convince others of my ideas for the lesson.
36. I avoid talking to my colleagues to discuss my ideas.