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Tackling Literacy: A collaborative approach to developing materials, for assessing science literacy skills in content classrooms through a STEM perspective.

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Defining the Problem

For content area teachers trying to embrace the incorporation of the Common Core Learning Standards for Reading and Literacy (Common Core State Standards Initiative, 2018) into their classrooms, understanding the best practices for accomplishing this task while enhancing presentation of content specific material can be challenging. According to the Nation's Report Card, only 37% of our 12th graders are reading at or above proficiency level (Nation's Report Card, 2015). Shanahan & Shanahan (2008) argue that "disciplinary literacy" — advanced literacy instruction embedded within content-area classes such as math, science, and social studies — should be a focus of middle and secondary school settings." With this in mind, our Literacy Professional Learning Team (PLT) in the NYS Master Teachers Western Region was generated to study literacy skills in our STEM content-area classrooms.

The goal of the initial eight members was to discuss strategies for developing and evaluating Literacy in STEM (Science, Technology, Engineering, and Mathematics) classrooms. Our group's purpose for the inaugural year was based on the idea that "Scientific literacy enables people to weigh options and make informed decisions as individuals and as citizens of democracy" (Annelli, 2011). Weak literacy skills in this area would make it difficult to perform tasks in their daily lives. Tasks we assume all members of society can complete successfully such as the ability to correctly read and use an advertisement, understanding the main purpose behind a newspaper article, and comprehending medical instructions related to a medication.

Keeping the focus on the development of an informed citizen, it was important to realize the difference between *scientific literacy* and *literacy in science*. The implication was that the latter needed to take precedence in the educational process. A student competent in literacy in

science had the ability to transfer the skills mastered to multiple content areas, whereas scientific literacy focused on skills specifically related to the comprehension of scientific literature and content.

Our Literacy PLT was formed. Our purpose was established. The problem was how to begin. The freedom of our PLT structure allowed for teachers (from different science fields) to share ideas and so our PLT started their journey. Members shared materials and techniques they used in class. But each discussion led us back to the question, what do we mean by "literacy in science?"

What are the skills needed to make our students capable of understanding and using the materials provided? Should we focus on ways to introduce content specific vocabulary? Is grammar and computer-use literacy required for the development of strong skills? Where does the reading of graphs and tables fall in literacy skills? Or, should we find an approach to develop skills involved in each situation?

Based on the ideas centered on the need to develop strong literacy skills, we elected to isolate specific literacy skills needed to improve student understanding of their world. In addition, we believed that development of curricula around popular media would engage the students. Our PLT leader happened to read the *The Martian* and realized that it would be a great way to develop materials for the classroom that are current and entertaining for the students since the popular book centered around a Mars astronaut caught in a dangerous situation, which included multiple connections and reference to science that were accurate.

Rationale for Work

In 2003, the National Assessment of Adult Literacy (NAAL) administered an assessment of English literacy to over 19,000 adults over the age of 16. Most participants took the assessment in their homes and some while in prison. Adults with less than or some high school education were found to be below basic proficiency for prose and quantitative literacy. The results also showed these adults to be at the low end of basic proficiency for documentative literacy (NAAL, n.d.). In 2011-2012, another large-scale assessment of adult skills called Program for International Assessment of Adult Competencies (PIAAC) was administered. The results for adults within the United States did not change significantly from the 2003 assessment given by the NAAL (NAAL, n.d.). There are clearly a considerable number of adults in the United States whose literacy skills are insufficient for the demands of contemporary life in our society. (Smith, M.C., n.d.) Adults lacking documentative literacy skills will find it difficult to locate and use information contained in various formats including job applications, payroll forms, transportation schedules, legal documents, newspapers, maps, tables, charts and food or drug labels. Reading and literacy skills must be taught and learned, and the process must continue in all content areas in the middle grades, high school and beyond (Willard & Hasselbring, 2014). It is the responsibility of all educators to greatly improve these literacy skills in our students so they are able to be successful as adults doing everyday tasks.

Our research ignited an interest in seeing if our students have problems comprehending literacy based on the reading tasks they encountered on a daily basis. Questions that emerged included: do the students have the correct knowledge and literacy skills to make sound decisions based on what they read or see in popular media? Can the students judge if information in books similar to *The Martian* are presenting accurate, realistic ideas in a fictional setting or can the students identify when fictional information is being presented as fact?

Isolating an Approach

Our answers came from a variety of resources but were focused on two specific sources: an article by Irina Holden entitled *Predictions of Students' Attitudes Toward Science Literacy* and the National Assessment of Adult Literacy (NAAL) from http://nces.ed.gov/naval/index.asp. Holden's paper (2012), supported the previously discussed ideas of NAAL, and our mission of not only assessing literacy skills of students but to evaluate the students' perceptions of their literacy skills. Holden explained that an understanding of students' perceptions of science literacy enhances teachers' understanding of the students and helps the classroom teacher to design curricula and classroom activities better tailored to their attitudes and expectations.

In addition, our approach included NAAL's assessment based on three types of literacy. These literacy skills are needed in order for adults to perform daily life skills, (National center for education statistics, n.d.). The Assessment divided literacy into three categories: Prose (focus on reading comprehension skills), Documentative (reading of graphs, maps, tables…), and Quantitative (computations completed based on information given).

Methodology

Our group used both the NAAL and the ideas from Holden to develop a three-question assessment which would include a question for each type of literacy along with a student perception of their success in completing the task parallel NAAL's results.

Our pre-assessment consisted of three questions selected from the NAAL that focused on literacy skills important to science classrooms (See Appendix A). The questions also fell under

the concept of Information Literacy which Holden (2012) describes as the ability to locate, evaluate and use information correctly.

- Our Prose question required reading a passage and identifying the main idea.

- Our Documentative question involved looking at a graph and table, extracting important information and labeling the graph correctly.

- Our Quantitative question required the calculation of a sale price using information from an advertisement.

Once the pre-assessment was developed, members of our PLT elected to administer it to their students to see how the student literacy skills compared to data from NAAL's assessment.

PLT members surveyed 486 of our students. The students ranged from grades 8-12, and included 8th grade science, biology, earth science, chemistry, and physics. Our six school districts assessed varied in size, location, and socio-economic conditions with a third rural, and the remainder of our students were part of larger suburban populations. All students completed the same question set during April of 2015 with the intent of gathering data from the responses to answer the following research questions. How do our students (grades 8-12) perform on the three types of literacy questions? And, how do our students' perceived scores relate to their actual scores on these items?

Results and Discussion

Of the three types of literacy assessed, students in grades 8-12 did the best on the Prose question with 65% of them getting it correct. Surprisingly, the Prose question alone showed a progression of skill development starting with a 41% score in 8th grade and ending with an 88% in 12th grade. The 9th graders struggled the most with the Documentative question with only 11%

correctly responding while 42% of the 11th graders mastered the question resulting in an average

29% of the students responding correctly to the Documentative question. The greatest deficiency

in literacy was the Quantitative question. Only, 15% of the students had correct responses to the

Quantitative question with a median score of 9 % received by the lowest two grades in the study

and the 11th graders lead with only 23% successful. While it was expected that younger students

would struggle more than older students, it was eye opening to see that only 21% of the 12th

graders could answer the Quantitative question correctly. As stated previously, the students'

stronger performance on the prose question was expected since it is a skill that consistently was

reinforced across content areas and grade levels throughout their academic studies. The concern

exposed in the data was the weakness highlighted in documentative and quantitative questions.

In the STEM class, there is a higher degree of focus on documentative and quantitative literacy

which may contribute to students struggling with these formats of questions which are common

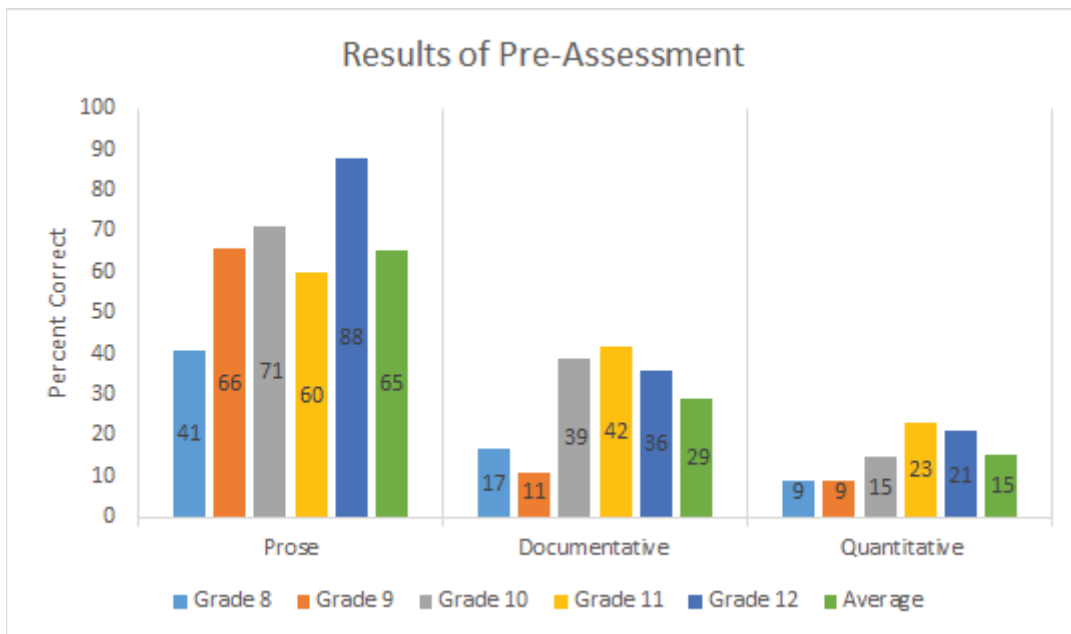on STEM assessments. The results are posted in Figure 1.

Figure 1. Grade Comparison for Pre-assessment

Our most dramatic finding was the mismatch between the students' scores and their perceived mastery of their skills. With each question, students were asked to rate their perceived mastery of the skills needed to answer the question. As shown in the Figure 2, the majority of the students agreed with the statement that "I have mastered the literacy skills necessary for answering this question" for both the Documentative and Prose questions. When analyzing the Documentative question specifically, 80% of students rated themselves as mastering the skills while only 29% of them actually answered it correctly. Students felt confident that they knew how to answer the problem when in fact the majority of them were answering the questions incorrectly.
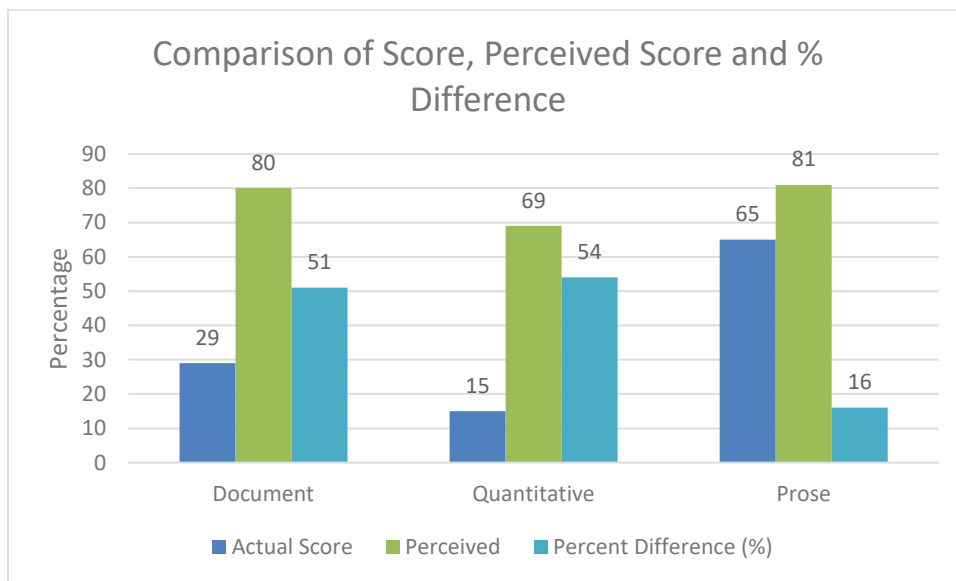

Figure 2. Actual versus Perceived Comparison

It is healthy for students to have self-efficacy and to believe that they can perform a required task in order to be successful with the task (Bandura, 1997). However, Bandura (1997) also described in his research the idea of reciprocal causation. He explains that accurate task

completion requires both the skills necessary and the self- efficacy beliefs to execute the task. The functioning of one component is dependent on the other. Our students may have been over confident on their level of task mastery. This phenomenon of overconfidence is not uncommon in decision related tasks (Stone, 1993).

The implications from our survey were clear. We needed to find more successful ways of explicitly incorporating science literacy skills within our classrooms, and we needed to help students who struggle with these types of questions to become more adept at noticing when they are being successful and when they need to keep refining their responses. There is a growing concern among secondary educators with the lack of information literacy skills observed in our students. Holden (2012) warns that if we don't address information literacy, then our students will not be prepared for the challenges of dealing with the rapid changes in the information landscapes. But the broader implications of repeated indications of gaps in students' information literacy skills are a significant indicator that schools must assume a larger responsibility for information literacy instruction. Leaving skill development to the post-secondary environment will not ensure that citizens are sufficiently skilled to participate fully (Julien & Barker, 2009).

Implementation Suggestions

As our team discussed each pre-assessment question, it became evident that questions like these could be developed and used in many science disciplines as well as other content areas. Even though some content area teachers believe that they are unable to do literacy activities in their classroom, our goal was to inspire these content area teachers to develop cross-curricula lessons based on books students are interested in reading and illustrate how easily they could be used to develop curriculum or update curriculum currently in use.

Our direction for starting the development of a curriculum resource became clear after a member of our PLT read Weir's (2014) The *Martian*. Multiple sections of the book perfectly fit the format of each type of literacy. As a group, our literacy PLT decided to read *The Martian* (Weir, 2014). Each member of the group was assigned selected chapters to develop Quantitative, Document and Prose questions. Many of the questions we developed could be used in all content areas. For the purpose of this paper, we focused on the development of document-based literacy materials due to the fact that multiple content areas would benefit from growth of these skills.

 (Sample Documentative question in Appendix B)

Once the bank of materials was prepared, each teacher selected a method of use which best fit the class instruction. Some teachers, especially in grades 7th-9th, elected to design a cross-curricular approach with the ELA teachers. The teachers collaborated to align content in the book for use in the ELA classroom with science topics covered in the science classroom. Other teachers used selections of the text, after viewing a trailer of the movie, to practice science skills such as dimensional analysis or graphing as means to reinforce the use of these skills in a more entertaining way. The bank of materials proved to be highly adaptable to multiple forms of implementation.

We selected one documentative question that matched the skill development needed in multiple content areas both within and outside of the STEM fields because it focused on a students' ability to read and analyze graphs, charts, maps, even political cartoons. The example we included required the students to identify locations on a map provided to get a better visual for the events being described in the story. The skills needed to properly complete the map included application of latitude and longitude coordinates, knowledge of compass rose headings,

use of a map scale, and drawing conclusions based on their plot and calculations. This particular question was documentative in its focus on the map and also provided an opportunity to practice quantitative skills. Teachers could guide a student through this problem to build these skills. A question of this nature would also be an appropriate assessment for a class that has worked previously on both skills. The teacher would easily identify when a student is successfully applying the documentative and quantitative strategies or could isolate the student's weaker skill, allowing for the development of further materials to refine the skills that require extra attention. Realization that documentative literacy is fundamental to the success in all content areas bolsters the need for teachers K-12 to place specific emphasis on the skills in the classroom.

As a group, the members of our PLT successfully used the curriculum materials to enhance and engage students' understanding of concepts. The map question showcased in this paper was used in multiple Earth Science classroom to develop mapping skills that utilized the concept of longitude and latitude. The use of the popular genre help students understand that the content was a current skill used in some fields. In one of our chemistry classrooms, materials generated where used to show how conversion factors of all kinds can be used to complete dimensional analysis problems as long as the reader isolates the correct relationship. Our work inspired the middle school teachers involved with the project to acquire the Young Readers edition of *the Martian* so that they could collaborate with the ELA teachers to develop a cross-curricula experience for the students that was age appropriate.

The Next Step

The greatest outcome of our work is the future prospects. Armed with a greater understanding of the fundamental skills that need to be developed, the NYS Master Teacher

Western Region Literacy PLT lives on. We continued to look for other activities that could be used to support content and literacy growth in the class such as games that require comprehension to complete a specific task on a document or calculate a specific outcome. Some teachers have encouraged the development of cross-curricular activities related to *the Martian.* Others have continued the same curriculum development techniques with other books such as The *Immortal Life of Henrietta Lacks.* We have a greater awareness of the literacy skills needed to tackle specific state assessment questions and some have elected to develop specific materials to aid in literacy skills to mastered exam content.

Outside of our PLT and classrooms, we continue to advocate for the growth of more professional development opportunities for teachers to collaborate together. While the organization of teachers from multiple districts in a region is challenging, the opportunities to collaborate within a district to develop curriculum both in a cross-content or linear aspect is easier to start. Our hope is that administrators will see the value in giving the teachers the autonomy to design district PLT's guided by the common goal of addressing literacy skills.

Appendix A

Pre- Assessment

Use the information in the table to complete the graph below. Label the axes and plot the points showing U.S. imports from OPEC and non-OPEC countries.

NAAL Printed Material Text Alternative

U.S. Petroleum Imports by Source
Source: Department of Energy
(in thousands of barrels per day)

Nation	1974	1975	1976	1977	1978
Algeria	207.1	288.2	438.3	565.2	632.1
Indonesia	310.9	437.7	569.4	576.2	538.2
Iran	731.0	524.8	546.5	786.4	544.7
Libya	40.3	329.3	529.3	837.7	641.1
Nigeria	912.2	837.8	1,119.2	1,229.6	904.7
Saudi Arabia	675.2	891.6	1,365.8	1,523.8	1,137.2
United Arab Emirates	87.8	154.2	323.2	446.3	378.4
Venezuela	1,457.8	1,030.1	972.2	908.8	633.5
Other OPEC[1]	217.0	259.3	216.0	378.1	224.0
Total OPEC	**4,669.3**	**4,753.0**	**6,079.9**	**7,252.2**	**5,636.9**
Arab OPEC Members	1,106.4	1,790.1	2,773.0	3,636.5	2,920.8
Bahamas	159.3	152.0	116.5	168.0	158.4
Canada	1,067.6	845.2	599.3	502.8	468.6
Neth'lands Antilles	509.6	323.6	274.6	218.3	317.8
Puerto Rico	90.4	89.7	88.1	102.8	230.1
Trinidad/Tobago	241.2	240.9	272.6	286.0	89.4
Virgin Islands	391.7	406.5	422.3	468.7	251.0
Mexico	8.4	71.4	87.1	179.3	426.8
Other non-OPEC	384.2	306.1	373.5	657.1	649.9
Total non-OPEC	**2,852.4**	**2,435.4**	**2,234.0**	**2,583.0**	**2,591.5**
Total Imports (avg.)	**6,112.0**	**6,056.0**	**7,313.0**	**8,714.0**	**10,843.7**

(1) Ecuador, Gabon, Iraq, Kuwait, Qatar. (2) Imports do no add to totals because OPEC figures include petroleum transshipped through, and usually refined in, other countries and counted again as imports from those countries.
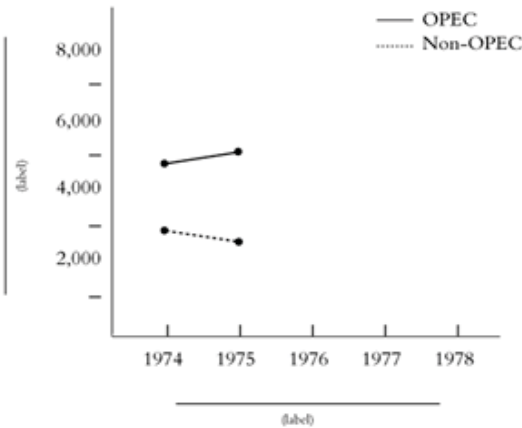
I have mastered the literacy skills necessary for labelling the axes of a graph

- Strongly disagree
- Disagree
- Not sure
- Agree
- Strongly agree

Suppose that you want to carpet your living room which is 9 feet by 12 feet, and you purchase DuPont Stain master carpet at the sale price. Using a calculator, compute the total cost, excluding tax and labor, of exactly enough carpet to cover your living room floor. Show your work below. Circle your answer.

The Carpet Store

DUPONT STAINMASTER CARPET

41% OFF DUPONT STAINMASTER

Incredible savings on carefree DuPont carpet.
Your choice of the many luscious colors.
Reg. 15.99

9.49 sq. yd. with Padding

ONE WEEK ONLY!
SAVE ON EVERY STYLE
EVERY COLOR
STAINMASTER

I have mastered the literacy skills necessary for calculating the cost of the carpet required.

- Strongly disagree
- Disagree
- Not sure
- Agree
- Strongly agree

Write one sentence that explains why the investigating committee thinks these practices are dangerous.

Panel: Sloppy work perils nuke plants

By THOMAS O'TOOLE
Washington Post

WASHINGTON—After investigating corruption in two of the nation's largest construction unions, the Senate Labor Committee charged Wednesday that so many incompetent welders and engineering technicians are helping build nuclear power plants it constitutes a national safety hazard.

"Unqualified workers have been routinely referred for work as skilled craftsmen, working qualification tests have been circumvented and favoritism is rampant in choosing who will work," according to a 72-page report released by the majority staff of the Senate Labor Committee.

The committee spent two years investigating the International Brotherhood of Boilermakers and one year investigating the International Union of Operating Engineers.

The report concluded that "new legislation to certify workers and make test cheating and extortion a federal crime is needed to ensure the safety, proficiency and durability of . . . construction sites."

The committee said that one of the most serious practices it uncovered is the sale of union cards for as much as $1,600 to welders who never took qualifying tests.

The committee also charged that experienced welders routinely took tests for inexperienced welders, who were then put to work on jobs that included the Three Mile Island and Beaver Valley nuclear plants in Pennsylvania and the Perry, Ohio, plan near Cleveland.

The committee said that one witness testified that "60 percent of the welders he worked with on the [TMI] fuel pool [where spent radioactive uranium was kept under water] were not qualified for the union journeyman books they held and had bought their books 'right on the job.'"

Another witness said that "some of the worst work I've ever seen" was done at the TMI fuel pool. The witness said "incompetent welders" made up to 25 or 30 bad welds in the pipe used to carry radioactive fuel, the report said. The witness added that the welders covered mistakes by "washing the bad welds down with a torch to make them all look uniform."

_____
_____

I have mastered the literacy skills necessary for determining why the investigating committee thinks these practices are dangerous.

- Strongly disagree
- Disagree
- Not sure
- Agree
- Strongly agree

Appendix B

Sample Questions from *The Martian*

Sample Document Question

Read the passage from p.88 of *The Martian* and complete the map and questions.

Passage

"He drove straight away from the Hab for almost two hours, did a short EVA, and then drove for another two. We think the EVA was to change batteries. …He's seventy-six kilometers from the Hab," Mindy said. "…He went south-southwest."

"Okay, maybe there's hope," Venkat said. "What's he doing right now?"

"Recharging. He's got all the solar cells set up," Mindy said.

"…We'll see what he does tomorrow."

p. 92, the next day:

"Still going in a straight line," Mindy said, pointing to her monitor.

"I see," Venkat said. "He's sure as hell not going to Ares 4."

"…He did the usual two-hour drive, EVA, two-hour drive. He's one hundred and fifty-six kilometers from the Hab now."

"…Wait…" Venkat said. "Wait, no way…"

"What?" Mindy asked.

Venkat grabbed a pad of Post-Its and a pen. "Give me his location and the location of the Hab."

Mindy checked her screen. "He's currently at … 28.9 degrees north, 29.6 degrees west." With a few more keystrokes, she brought up another file. "The Hab's at 31.2 degrees north, 28.5 degrees west. What do you see?"

…Looking at his Post-It and sliding his finger along the map, he drew an X. "That's the Hab," he said. …Then he drew another X. "That's his current location. Get me a ruler."

Mindy looked left and right. Seeing no ruler, she grabbed the technician's notebook. …Using the notebook as a straight-edge, Venkat drew a line from the Hab to Mark's location and beyond. Then he took a step back.

"Yup! That's where he's going!" Venkat said excitedly. "Pathfinder!"

Map

Questions

Then, do the following:

1. Draw the line that Venkat drew.

2. Use the map's scale, plot two Xs to indicate Mark's position on that line after day 1 and day 2 of driving. Label them 1 and 2.

3. Label the latitude and longitude of the Hab and his second day position is indicated by Mindy.

4. Based on this information, mark appropriate values on the latitude and longitude lines on the map between Ares 3 (the Hab's location) and Pathfinder.

5. Determine the amount of distance Mark still had to go to reach Pathfinder after the second day. Assuming it takes him 8 more Sols to get there from his day 2 position, what is his rate of travel in kilometers per Sol?

Using document based questions allows students to read for information and incorporate that material into well thought out answers. Students may have to construct a drawing, develop a list, or develop an outline. Again, all of these skills are important in every content area.

These developed skills are important for inquiry lessons.

Acknowledgement

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