

Introducing the ASSIST Approach to Preservice STEM Teachers

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Abstract

The Argument-based Strategies for STEM Infused Science Teaching Approach (ASSIST) is a pedagogical approach based on the Science Writing Heuristic (SWH). In addition to framing instruction around the SWH approach, ASSIST emphasizes the use of multimodal communication, focuses on purposeful integration of mathematics, technology, and engineering in science learning, and provides templates to help teachers plan activities and units aligned with the approach. The authors of this paper have utilized the approach in their classrooms as well as helped inservice teachers understand and utilize the approach through professional development. Recently, the authors have also begun to develop and implement methods courses for preservice elementary and secondary science teachers based on the approach. In this article, an engaging activity based on a card trick is described that introduces preservice students to the SWH as a way to promote more general understanding of the approach. The goal of the activity is to help the preservice students identify the major characteristics of the SWH approach that is central to the ASSIST approach while simultaneously experiencing the potential for student learning the approach provides and the connections to development of an appropriate view of the nature of science. This sets the stage for future learning related to implementing the overall ASSIST approach in classroom settings.

Introduction

Science and STEM teachers are faced with an ever-increasing list of characteristics to include in their instructional repertoires. Adoption of the Next Generation Science Standards (NGSS) in many states (NGSS Lead States, 2013), the momentum surrounding STEM and STEM education (ACT Inc., 2014; LaForce, Century, Noble, Holt, & King, 2014), and the encouragement to contextualize literacy development within disciplines (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) all call for science teachers to examine their pedagogical and instructional ideas. The desire to incorporate aspects of all these separate “calls-to-action” can overwhelm teachers. The Argument-based Strategies for STEM Infused Science Teaching (ASSIST) approach is one attempt to provide teachers with a framework to develop engaging science learning environments built on characteristics of all the aforementioned initiatives, as well as tools to help teachers plan and implement instruction based on the approach. In working with both inservice and preservice teachers to help them understand and utilize the ASSIST approach, we have developed an activity based on a card trick designed to introduce the characteristics

of the approach. The goal of the activity is to provide an engaging entry point to explore some of the core aspects of the approach as a way to set the stage for further learning about how to implement the approach in classroom settings. In this article, we first describe the theoretical background and framework of the ASSIST approach, followed by a description of the activity we have utilized to introduce the approach. We conclude by providing suggestions for future use.

Theoretical Background and Overview of the ASSIST Approach

The ASSIST approach is based on several research supported ideas. These ideas are related to important recent initiatives in science education. In this section, a brief discussion of the foundational ideas supporting the ASSIST approach will be provided, as well as an overview of the general aspects of the approach.

Argument-based Practices

The ASSIST approach is fundamentally an attempt to encourage immersive, argument-based inquiry in science classroom settings as these have been shown to improve student learning (Hand, Cavagnetto, Chen, & Park, 2016). Argument-based Inquiry (ABI) strategies promote a classroom environment in which students are encouraged to actively engage in negotiation of meaning throughout the learning process. This negotiation of meaning should be both personal and social (Hand et al., 2016). Personal negotiation involves individual students clarifying their own understanding of targeted scientific concepts through continual engagement in the development of claims supported by evidence. The claims/evidence process, however, takes place in a social environment in which peers argue the validity of claims and evidence based on both observational data from testing procedures and consultation with expert sources. The social negotiation ideally leads to group consensus of a shared understanding that has been built through engagement in argument with different-sized groups. The social and personal negotiation of meaning serve as iterative catalysts in an ongoing search for meaning making (Hand, 2007; Hand et. al, 2016). The goal of the ASSIST approach is to not only encourage beneficial argument and negotiation, but to make the classroom environment an immersive argument-based situation in which continual cycles of refinement of understanding result from a progressively more “natural” infusion of argument and negotiation into classroom activity.

The specific ABI approach forming the foundation of the ASSIST approach is the Science Writing Heuristic (SWH). The SWH advocates for classroom activity in which authentic student questions lead to the development of student designed tests to gather observations and data. The observations are then utilized by students to form claims that are supported by evidence. In this way, science practices (NGSS Lead States, 2013) are integrated with argument and negotiation (Hand, 2007). Students engage in argument about the strength of claims and evidence as a means for both modeling the way science knowledge is developed in real world scenarios, and as a way for developing conceptual understanding of targeted

concepts. The student developed claims are also compared to information from sources of scientific information, including journals, textbooks, and outside experts in the field. Finally, students are asked to reflect on their understanding and the process that led to that understanding, and are often engaged in the development of communication pieces to convey this information to peers and outside audiences (Hand, 2007; Gunel, Hand & McDermott, 2009). The SWH approach has been consistently shown in a variety of situations to not only promote development of conceptual understanding of science ideas, but also improve mathematical understanding, critical thinking, awareness of the nature of science, and development of literacy skill (Hand, 2007; Akkus, Gunel, & Hand, 2007).

Multimodal Communication

One key component of the SWH is the infusion of written communication throughout the process. In these tasks, students are encouraged to write in non-canonical formats to authentic audiences as a way to clarify their own understanding of targeted science concepts (McDermott & Hand, 2015). Previous research supported the benefit of these types of writing tasks, both as recognized by researchers and as recognized by students themselves (McDermott & Hand, 2010). The benefit from these tasks was at least partially attributed to student engagement in “translations” between the language of the classroom, the language of the discipline, the language the student typically utilized, and the language of the authentic audience. As students cognitively worked through these translations, they were able to better identify the gaps in their own understanding and then work to improve that understanding (Gunel, Hand, & McDermott, 2009; McDermott & Hand, 2010).

This idea of translation in communication has been expanded to include utilizing multiple modes of representing scientific information outside of text. Much current research is exploring both the theoretical foundation for potential benefit from this type of communication as well as the pedagogical implications related to these sorts of tasks (Prain & Hand, 2016). In general, these tasks encourage students to not only use different modes to represent their scientific understanding, but also encourage the effective integration of the modes in the communication. This effective integration involves both the understanding of the benefits and drawbacks, as well as the affordances and constraints of different modalities for communication (Tytler & Hubber, 2016), but also the consideration of effective strategies to link different modes referring to similar ideas (Gunel et. al, 2016). Student development of a “multimodal competency” has been shown to be positively impacted through engagement with instruction aimed at helping students recognize and utilize strategies for integration (McDermott & Hand, 2015). In addition, students who display a greater degree of integration in their communication tasks have also been shown to exhibit improved conceptual understanding (McDermott & Hand, 2013). Again, the multimodal communication can be both a way to demonstrate and model how scientists communicate and a way to help students develop their understanding. The intentional use of multimodal communication is another critical aspect of the ASSIST approach.

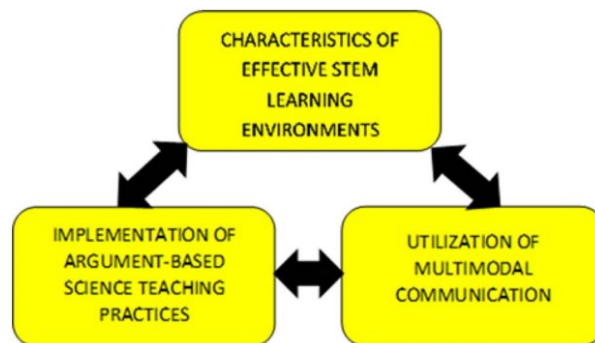
STEM Integration

Although no universally agreed upon definition of STEM and STEM education exists, most definitions in some way incorporate the critical idea of “integration” (Becker & Park, 2011). For example, Vasquez, Sneider & Comer (2013) define STEM as “an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering and mathematics and integrates them into real-world, rigorous, and relevant learning experiences for students,” (p. 4). The goal for most advocates of STEM education is to move beyond a singular focus on just one of the disciplines within the STEM fields toward the consideration of how learning opportunities can involve multiple disciplines (Asghar, Ellington, Rice, Johnson & Prime, 2012).

Emerging research is beginning to provide suggested characteristics of what effective integrated STEM learning environments include. For example, the Outlier Research Center at the University of Chicago recently examined several STEM schools as a way to help “identify and describe the components that are most related to desired student outcomes” (LaForce et al., 2014). Their project, known as the STEM School Study (S3) project, identified several key components of effective STEM learning environments. These components included a clear focus on cognitively demanding targeted concepts, staff developed curriculum, development of multi-disciplinary teams, authentic problems and questions, collaboration with peers, and use of emergent technology.

While the ASSIST approach emphasizes the characteristics above as a way to develop an effective STEM learning environment, unlike some other STEM approaches, the ASSIST approach is squarely focused on the development of targeted science conceptual understanding. The goal in the approach is for students to utilize, and recognize the importance of other STEM disciplines in order to develop a true, and thorough, scientific understanding aligned with the philosophy of the NGSS and the *Framework for K-12 Science Education* (NGSS Lead States, 2013; National Research Council, 2012). We do not view this as separating science content from the other STEM disciplines, but rather enhancing science literacy through the use of the other STEM disciplines. For example, the ASSIST approach could be utilized to help teachers develop unit plans designed to engage students in understanding a scientific “big idea” such as the relationship between forces and motion. However, the fundamental perspective guiding the approach would posit that a deep understanding of forces and motion would necessitate the use and understanding of key mathematical concepts and practices, engagement with technology, and the ability to apply the scientific understanding in an engineering context. Figure 1 below represents the three key research based factors infused in the ASSIST approach.

Figure 1 (Click on image to enlarge). Research-based aspects of the ASSIST approach.



Alignment with Next Generation Science Standards

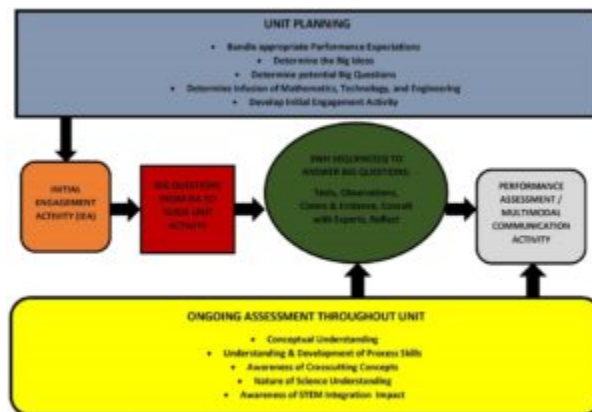
A recent major change nationally in science education has been the advent and promotion of the Next Generation Science Standards (NGSS). The NGSS provide educators with guidance in terms of the conceptual big ideas that students should engage with, the science and engineering practices that students should utilize, and the crosscutting concepts that emerge across all science disciplines (NGSS Lead States, 2013). However, although the NGSS and the *Framework* document that they were built on advocate a “3-dimensional” instructional approach in which students engage simultaneously with the three aforementioned aspects of science learning, they do not provide a specific instructional approach or specific guide to planning. Those decisions are left to individual teachers, schools or districts, as they are seen as ways to encourage locally relevant and authentic implementation of the NGSS (National Research Council, 2012; NGSS Lead States 2013).

The ASSIST approach embraces the philosophy of empowering teachers to develop their own unit plans and activities, based on the NGSS, but in a relevant, locally contextualized way. However, experience with professional development activities related to the SWH has indicated the need for some scaffolding to help teachers capture the essence of the approach in a way that is flexible enough to apply to their own specific, locally relevant links to the standards (McDermott & Kuhn, 2015). Taking all these ideas into account has led to the development of tools and templates to help instructors develop unit plans, based on big ideas from the NGSS that allow for a sequence of activity utilizing the SWH approach with multimodal communication, and realizing the characteristics of the effective STEM learning environments.

Overview of Aspects of the ASSIST Approach

The overall ASSIST approach, therefore, includes not only the advocated argument-based SWH that the approach is based on, the emphasis on multimodal communication, and the encouragement to incorporate the characteristics of effective STEM learning environments, but also tools that have been designed to both plan for and assess student activity. Figure 2 below provides an overview of the ASSIST approach built on the theoretical ideas described in this section.

Figure 2 (Click on image to enlarge). Overview of ASSIST approach.



Description of Activity to Engage with ASSIST Approach

The ASSIST approach combines many research supported practices in science teaching and learning, but is fundamentally based on the SWH argument-based approach. It likely not only represents a new method of instruction and planning for preservice teachers, it is also quite likely different from the way preservice teachers have learned science through their own experience as students. In addition, many of our preservice elementary education students are to some extent apprehensive of science concepts and lack confidence in their own science understanding. Therefore, in order to help introduce the fundamental aspects of the approach to preservice teachers, to help them experience the learning potential associated with designing and carrying out instruction in this way, and to do so in a non-threatening way that is not focused on science content, we have developed an engaging card trick activity. The activity is primarily focused on helping preservice teachers with little experience in immersive, argument-based learning environments to experience the SWH aspect of the ASSIST approach in a way that sets the stage for future learning about the overall ASSIST approach, including the tools we have developed to help with planning and implementing the approach. The activity is not designed to develop a complete understanding of the entire ASSIST approach, rather it is focused on providing an entry point to the approach, as well as an anchoring activity that can be consistently referred back to as a deeper understanding of the overall approach is developed throughout the remainder of the course. In this section we describe the activity itself as well as point out ways the activity can be utilized to model some specific aspects of the ASSIST approach and effective science teaching in general.

General Overview of Activity

The activity is focused on the participants engaging in trying to figure out how a particular card trick works. Throughout the experience, we try to accomplish three main goals:

- 1. Figure out how the card trick works and why the card trick works.** The authentic task that the participants are faced with is to determine *how* a card trick that they observe works and *why* it works. All activity that participants engage in is designed to ultimately answer these two questions.

2. Identify the characteristics of the SWH framework that are critical to the ASSIST approach. As participants engage in answering the overall questions, they progressively encounter the characteristics of the SWH that the ASSIST approach is built on and these are made explicit. In addition, ways to infuse mathematics, technology, and principles of engineering are also discussed, ideally as they naturally emerge in the context of trying to answer the big questions driving the activity.

3. Discuss how the activity demonstrates the nature of science. In the experience, the card trick itself is modeling some aspect or experience in nature that calls for an explanation. As the participants attempt to develop their answer using the practices of the SWH, they are also asked to make connections to how the overall experience is related to how science knowledge is developed in general. The parallels to appropriate views on the nature of science, and how this relates to the type of instruction advocated in the NGSS, are drawn and identified.

Getting Started

The initial engagement with the participants involves the instructor asking all students to observe a card trick that he/she performs with one volunteer student. This emphasizes the importance we place on an engaging “initial” activity to start an ASSIST unit of study that leads to the emergence of authentically developed questions of student interest that can be answered using the SWH framework. The card trick we typically utilize is commonly known as the “21 card trick” and involves the participant picking one of 21 cards dealt into 3 columns of 7 cards. The participant tells the instructor which column their selected card is in. The cards are then picked up, with the instructor placing the pile containing the participant’s card in between the other two columns. The instructor then deals the cards out into three columns by completing each individual row before moving to the next row, and the participant is again asked which column their card is in. This process is repeated one final time. After the cards are dealt a third time, the participant’s card is always the fourth (middle) card in the column they indicate their card is in. At this point, the instructor can utilize a number of different ways to eventually “reveal” the selected card. An internet search for “21 card trick” will result in multiple step-by-step instructions for the trick (e.g. https://www.youtube.com/watch?v=_RS79RionDU&t=60s).

After the initial observation of the trick, the participants are asked to brainstorm what they know about card tricks in general. These ideas are shared and discussed as a group. All participant responses are communicated and recorded, but one key response is emphasized. This critical response is the “big idea” that a card trick, rather than actually being “magic,” is in reality some process or series of steps that the person playing the trick is aware of and the crowd or audience is typically not aware of. Therefore, we assume any specific “trick” we observe actually has some potentially explainable process behind the

outcome that is observed, even if that process is not immediately (or in some cases ever) perceived or understood by the audience. This is recorded publically as a “big idea” about card tricks.

This is also an ideal way to initiate discussion about how this is the same philosophical perspective taken when applying scientific procedures to try to determine “how nature works.” In the case of science, we assume natural events are the result of potentially explainable, repeatable processes that are not always immediately perceptible or understood by humans. And, as in the case of the card trick, in science, we do not accept as scientific, answers to how nature works that rely on information that is outside of our senses, precisely because we cannot rule out these sorts of explanations.

At this point, we ask the participants what questions they have about what they observed, and discuss how this is similar to scientists having questions about interesting or strange occurrences in nature. Ideally, either a large majority have questions similar to the two we would like to deal with in the activity (how did the instructor do the card trick and why does the card trick work?) or several individual questions can be grouped together into these two overarching questions. We then ask the participants if they would like to observe the card trick again, but now with the two questions we are attempting to answer in mind.

The conversation surrounding this important overarching idea and the questions participants have allows the instructor to explain to the participants they will be engaging in an activity that will ideally help accomplish the three goals mentioned at the beginning of this section. Often, when utilizing this activity, we designate three separate areas in the classroom to record information related to each goal. One area will be labeled “What We Know about the Card Trick,” one is labeled “What Did We Do,” and the third is labeled “Characteristics of Science.” We then add the big idea and the questions the class has generated to the first area and the information just discussed about the nature of science – the idea that science is a process that tries to determine how nature works, it assumes that nature is built on repeatable processes, and that it relies on and demands empirical evidence in attempting to answer questions about how nature works – to the third area.

At this point we also point out that two main aspects of effective instruction (which are also critical to the SWH process) have been modeled up to this point in the lesson. First, we have generated a class “big idea” that future student activity can help develop a deeper understanding of. Secondly, we discuss the fact the student questions have now been generated that can provide the motivation for engaging in the processes of science as we attempt to develop a better understanding about some event we are curious about. These instructional characteristics are recorded in the “What Did We Do” section.

Modeling the SWH as a critical component of the ASSIST approach

At this point, we ask the participants how scientists would go about answering their questions. When participants inevitably describe a process of experimentation and testing, we encourage them to utilize decks of cards in the classroom to design and run their own tests. In addition, at this point, we point out on the “characteristics of science” recording area how science, rather than employing a strictly linear process called “the scientific method,” utilizes certain typical processes and shared “habits of mind” to answer questions. These processes are then demonstrated as the participants attempt to answer the two questions related to the card trick. This process allows us to capture the aspects of the SWH approach we are hoping to model.

Tests

In the SWH sequence, student-generated questions are investigated through the development and implementation of student-generated tests. In the card trick activity, we encourage the participants to record, and collect observations from whatever tests they develop. Importantly, we continue to emphasize the importance of the link between the questions and the tests that they design. Participants are continually asked to justify how and why their test is related to the questions they are attempting to answer. In addition, participants are asked to explain why the tests that they are developing are “valid” testing procedures. The discussion surrounding valid testing procedures can link to conversations about the characteristics of science and how the makeup of the testing procedure will impact how strong the claims emerging from the data analysis will be.

Observations / Data

As the participants gather observations from the testing procedures they are developing, they are encouraged to record the information they are obtaining. Rather than providing the participants with a specific data table or graphic organizer to fill in, participants are encouraged to record their observations in whatever manner makes the most sense to them. In addition, the importance of having a mode of presenting and communicating the collected information to an outside audience that was not present during the testing procedures is emphasized. Finally, encouraging participants to consider how the representation of the data collected facilitates the recognition of patterns and trends in the data for further interpretation is encouraged.

Claims & Evidence

Once participants engage in their testing procedures and accumulate data, they are then asked to make claims that answer the questions driving the experience. The claims need to be supported by evidence. In this phase, discussion focuses on the idea that claims attempt to answer the questions driving the investigation and that evidence is the interpretation of data, combined with participant prior knowledge that supports the claims made. Participants are asked to communicate their claims and evidence to other groups and discussion among groups about the level of agreement among different claims and the strength of different claims is encouraged. As this discussion progresses, the participants are encouraged to

think about how this type of activity mirrors the activity that scientists engage in as they make sense of their own data, develop justifications for their claims from their interpretation of data, argue that their testing procedures allow for valid claims, and evaluate the claims and evidence of other scientists. The students are asked to periodically reflect on these connections as the activity progresses by directly asking them questions about these connections as they emerge in the activity. This conversation highlights the tentative yet durable nature of science, in that although different claims about how the card trick is done can be supported to differing degrees, there will never be an ultimate level of certainty based on the inability to comprehensively rule out all possible alternative explanations.

Consulting with Experts

Finally, the claims and ideas that participants generate throughout their experience are compared to outside sources of information about card tricks. Typically, participants will explore online resources to collect information about similar card tricks and how they are carried out. As participants engage in this consultation, we discuss the need for scientists to compare their claims and evidence with those of others studying similar phenomenon. In addition, this portion of the activity allows for discussion about the overarching type of student activity advocated for in a classroom utilizing this approach. Rather than students being provided information about a targeted concept through direct instruction and then running a confirmatory lab procedure, the activity modeled here and encouraged when utilizing the full ASSIST approach, would involve students first developing their own claims about how phenomenon work and then comparing those claims to accepted sources of scientific information.

Multimodal Communication

Although the main focus of this activity is to experience and explore the SWH that is grounding the overall ASSIST approach, the other characteristics of the approach are also modeled to a lesser extent. Throughout the process described here, participants are encouraged to represent their information in multiple modalities. While stressing the importance of communication for scientists, the use of multimodal communication also allows for exploration of how different representations can make explanations more accessible to different audiences, how different modalities can help emphasize different characteristics of explanations, and how re-representing the same idea or concept in different modes can help clarify understanding for the student doing the representing. Multiple opportunities to communicate in this activity, including ways to explain and describe testing procedures, methods of displaying data and observations, and ways to express the developed understanding of how the card trick works can all be utilized to begin to explore ways to utilize multiple modes of representation and communication effectively. For example, one of the authors has asked his preservice students to develop a video explaining the card trick to kindergarten student as a way to model multimodal communication to an outside audience.

Although this aspect of the ASSIST approach is not fully developed in this activity, this provides a reference that can be linked back to in further classroom instruction related to the approach.

STEM Infusion

The experience with the card trick can also begin to facilitate a discussion centered on how the different STEM disciplines can be infused in an approach to teaching science that relies on testing, observations, claims, evidence, and consultation with experts. Different mathematical strategies can be useful in evaluating and in demonstrating the patterns in the trick and discussion can center on why those patterns exist. Technology and engineering can be utilized to develop methods for simulating multiple trials of the card trick without having to physically manipulate the cards, ways to effectively collect and present data and observations, and ways to discover further information about the trick and how it works. For example, one student engaged in this activity created a computer program that simulated systematically changing the starting point of each card in the trick to provide evidence that the card ultimately ended up in the 4th position of the column after 3 consecutive rounds of dealing the cards out. Table 1 below summarizes the different aspects of the SWH approach and how they are modeled throughout the activity, as well as some potential connections to the STEM infused aspect of the overall ASSIST approach.

Table 1 (Click on image to enlarge)

Aspects of SWH and ASSIST Approach Emerging from Card Trick Activity

Aspect of ASSIST Approach	How the Aspect Emerges in Activity
Big Ideas	Students discuss what they know about card tricks and determine card tricks are not magic and have a pattern to them
Questions	Students determine what they would like to know about the card trick
Tests	Students develop methods for testing to determine how the card trick works and why the card trick works
Observations	Students collect data from tests and record the observations in the most effective manner
Claims and Evidence	Students develop claims about how the card trick works and support their claims with evidence from observations and prior knowledge
Consult with Experts	Students find sources of information that supports or refutes their ideas about how the card trick works and why card trick works
Reflection	Students summarize their understanding of the card trick and how it has changed over the course of the activity
Multimodal Communication	Students describe how the card trick works to an authentic outside audience and utilize multiple modes of representation in their communication
Mathematics Infusion	Students identify patterns in data, students attempt to explain why the card trick works through mathematical relationships
Technology Infusion	Students develop simple computer programs to simulate card trick and discover patterns
Engineering Infusion	Students determine goals and constraints for the card trick simulation computer program and modify prototypes they develop

Wrapping Up and Connections to Further Course Activities

Ultimately, a concluding discussion in which students present and debate their final claims about how the card trick works takes place. Upon concluding this discussion, the students are then asked to identify the different characteristics of the activity they have engaged in (most of which have been listed on our “What Did We Do” chart) and a list similar to Table 1 above is generated. At this point, the aspects of the SWH are clearly identified, the idea of multimodal communication is highlighted, and the hope to infuse the other STEM disciplines as a way to develop deep conceptual understanding in science is presented. In addition, students are asked to identify the characteristics of the nature of science that were modeled in the activity and how they were modeled. This typically leads to a list similar to Table 2 below, based on summaries of the tenants of the nature of science from sources such as McComas and Olson (1998) and the NGSS (NGSS Lead States, 2013).

The overarching goal of the instructor at this point is to emphasize to the students that in the process of developing their understanding of the card trick (as they attempted to scientifically answer the questions driving the activity), the students also experienced and modeled the practices of science and experienced and modeled the nature of scientific inquiry and the pursuit of scientific knowledge.

Table 2 (Click on image to enlarge)

Nature of Science Characteristics Emerging from Card Trick Activity

Nature of Science Characteristic	How Demonstrated in Card Trick Activity
Science demands and relies on empirical data	The explanation for the card trick must be supported by observations that came from the senses or enhancement of the senses
Scientific explanations are tentative but durable	Students develop claims that are supported by evidence but realize they must always leave open the possibility for new evidence to emerge that could change their claims
Science has shared characteristics but does not involve a set “scientific method”	Students utilized similar processes to develop their explanations but did not all employ the same set of lock-step procedures
Science is creative	Students utilize a variety of methods to answer their questions
Science is a human endeavor influenced by social and cultural factors	Student claims are influenced by factors outside of data and observations alone
Theories and laws are related but different ideas	Students determine that the “theory” behind the card trick is the explanation of how it works while “laws” refer to relationships
Science assumes a natural order and consistency	Students assumed there was an order and pattern to the card trick that was potentially accessible through testing

Ideally, the preservice students are able to emerge with a greater understanding of how this sort of a learning environment in a science classroom can help their future students develop sound conceptual understanding of fundamental science concepts through the employment of science and engineering practices that demonstrate an accurate view of how science works. This is exactly the three-dimensional learning that the NGSS calls for. At this point, a graphic similar to Figure 2 (discussed earlier in this article) is presented to the students and they are engaged in discussion centered on pointing out that throughout the remainder of the course, an overall approach to planning and implementing a science learning environment with the characteristics encountered in the card trick activity will be addressed. As students engage in further course activities, both the graphic and the card trick activity are continually

referenced. In this way, the card trick activity provides a common experience to both begin the process of understanding the SWH and the ASSIST approach, and to link back to as that understanding is further developed in relation to actual science unit development. For example, one of the authors immediately follows this activity by engaging his students in sequence of activity modeling how conceptual understanding of energy could be developed in a science classroom. As the instructor and the students engage in this activity and discuss the planning associated with developing this activity, the ideas generated in the card trick activity are built on in a more authentic science learning environment.

Student Identified Benefits and Challenges to Address

Our experience using this activity in our preservice methods classrooms (with both secondary and elementary methods students) has allowed us to collect some initial data and feedback on its effectiveness, as well as the challenges preservice students recognize. We have typically utilized the activity in the same way with both elementary and secondary students and received similar reactions. We attained informal qualitative student feedback highlighting evidence supporting our findings of utility of using this activity as a way to introduce students to the ASSIST approach. This feedback is summarized below:

1. Links to Specific Science Concept: It could be argued that engaging students in an activity that not only models the SWH and aspects of the ASSIST approach but also links more directly to a science conceptual focus would be more powerful and more efficient. Many students have actually indicated the lack of a clear link to a specific science concept is a beneficial aspect of this activity. From their perspective, it allows them to focus more directly on the characteristics of the approach itself without having to simultaneously consider science concepts. This is particularly beneficial for our preservice elementary education majors who tend to be less comfortable with science concepts. However, one drawback noted by some students from this lack of connection is that they do not directly experience the benefit of developing science conceptual understanding through the use of the approach advocated in this activity. For some students, there is a difficulty realizing the potential benefit for developing science understanding when they are not directly engaging in the development of their own science understanding. To meet this challenge we follow up this card trick with engagement in learning activities associated with specific science concepts later in the course.

2. Links to Planning Aspects of ASSIST Approach: Although the activity highlighted is effective at helping students identify and experience the aspects of the SWH and multimodal communication that the ASSIST approach is built on, the engagement described here does not typically allow for direct experience with the planning tools associated with the approach. The tools developed for help with the approach are based on planning classroom activity aligned with the NGSS. The fact that this activity is not designed to develop scientific understanding of a targeted science concept makes it challenging to evaluate and interact with the ASSIST planning tools or even explore how this particular activity could have been

designed using the tools. However, the fact that the activity does tend to motivate the preservice teachers to explore the ASSIST approach more deeply in most cases increases interest in the planning tools that are described later in the course sequence. Student feedback has verified this assertion and students often refer back to the card trick activity as a reference point when we discuss the planning tools associated with the approach in later class sessions.

3. Links to Communication: The infusion of multimodal communication is easily accomplished in this activity and can set the stage for further exploration of this technique. Students who are well-versed in literacy strategies and value linking literacy skill development to specific disciplinary instruction have especially indicated interest in the communication aspect of the approach. We often find the emphasis on the “literacy” aspect of science literacy that multimodal communication provides can be an effective hook for some preservice teachers. However, the use of multimodal communication is itself an instructional idea that needs development and further clarification, and for some students, introducing this aspect of the approach as they are also being introduced to the other overall characteristics can be overwhelming. In most cases we provide a more detailed discussion on multimodal communication and its potential in the science classroom as a follow-up to this activity or as a part of discussing further course activities in which specific science concepts are addressed. This follow-up helps emphasize that it is a critical, rather than supplemental, aspect of the approach. Again, students often mention the value of having an initial experience with multimodal communication during the card trick activity as an effective way to increase their interest in further learning about the use of communication in science classrooms.

4. Links to STEM Infusion: While most students are able to identify multiple potential STEM infusion points throughout the card trick activity, it is often most difficult to find an appropriate way to naturally link this activity to the engineering design process. As this is an aspect of the NGSS often identified as a challenge or as the part preservice teachers are least familiar with, the lack of effective link to engineering design can be problematic. It is possible that to some students, this would confirm the difficulty infusing science with engineering that they already assume to be true. The card trick activity, however, allows for discussion related to the challenge of infusing engineering in science instruction and sets the stage for further course activities in which this vital aspect of science instruction is addressed.

Based primarily on the feedback described above received from our students, both authors utilize a similar overall course progression in their methods courses to build on the card trick activity described here. Table 3 summarizes the overall progression.

Table 3 (Click on image to enlarge)

Potential Overall Preservice Course Sequence Building from Card Trick Activity

Activity	Purpose / Instructional Goals
Card Trick Activity	Students experience SWH / ABI Students introduced to SWH / ABI characteristics Students introduced to overall ASSIST approach Students identify links to NOS, NGSS
Engagement in Science Activity Sequence based on ASSIST - Initial Engagement Activity - SWH Sequence(s) - Multimodal Communication Task	Students experience sequence of Initial Engagement Activity, SWH Sequences, Multimodal Communication related to developing conceptual understanding of targeted science concept
Multimodal Communication Activity	Students experience activity and discussion focused on developing Multimodal Communication activities, the process for helping students develop understanding of these activities, and the theoretical framework supporting these activities
STEM Infusion Activity	Students discuss how to better infuse other STEM disciplines in the Science Activity Sequence they experienced and in classroom settings in general
ASSIST Planning Tools Discussion - Big Idea Planning Tool - Initial Engagement Planning Tool - Unit Planning Tool - SWH Sequence Planning Tool - Multimodal Communication Planning Tool	Students explore planning tools for ASSIST
Development of Unit Plan	Students utilize planning tools to develop coherent science units based on the ASSIST approach

While the card trick activity described here, like any introductory activity, does not provide a guaranteed opportunity to cover all critical aspects of the ASSIST approach in a way that completely meets the needs of all students, it has consistently provided an engaging and motivating avenue for initiating understanding of the approach. Many of the more specific instructional goals of our methods courses can be related back to this introductory activity. In this way, the card trick provides an overarching “big idea” that can be continually improved upon, built upon, and clarified as our preservice students personally and socially construct their own pedagogical outlook throughout our courses.

References

- ACT, Inc. (2014). *The condition of STEM 2014*. ACT, Inc.: Iowa City, IA.
- Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? *International Journal of Science Education*, 29, 1745 – 1765.
- Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G.M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-Based Learning*, 6, 85-125.
- Becker, K., & Park, K. (2011). Effects of integrative approaches among science technology, engineering, and mathematics (STEM) subjects on students’ learning: A preliminary meta-analysis. *Journal of STEM Education* 12, 23 – 37.
- Gunel, M., Hand, B., & McDermott, M. (2009). Writing for different audiences: Effects on high-school students’ conceptual understanding of biology. *Learning & Instruction*, 19 , 354-367.

Gunel, M., Kingir, S., & Aydemir, N. (2016). *The effect of embedding multimodal representation in non-traditional writing task on students' learning in electrochemistry*. In B. Hand, M. McDermott, & V. Prain, (Eds.) *Using multimodal representations to support learning in the science classroom*. Switzerland: Springer International Publishing.

Hand, B. (2007). *Science inquiry, argument and language: A case for the Science Writing Heuristic*. Rotterdam, The Netherlands: Sense Publishing.

Hand, B., Cavagnetto, A., Chen, Y. C., & Park, S. (2016). Moving past curricula and strategies: Language and the development of adaptive pedagogy for immersive learning environments. *Research in Science Education*, 1-19. DOI: [10.1007/s11165-015-9499-1](https://doi.org/10.1007/s11165-015-9499-1)

LaForce, M., Century, J., Noble, L., Holt, S., & King, H. 2014. S3 STEM School Study. Outlier Research and Evaluation, University of Chicago.

McComas, W.F., & Olson, J.K. (1998). The nature of science in international science education standards documents. In McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41–52). Kluwer Academic Publishers: The Netherlands.

McDermott, M., & Hand, B. (2015). Improving scientific literacy through multimodal communication: Strategies, benefits, and challenges. *School Science Review*, 97, 15 – 20.

McDermott, M. & Kuhn, M. (2015). A collaborative professional development program for an argument-based inquiry teaching approach. *Paper presented at the International Conference of the Association for Science Teacher Education (ASTE)*, Portland, OR: January 8-11.

McDermott, M., & Hand, B. (2013). The impact of embedding multiple modes of representation within writing tasks on high school students' chemistry understanding. *Instructional Science*, 41, 217 – 246.

McDermott, M., & Hand, B. (2010). A Secondary reanalysis of student perceptions while participating in non-traditional writing in science. *Journal of Research in Science Teaching*, 47, 518 – 539.

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common core state standards*. Washington D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.

Prain, V., & Hand, B. (2016). *Learning science through learning to use its languages*. In B. Hand, B., M. McDermott, & V. Prain, (Eds.) Using multimodal representations to support learning in the science classroom. Switzerland: Springer International Publishing.

Tytler, R., & Hubber, P. (2016). *Constructing representations to learn science*. In B. Hand, M. McDermott, & V. Prain, (Eds.) Using multimodal representations to support learning in the science classroom. Switzerland: Springer International Publishing.

Vasquez, Jo Anne, Cary Sneider, and Michael Comer. (2013) *STEM lesson essentials, grades 3-8: Integrating science, technology, engineering, and mathematics*. Portsmouth: Heinemann.