Is There Water on Mars?

A de Bono Skills Mystery for Twice-Exceptional Gifted Students

Christopher Cox,
Megan Sova-Tower, and
Nathan Wear
University of Northern Iowa

Journal of STEM Arts, Crafts, and Constructions
Volume 3, Number 1, Pages 61-77.

The Journal's Website:
http://scholarworks.uni.edu/journal-stem-arts/

Abstract

Is there water on Mars? Gifted adult graduate students, some of whom represented the learner exceptionalities of Autism Spectrum Disorder and Slow Information Processing Speed, were asked to explore this mystery by applying Edward de Bono's CoRT thinking skills of "Aims, Goals, and Objectives," "Select," and "Planning" to photographs of Mars landforms. Once they had determined the likelihood that the pictures depicted water on Mars, students were asked to develop three-dimensional models with recycled materials. Analysis of the findings revealed that in utilizing the de Bono CoRT thinking skills, students were able to identify sixteen different categories. Student responses had three similar themes. The first theme was "whether the land mass had the characteristics of water," the second theme was "similarities to areas on Earth," and the third theme was "conducting research in books and journals." Following analysis of the question, "Is there water on Mars?" all students expressed their beliefs that the photos depicted water on Mars. Students in the class provided the following as their reasons for this conclusion: the photograph had "characteristics of water," the photograph had "similarities to land masses on Earth," and the photograph reinforced "research supporting the presence of water on Mars." Student confidence and engagement in the lesson increased with the use of both the de Bono CoRT thinking skills and hands-on learning.

Key Words

Mars mysteries, twice exceptional gifted students, Autism Spectrum Disorder, Information Processing Disorder, Edward de Bono CoRT Thinking Skills, arts integration

Introduction

For centuries, humans have hypothesized whether water might be present on Mars. As the closest planet to Earth in the solar system and most similar in development and atmosphere, the presence of water on Mars would mean the possibility of life. At first, this exploration was limited to the observations of astronomers. The National Aeronautics and Space Administration's (NASA's) recent unmanned missions to Mars, including the Mars Odyssey and Mars Reconnaissance Orbiters, along with their rovers Spirit, Opportunity, and Curiosity, beamed back pictures which seemed to present evidence of water on Mars in liquid or ice form and evidence of erosion which presupposed the presence of water in Mars's past.

Without the ability for humans to see and test these assumptions in person on the surface of Mars, people are forced to hypothesize based on the evidence in the photographs and scientific analyses made available. Too often, people jump to conclusions regarding what is seen. To encourage students to explore as many options as possible during the example lesson presented in this article, the authors employed Edward de Bono's concept of lateral thinking to solve problems through a more indirect and creative approach (de Bono, 1970). Students were asked to

apply de Bono's CoRT thinking skills (de Bono, 1985) to pictures of landforms or landscape on Mars that might or might not depict water. The point of the lesson was not to solve these Mars mysteries but to expand student's ways of approaching the problem – through brainstorming, research, art, and engagement. The lesson was designed with de Bono's CoRT thinking skills to challenge gifted learners who are twice-exceptional, being exceptional in being gifted along with being exceptional in having the learning disability of Autism Spectrum Disorder and/or Information Processing Disorder. The authors hypothesized that by applying the de Bono CoRT thinking skills and adding an arts-integrated project to the lesson would both increase the number of ideas generated by the students and the level of engagement of the students.

Literature Review

To best understand the history and current evidence regarding the possible presence of water on Mars, as well as best apply the latest educational theories and pedagogical methods for the gifted learner's exceptionalities, the authors examined the literature in each area to inform their lesson planning. First, information regarding possible water on planet Mars will be explored. Then, the literature on gifted learners with autism spectrum disorder will be briefly reviewed. Finally, the literature on gifted Learners with information processing disorder is discussed.

Water on Mars as Depicted in Photos of the Mars Surface

The notion of water on Mars has its beginning in the observations of astronomers as far back as 1777 (Harland, 2005). In 1781, William Herschel calculated the rotational period of Mars as 24 hours 39 minutes and 22 seconds; periodicity surprisingly similar to that of Earth (Harland, 2005, p. 5). Herschel was also one of the first astronomers to identify the presence of a Mars atmosphere.

Astronomer G.V. Schiaparelli sketched the surface of Mars in 1888, depicting *canali*, meaning channels: "The canali run from one to another of the dark areas, usually called seas, and form a well-marked network over the bright part of the surface" (Schiaparelli, cited in Harland, 2005, p. 12). Percival Lowell (1896) proposed these canali were an irrigation system by which Martians moved the apparent dearth of water on the planet's surface (Harland, 2005, p. 17). Lowell's work later inspired H. G. Wells to write *War of the worlds* (Wells, 2005, 1898).

It was not until Mariner 4 in 1965 that the world caught the first glimpses of the Mars surface, a cold, cratered wasteland that had more in common with the Moon than with Earth (Taylor, 2009, p. 30). Almost a decade later in 1971, Mariner 9 provided higher resolution imagery of a more water-friendly planet with "sinuous channels, resembling riverbeds, complete with tributaries and deltas," and ridges and valleys in the northern polar ice cap that "spoke of long-term climatic change" (Taylor, 2009, p. 35). The Viking orbiters (1976-1980) "revealed even more channels and valley networks across the Martian surface, along with evidence for possible ancient shorelines of a long-gone ocean in the northern plains" (Harrison, 2017, p. 24). The Viking orbiter photos have been examined by countless scientists, many of whom believe they depict outflow/flood channels, "such as those of the Channeled Scablands of eastern Washington (Baker, 1982; Carr, 1996, p. 56).

The more recent NASA missions of the 1997 Mars Global Surveyor, the 2001 Mars Odyssey, Mars Exploration Rovers, and Mars Reconnaissance Orbiter, as well as the European Space Agency's (ESA) Mars Express in 2003, have provided more detailed photos and evidence of water on Mars. Surveyor's Thermal Emission Spectrometer detected crystalline hematite, or iron oxide (a mineral requiring the presence of water to form), from orbit in Meridiani Planum, an area roughly the size of Illinois (Harrison, 2017, p. 24). NASA chose this site as the landing location for the Mars rover Opportunity in 2004, which not only verified Surveyor's findings, but also discovered "other mineralogical evidence for ancient surface and subsurface water in the region" (Harrison, p. 24-5).

With evidence of past Martian water apparent not only on the Martian terrain but in the rocks and on their erosive surfaces, scientists moved on to determining whether liquid water existed on present-day Mars. While many scientists believe that almost all water on Mars today exists as ice owing to the planet's low average global temperature (-82 degrees

F), pictures from the surface have caused some scientists and amateurs alike to insist that flowing liquid water has previously existed and may still exist. The availability of NASA Mars exploration photos on the Web has resulted in the development of amateur web sites such as Mars Anomaly Research which presents "hard verifiable surface water in a liquid state" through the examination of Mars photos depicting what the researcher believes is liquid water in craters, lakes, and river formations on the Mars surface (Skipper, 2014).

The Mars Reconnaissance Orbiter discovered features dubbed "slope lineae – dark streaks that form on steep slopes during warm periods, grow incrementally over short periods of time, and then gradually fade" (Harrison, 2017, p. 27). The shape and growth of these slope lineae may be been formed from liquid water. This discovery was widely reported in October 2015 as evidence that liquid water flows on today's Mars (Space Daily, October 1, 2015). A study in recent issue of Nature Geoscience suggests that the slope lineae may be the result of granular flows like sand and dust (Dundas, McEwen, Chojnacki, Milazzo, Byrne, McElwaine, & Urso, 2017). Now that evidence related to water on Mars has been discussed, attention is turned to the disabilities of twice exceptional students that were accommodated through the lesson.

Gifted Learners with Autism Spectrum Disorder

The first exceptionality, "high functioning autism," refers to a broad spectrum now known as "Autism Spectrum Disorder (ASD)." As the name states, this disorder is measured on a continuum from high functioning Autism (Autism Spectrum behaviors as well as high functioning intellect) to low functioning Autism (nonverbal, IQ below 70). According to the article, "Critical issues in the identification of gifted students with co-existing disabilities: The twice-exceptional" (Gilman, Lovecky, Kearney, Peters, Wasserman, Silverman. 2013), students that have a diagnosis of ASD often suffer from anxiety triggered by sensory overload, have poor executive functioning skills, often find communication difficult, and have social/emotional deficits. These students are often overlooked because teachers are not able to "see" any deficits on the surface or because they are judged based on their disability and not their intellect. "If these twice-exceptional children are not given appropriate remediations because they score too high on academics, then they are being deprived of the chance for a productive adult life" (Gilman, et. al., 2013, p. 8). Identification of twice-exceptional students and accommodate for their needs is therefore critical. Recognition of exceptionalities and implementation of necessary accommodations such as: written directions instead of verbal directions, quiet work space, step-by-step directions, social stories, visual aids, extended time to complete assignments/tests, awareness of sensory needs, review of socially appropriate behavior, among others, is important. Additionally, students with difficulties in their executive functioning skills and a diagnosis of ASD are often seen as more of a "behavior problem" than someone that needs specific accommodations to succeed. This mistaking of disabilities for misbehaviors tends to mask the twice-exceptionality of the student.

One recommendation by the authors is for educators to be vigilant in reporting performance concerns in otherwise intelligent and high-achieving students. Educators must be able to identify twice exceptionality when, "...symptoms (low achievement by high functioning students) often present a conundrum" (Gilman, et. al., 2013, p. 13).
Many different strategies for those with a diagnosis of Autism Spectrum Disorder exist. An old saying suggests, "If you know one person with Autism... you know one person!" Each person diagnosed with ASD is unique as are the strategies that can help that individual. Each person has a different set of talents and abilities; therefore, they don't all need the same strategy. A few strategies are: increased wait-time to respond and to create products; provide summary or outline of ideas; calculator available; and the use of word webs and graphic organizers (Newman, 2007).

Strategies that might help a student who is considered twice-exceptional (gifted and talented along with Autism Spectrum Disorder) can include: visual schedules, visual directions, shortened assignments, limited verbal directions and more use of written/visual directions, check-schedules, time limits, multiple opportunities to show mastery, verbally completing a task instead of writing, headphones, small amount of noise or limited strong smells (Newman, 2007). Communication and executive functioning skills can be a struggle for those with ASD (Gilman et al, 2013).

Strategies to help students communicate as well as stay organized, understand social/emotional exchanges, or knowing how to ask for help, are all areas that might need strategies or accommodations implemented for the twice exceptional student with a diagnosis of Autism Spectrum Disorder. According to results of a case study of a student with ASD (Durrani, 2014), arts can provide an alternative way of self-expression for such students, which is particularly helpful in cases when language development is delayed. In the same fashion, arts integrated activities are beneficial for gifted learners because they offer a multitude of ways of self-expression and communication of the newly acquired knowledge (Cornett, 2015, p. 564). Visual arts integrated activities may also aid in making the students less sensitive to certain textures which may have been unpleasant to them (Durrani, 2014).

Gifted Learners with Information Processing Disorder

Along with a diagnosis of ASD (Autism Spectrum Disorder), another exceptionality that many twice-exceptional students present is that of "information processing disorder." This label refers to someone who has difficulty with the input and/or output of information. This difficulty can often be seen in twice exceptional students who may understand and learn material but need additional accommodations to process and/or communicate their understandings. Often those with a diagnosis of an information processing disorder have difficulty with executive functioning skills, as well as interpretation of information. Accommodations for information processing disorders can include: increased wait-time to respond and to create products; provide summary or outline of ideas; calculator available; use of word webs and graphic organizers (Kelly, 2017).

The authors of an article titled, "An operational definition of twice exceptional learners: Implications and applications" (Reis, Baum, & Burke, 2014) found a definite need for attention to twice exceptional learners with learning impediments such as information processing disorder. Many times these students do not fit the traditional definitions of "talented and gifted" nor do they fit the definitions of a person with a disability. As is the case with students who struggle with information processing; just because the way they receive and give information is different or must be altered, does not mean they do not understand or think beyond the material. "A simple observation of behaviors associated with a definition can lead to misidentification without examining the context in which these behaviors occur and the ability to view the behavior through multiple lenses and possibilities" (Reis, Baum, and Burke, 2014, p. 220). Having a unique "comorbidity" results in a student with a unique set of skills that must be acknowledged. As with ASD, those with information processing disorders have a specific set of cognitive and psychosocial needs. The difficulty a student has expressing or organizing thoughts verbally or in writing may manifest into negative behaviors if not recognized and accommodated.

In addition to a variety of ways of self-expression, arts integrated activities teach students to organize their thinking, for example, through selection of appropriate dance elements (Cornett, 2015, p. 397) or through applying the beginning-middle-end format common in many areas of the arts, such as drama (Cornett, 2015, p. 330). Finally, arts develop higher order thinking skills by providing a chance for the students to practice mental experimentation and viewing a problem from multiple perspectives (Cornett, 2015, p. 75). Any definition of twice exceptional students must also acknowledge that talented and gifted can coexist with disabilities.

The Lesson

The lesson presented in this article was conducted on November 11, 2017. The lesson began with a projected slide presentation that introduced the topic of water on Mars through a brief verbal presentation and video followed by the presentation of three pictures from the surface of Mars that may or may not contain evidence of water on Mars. Following a presentation of the two gifted learner exceptionalities and accommodations, students were asked to participate in three de Bono thinking skill activities and one art project depicting their impressions of water on Mars. The lesson took a total of 40 minutes to complete.

Participants

Twenty-one adult participants (14 white, 4 Black, 3 Asian; 11 male, 10 female with a mean age of 38 years) engaged with the lesson activities. These participants were high-achieving doctoral students who may be considered to be gifted and talented students.

Lesson Procedures

The lesson began with a brief overview of the literature and findings related to water on Mars and the presentation of a video overview of the topic titled, “There's water on Mars, but is there life?” (Sample, 2015).

Mars photographs. Next, three photos were presented which supposedly depicted bodies of water on Mars. The first image showed a tan crater with a circular blue-white area that resembled snow or ice inside the crater and a frosting of possible snow along one side (European Space Agency, 2005). The authenticity of the photographs had been previously determined, and all three photos were from either ESA Mars Express or NASA Mars Reconnaissance Orbiter missions. Figure 1 and Figure 2 show NASA images used in the lesson. In presenting the photos, information about how and when the photos were taken was presented. The only prompt was for the students to examine the photos and determine for themselves whether they felt they depicted water on the surface of Mars.

Figure 1. This image from the High Resolution Imaging Science Experiment on NASA's Mars Reconnaissance Orbiter shows "Victoria crater," an impact crater at Meridiani Planum, near the equator of Mars. The crater is approximately 800 meters (half a mile) in diameter. It has a distinctive scalloped shape to its rim, caused by erosion and downhill movement of crater wall material. Layered sedimentary rocks are exposed along the inner wall of the crater, and boulders that have fallen from the crater wall are visible on the crater floor. The floor of the crater is occupied by a striking field of sand dunes (NASA/JPL/University of Arizona, 2017). Image Courtesy NASA/JPL/University of Arizona

Figure 2. Sulfate Strata in Ius Chasma (NASA, 2006). Image Courtesy NASA.

Explanations of exceptionalities. Following the presentation of the photos, the gifted learner exceptionalities - Autism Spectrum Disorder (ASD) and slow information processing speed – were presented. For each of these exceptionalities, the accommodations made in the lesson were detailed. For example, the authors provided very clear, explicit directions for the tasks on the handouts, and noted when social interaction needed to take place in verbal directions. For slow information processing speed, the authors gave more time to individuals to complete the tasks and added a goal statement at the beginning of every exercise. Exercise packets were then provided to each student in the class (see Appendix A). Students were asked to put their names at the top of the packet to help determine who participated in the exercise.

Student activities A, B, C and D. Activity A presented the de Bono CoRT skill "Aims, Goals, and Objectives." The Aim of examining a picture of Mars to determine landform characteristics that may OR may not support water and the Goal of determining if photos of landforms can be bodies of water on the planet Mars were

both provided by the instructor. The students were asked to brainstorm three things they could do to best determine if a landform were really water on Mars. Students completed this activity individually and then discussed the answers with the others at their table. The activity took approximately ten minutes.

Activity B presented the de Bono CoRT skill "Select." Students were given three options: to read an article, watch a video, or examine the pictures from the presentation. Students were asked to give a reason why they made their selection. Students also completed this activity individually. The activity took approximately five minutes to complete.

Activity C presented the de Bono CoRT skill "Planning". Students were asked to transfer their answers from the first two activities to this worksheet and to answer the questions in Step #4. Students needed to answer whether or not they felt that the landforms presented in the pictures were bodies or water and then give three reasons why they thought that was the case. This activity took approximately five minutes.

The worksheet for the final activity (Activity D) was distributed (see Appendix B) and students were again asked to write their name on it. Students used recycled materials to create an art project that resembled water. Recycled materials provided included cardboard, yarn, tissue paper, aluminum foil, and plastic shopping bags. Art supplies such as pipe cleaners, cotton balls, Popsicle sticks, glue, crayons, colored pencils, and markers were also provided to the students. The worksheet asked students to provide a list of the materials they used, to check off various parts of the activity as complete (sketch an outline of the project, etc.). Lastly, students were asked to provide a description of their final product, including why it looks like a body of water. The activity culminated with each student sharing a brief description of his or her art project to the class. This activity took approximately 20 minutes. All of the worksheets were collected at the culmination of the lesson and each of the art projects was photographed for later examination.

Results and Discussion

An analysis of each of the de Bono skill activities was conducted using a spreadsheet. For activity A, the analysis included the compiling of all responses to the de Bono CoRT skill "Aims, Goals, and Objectives." organizing them into categories, and then determining the frequency of each. The same analysis was conducted for the other de Bono skills – "Select" and "Plan" - though for each the author also asked students to either select a way to investigate further or answer a question and those results were compiled separately.

Thinking Skill Responses to Activity A. The task for Activity A received a total of 63 responses from the students in the class. See Table 1. These 63 responses were divided into sixteen categories. The most popular categories were "Has characteristics of water" (9 or 14%), "Identify similarities to areas of the Earth" (9 or 14%), and "Conduct research in books or journals" (8 or 13%). Some of the answers such as "Conduct research in books or journals," "Watch a video," "Study Mars Pictures" (14 or 63 or 22%) anticipated responses to the next activity. Four responses, "Conduct a scientific test," "Use de Bono skill," "Use imagination," and "Visit Mars and see for myself," were unable to be categorized with others, therefore forming categories of one. The sheer diversity of the answers demonstrates the power of the de Bono technique to encourage students to think about what avenues are available to them.

Table 1. *De Bono Thinking Skill: Aims, Goals, and Objectives*

Category	Frequency
Has characteristics of water	9
Identify similarities to areas on Earth	9
Conduct research in books, journals	8
Speak with an expert	6
Discuss with class/peers/someone else	5
Utilize existing knowledge	5
Visit NASA website	4
Study Mars pictures	3
Watch a video	3
Determine authenticity of the pictures	2
Find other pictures of water on Mars	2
Make my own assumptions	2
Conduct a scientific test	1
Use de Bono skill	1
Use imagination	1
Visit Mars and see for myself	1

Thinking Skill Responses to Activity B. For Activity B, a total of ten students (48%) chose the video, six (28%) chose the article and five (24%) chose the Mars pictures to learn more about the topic. See Table 2. During the activity, the authors made the mistake of not providing devices for students to view the videos or provide the article in print. Luckily many of the students had their own devices and so there was a relatively even distribution of students who selected each of the options. The majority of students who chose the video (70%) stated they did so because they were visual learners. A similar percentage (67%) chose the article because they preferred reading. Three students seemed to misunderstand the question and stated that they made their selection based on reasoning related to their beliefs about water on Mars. By allowing students to choose the information format that best met their learning style, students with wither ASD or Slow Information Processing Speed could be accommodated.

Table 2. *De Bono Thinking Skill: Select*

Category	Frequency
Visual learner	7
Prefer reading	4
Reason for believing water is on Mars	3
Like videos	2
Photo was only mode available	2
Different choice than my partners	1
Interested in photos	1
Liked video from presentation	1

Thinking Skill Responses to Activity C. Activity C asked students to review what they had learned from the previous two activities and decide whether they thought the pictures in the presentation depicted bodies of water. Students were asked to stand to represent their answer. A surprising 100% believed the pictures depicted bodies of water on Mars. This result was not what the authors expected. Perhaps the authors did too good a job of providing the background evidence regarding the possibility of water on Mars. An analysis of the student's responses regarding why they answered this way illustrates their reliance on perception and other research.

The top three responses were "Has characteristics of water" (25%), "Identify similarities to areas on Earth" (22%) and "Research supports water/life on Mars" (16%). These answers directly align with the top three responses given by students in the first activity regarding Objectives. In each case, the number of responses increased. The remaining answers both aligned with other responses from Activity A such as "From the video," "Made my own assumptions," "Experts" and represented other, new responses for example, "NASA naming of Mars locations".

In general, participating in the de Bono thinking skill activities made the students more confident in their answers. Students seemed highly engaged in the activities, as was represented by the collaborative and engaging conversations taking place at the tables, even when the activities were to be conducted individually, the sharing of devices when it came to viewing the videos and articles for Activity B, and the evidence of learning that took place as students codified their learning. Figure 3 shows students engaged in Activity C.

Unsurprisingly, studies have shown that students who used this problem-based approach showed significant student gains in pretest/posttest assessments of science content, interest, and descriptive vocabulary (Rule & Barrera, 2006). Conducting a pretest/posttest exercise to determine the breadth of learning that occurred as part of this lesson would be interesting as a future investigation.

Table 3. *De Bono Thinking Skill: Plan*

Category	Frequency
Has characteristics of water	16
Identify similarities to areas on Earth	14
Research supports water/life on Mars	10
From the video	7
Made my own assumptions	3
From the presentation	2
No other explanation	2
Definition of life	1
Experts	1
From NASA research	1
From the article	1
Mars exploration evidence	1
NASA naming of Mars locations	1
Photos from NASA	1
Utilize existing knowledge	1

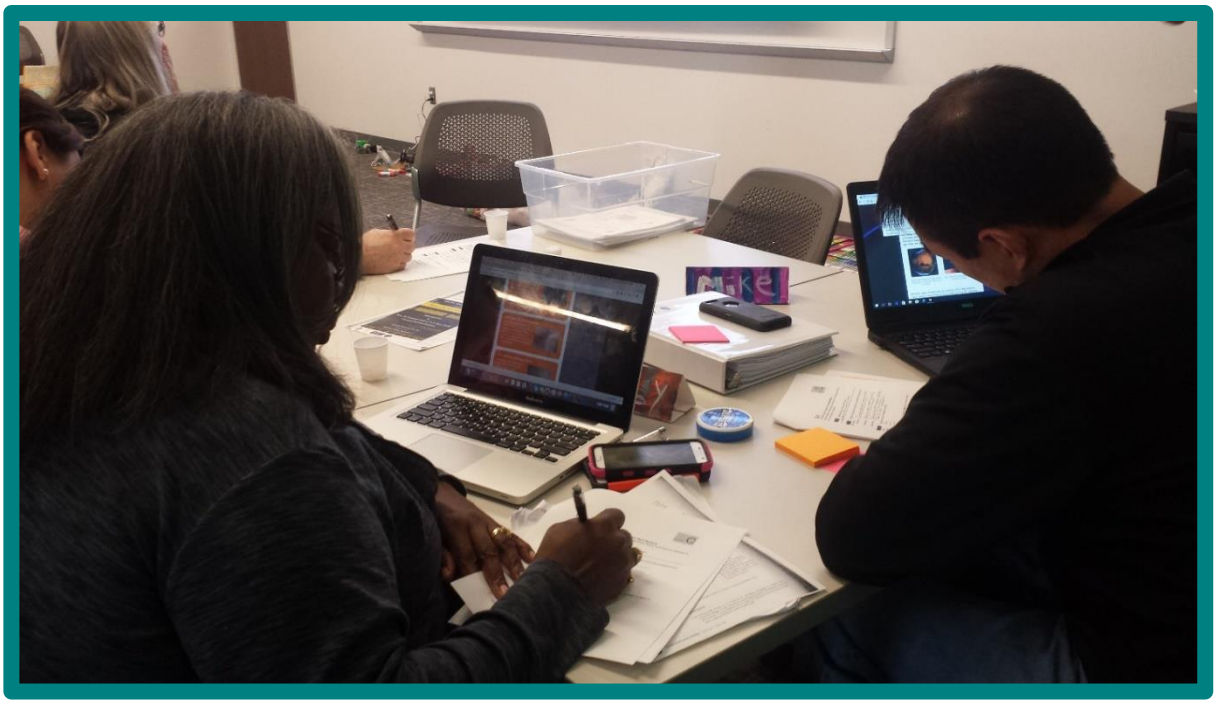

Figure 3. Students engaged with Activity C

Results of Activity D. The art project (Activity D) was by far the most fascinating and the most engaging of the activities conducted. The authors expected the activity would take about ten minutes, but it ended up taking double that because of student interest. As mentioned previously with the exceptionalities, giving more time for projects is one of the expected accommodations. The authors witnessed students sharing art materials and discussing their designs with other students. This level of engagement has been noted in other hands-on student activities such as mobile gaming (Atwood Blaine, Huffman, 2017) and STEM Learning Centers (Donegan-Rotter, 2015).

While many of the art projects depicted water filled craters, they displayed a startling degree of creativity. Almost all of the projects were unique in some way. Many students used a variety of media (Saran Wrap, tape, colored paper, etc.) to represent water. Additionally, students used a variety of media (cardboard, holiday lights, boxes, etc.) to represent altitude gradients on the Martian surface. Using recycled products allows for gifted students who have additional exceptionalities to make choices they are comfortable with and demonstrate creativity. See Figure 4.

Figure 5 shows six images of creative models that students made during Activity D. The first model on the top left shows a three dimensional water feature using various blue colored pipe cleaners. The next model, located in the top row center, features a creative layering process in which cotton balls reflect formations on Mars's surface with a water feature sunk below the surface. The third photo at top right suggests a possible water cycle on the Martian surface that could produce liquid water. A fourth student used transparent tape to mimic waves on a Martian surface, as shown at bottom left. The water feature is then sunk below the surface. The fifth picture at lower center provides creative uses of color and ribbon to mimic water on the surface of Mars. Finally, the sixth student used cardboard to create a tiered elevation on the Martian surface filled with water (lower right image).

Figure 4. Photographs of students engaged in making models with recycled and craft materials.

Figure 5. Models made by students during the lesson.

Conclusion

The application of de Bono CoRT skills to this Mars Mystery lesson successfully increased the variety of answers given by the participants and assisted them in becoming more confident in their methods of inquiry. Both the application of the de Bono skills and the art project encouraged active student engagement and learning. Particularly, the CoRT thinking skills were employed to strengthen academic performance of twice exceptional students with Autism Spectrum Disorder and information processing disorder. The "Aims, Goals, and Objectives," "Select," and "Planning" CoRT thinking skills in combination with the arts-integrated activity provided necessary scaffolding and structure for the twice exceptional students and allowed to split a complex task of investigating a Mars water mystery through a set of distinct steps implemented in activity A, B, C, and D. The arts-integrated project, in addition to providing student engagement and heightened attention, allowed them to practice various means of self-expression and communication of a science-related concepts and ideas through art.

Future studies might explore the connection between de Bono skills on student decision-making and response confidence when presenting a lesson that includes a difficult issue with no clear right or wrong answer. The correlation between student confidence with their answers and satisfaction with the lesson or increases in engagement and learning would also be of interest.

References

Atwood-Blaine, D., & Huffman, D. (2017). Mobile gaming and student interactions in a science center: The future of gaming in science education. *International journal of science and mathematics education*, 15(Supplement 1), 45-65.

Cornett, C. E. (2015). *Creating meaning through literature and the arts*. Boston, MA: Pearson.

Baker, V. R. (1982). *The channels of Mars*. Austin, TX: University of Texas Press.

Carr, M. H. (1996). *Water on Mars*. New York, NY: Oxford University Press.

de Bono, E. (1970). *Lateral thinking: A textbook of creativity*. London, England: Penguin Books.

de Bono, E. (1985). The CoRT thinking program. *Thinking and learning skills*, 1. 363-88.

Donegan-Ritter, Mary. (2017). STEM for all children: Preschool teachers supporting engagement of children with special needs in physical science learning centers. *Young Exceptional Children*, 20(1), 3-16.

Dundas, C. M., McEwen, A. S., Chojnacki, M., Milazzo, M. P., Byrne, S., McElwaine, J. N. and Urso, A. Granular flows at recurring slope lineae on Mars indicate a limited role for liquid water. *Nature geoscience*, 2017. Retrieved from https://www.nature.com/articles/s41561-017-001205.

Durrani, H. (2014). Facilitating attachment in children with autism through art therapy: a case study. *Journal of Psychotherapy Integration, 24*(2), 99-108.

European Space Agency. (2005). Mars Express. These images, taken by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, show a patch of water ice sitting on the floor of an unnamed crater near the Martian north pole. Retrieved from http://www.esa.int/Our_Activities/Space_Science/Mars_Express/Water_ice_in_crater_at_Martian_north_pole.

Gilman, B., Lovecky, D., Kearney, K., Peters, D., Wasserman, J., Silverman, L., . . . Rimm, S. (2013). Critical issues in the identification of gifted students with co-existing disabilities. *SAGE Open*, 3(3).

Harland, D. M. (2005). *Water and the search for life on Mars*. Berlin, Germany: Springer.

Harrison, T. (2017, July). The past and present of water on Mars: Mars has evolved from a lush water planet to a frigid desert, yet water persists there today. *Astronomy*, 45(7), 22+. Retrieved from http://go.galegroup.com/ps/i.do?p=ITOF&sw=w&u=uni_rodit&v=2.1&it=r&id=GALE%7CA492665004&asid=e58471463fdd7d8b4a05f3738ccaa982

Kelley, Kate. Processing speed: What you need to know. Understood for learning and attention issues.

Retrieved from https://www.understood.org/en/learning-attention-issues/child-learning-disabilities/information-processing-issues/processing-speed-what-you-need-to-know.

NASA. (2006). 'Victoria Crater' at Meridiani Planum. This view is a portion of an image taken by the High Resolution Imaging Science Experiment (HiRISE) camera onboard the Mars Reconnaissance Orbiter spacecraft on Oct. 3, 2006. The complete image is centered at minus7.8 degrees latitude, 279.5 degrees East longitude. Retrieved from https://www.nasa.gov/mission_pages/MRO/multimedia/pia08813.html.

NASA confirms evidence that liquid water flows on today's Mars. (2015, October 1). *Space Daily*. Retrieved from http://go.galegroup.com/ps/i.do?p=ITOF&sw=w&u=uni_rodit&v=2.1&it=r&id=GALE%7CA430391779&asid=68dbbe4fffc6385fb9deb81b7c1a3824

NASA/JPL/University of Arizona. (2017). High Resolution Imaging Science Experiment. Sulfate Strata in Ius Chasma. ESP_012625_1720. Acquisition date 06 April 2009. Latitude (centered) -7.903° Longitude (East) 276.499°. Retrieved from https://hirise.lpl.arizona.edu/ESP_012625_1720.

Newman, L. (2007). Facts from NLTS2: Secondary school experiences of students with autism. Menlo Park, CA: SRI International. Retrieved from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=NCSER20073005

Reis, S. M., Baum, S. M., & Burke, E. (2014). An operational definition of twice-exceptional learners: Implications and applications. *Gifted Child Quarterly*, *58*(3), 217-230.

Rule, A. C., & Barrera, M. T., III, (2006). CoRT thinking skills guide PBL science. *Academic Exchange Quarterly*, *10*(4), 145-149.

Sample, I. (2015, September 30). There's water on Mars, but is there life? – video. Retrieved from https://www.theguardian.com/science/video/2015/sep/30/mars-water-is-there-life-video/.

Skipper, J. P. (1994). Mars anomaly research: In pursuit of the planetary truth. Retrieved from http:// http://www.marsanomalyresearch.com/.

Taylor, F. W. (2009). *The scientific exploration of Mars*. Cambridge, England: Cambridge University Press.

Wells, H. G. (2005). *The War of the Worlds*. 1898. *The Complete Science Fiction Treasury of HG Wells*, 265-388. New York, NY: Harper and Brothers Publishers.

Appendix A

Activity: A

Name _____
De Bono Thinking Skill Activity

[I can use the De Bono Thinking Skills (AIMS, GOALS, OBJECTIVES) to determine if NASA pictures of landforms could be bodies of water on the planet Mars]

AIM:

Examine a picture from Mars to determine landform characteristics that may OR may not support water.

GOALS:

My goal is to determine _____

OBJECTIVES:

List three ways (objectives) that will help you figure out if a landform is really water on Mars.
(EXAMPLE: I can use Google to look up different pictures of Mars)

1.

2.

3.

DONE: ☑ **Move on to activity B**

Activity: B

SELECT:

[I can pick ONE (1) of these three ways to investigate this Mars Mystery]

1. Read this article- Water on Mars: Exploration and Evidence (Handout)
https://spaceplace.nasa.gov/mars-adventure2/en/

OR

2. Watch this YouTube video- https://www.youtube.com/watch?v=n2o65UsFR9o

OR

3. Select one of the pictures- Talk with a table partner about what features you see. What do you know about water on Earth? Does that look similar or different than these pictures from Mars?

****

I selected _____ (put the number), because _____

_____.

DONE: ☑ **Move on to activity C**

Activity: C

PLAN:
[I can develop a plan for to support or reject this Mars Mystery]
Follow the steps below- include your goal, your objectives (AGO), and what you selected to study. Write the steps to your plan below.

STEP #1 **I will determine what my goal is and write it here:**

_____

STEP #2 **I will write 3 ways (objectives) that will help me determine if the pictures show water on Mars:**

Objective #1. _____

Objective #2. _____

Objective #3. _____

STEP #3 **I will select one way to investigate: (check one)**

Article _____
Youtube _____
Pictures _____

STEP #4 **I will determine if what I am investigating MAY be a body of water on Mars or MAY NOT a body of water on Mars.**

I have determined by my research and study:

_____ **Mars Landforms MAY be Bodies of Water**

_____ **Landforms MAY NOT Bodies of Water**

There are 3 reasons I made this choice:
1.

2.

3.

DONE: ☑ **Move on to activity D**

Appendix B

Activity: D

Mars Mystery Art Project

[Using recycled materials I can create a project that resembles water]

Follow the steps below and check off when you complete them.

STEP #1

Pick the materials you would like to use (at least 3 or more).

List them here: _____, _____, _____,

_____, _____

STEP #2

Draw a rough draft of your idea on the blank piece of paper at your table.

STEP #3

Create your body of water using the materials you chose.

STEP #4

When your body of water is complete, check with a teacher.

(TURN PAPER OVER)

STEP #5

Fill in the blanks below:

My finished project is _____.

It looks like a body of water because _____

_____.

The materials I used were:
_____, _____, _____

I used them because _____

_____.

STEP #6

Put project and completed activity sheets A-D into the box at the front of the classroom that says, "DONE."

DONE: