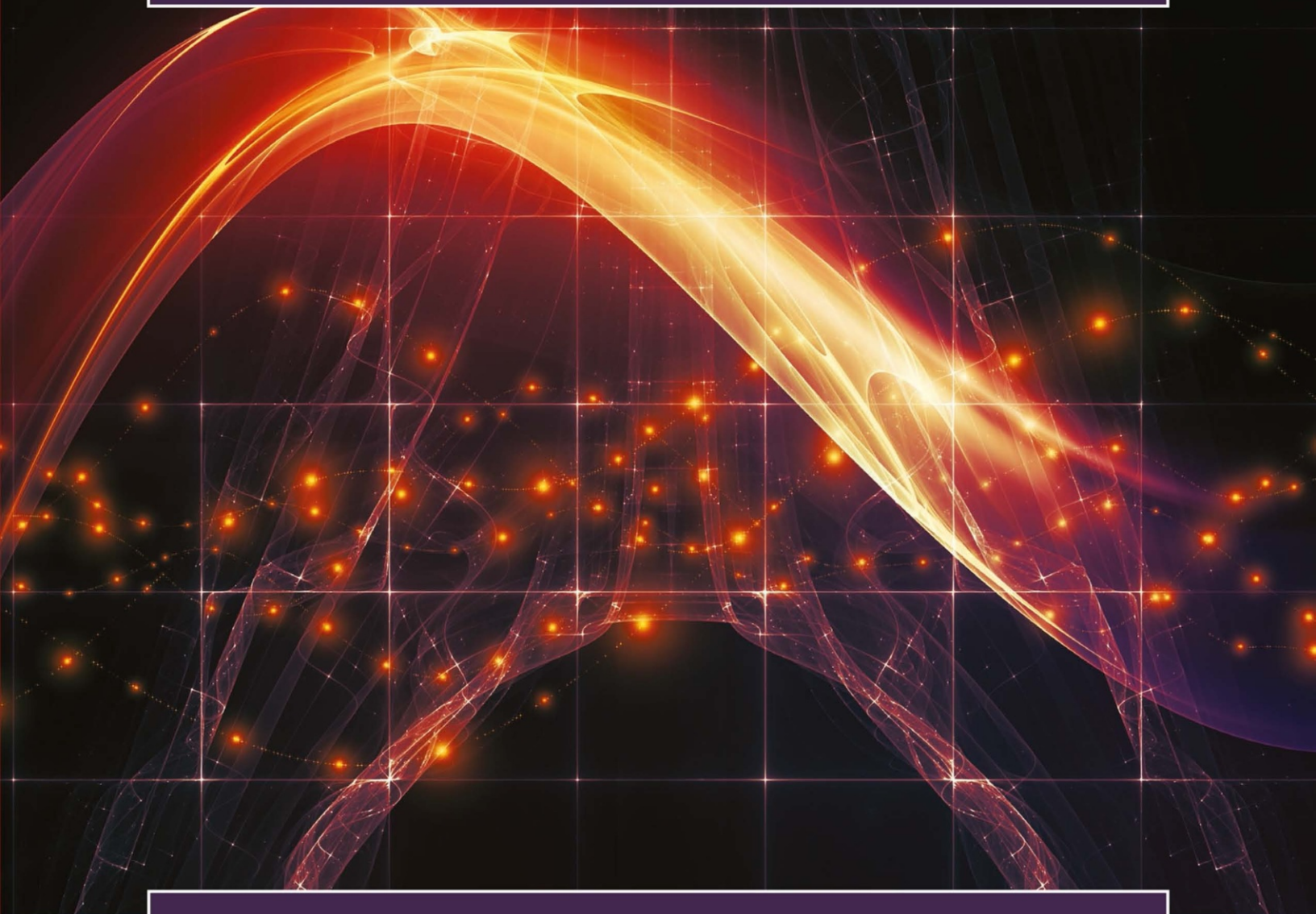


More Voices from the Classroom

International Teachers' Experience with Argument-Based Inquiry

Brian Hand, Lori Norton-Meier and
Jeong-yoon Jang (Eds.)



SensePublishers

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As we put the finishing touches on this volume, we find ourselves extremely grateful for many individuals who helped make this possible. For many years, we have theorized our work using Halliday's frame of learning about language, while we learn through language, all while living language (1975). It seems fitting to make our acknowledgements in a similar fashion.

LEARNING ABOUT LANGUAGE

Through the pages of this book, we learned valuable lessons about how language works – across languages and continents, from our spoken word to the written word, from thinking like teachers and writing with an academic voice. A special thank you to Emily Zuccaro for her work at editing this volume and to Michel Lokhorst at Sense for his ongoing support of our work to bring teachers' voices to the educational community.

LEARNING THROUGH LANGUAGE

Learning through language is a critical means by which we push knowledge forward. For this work it means we are surrounded by a community of scholars who ask questions to challenge our claims, provide new insight into our developing thinking, and respond to our many attempts to put our thinking into writing. To our colleagues, many graduate students, and the SWH community of teachers ... we thank you for always being willing to engage in dialogue.

LIVING LANGUAGE

Living the language ... we are immersed in a community of teachers who open their classrooms to us, share in our questions, wonder with us about student learning and teacher actions that support that learning. Truly, this volume is not possible without teachers. In this volume, you will hear the voices of teachers from three different countries. We thank you for your willingness to engage in the study of your own practice and to do your own writing-to-learn to not only make sense of what you learned but to share it with an audience to help them engage as teacher researchers as well.

BRIAN HAND, LORI NORTON-MEIER
AND JEONG-YOON JANG

1. EXAMINING THE IMPACT OF AN ARGUMENT-BASED INQUIRY ON THE DEVELOPMENT OF STUDENTS' LEARNING IN INTERNATIONAL CONTEXTS

A REFLECTION FROM AN SWH TEACHER

I have come to the conclusion in my own research and learning that this idea of control and managing is taking over and hindering the authentic opportunities for students to engage in their own learning. I have found through providing support for students through the gradual release of control has allowed for authentic learning opportunities to take place around dialogue, questioning, and investigating.

I see evidence daily of students using and applying the SWH approach in every subject. The flow of our day is amazing and doesn't seem so disjointed. This year it has started to feel less start and stop and more flowing with math, science, and social studies. Students are using concept maps to link their understanding and negotiate with peers their understanding of concepts. The most recent example of the students using SWH in our language-based work was just a few weeks ago. I was reading aloud to my students and a problem arose within the reading with one of the characters. He was stranded on a deserted island and needed to find food. He was trying to figure out how he could get coconuts down from the tree. The chapter ended leaving the students hanging. The students were sharing their predictions and posing questions, and students started to negotiate about how to solve the problem of getting the coconuts down from the tree. Students asked if they could break off and come up with their claim of how to get the coconuts down. Students began to make their claims and problem solving using evidence from the story. They drew diagrams and presented what they felt was the best way to get the coconuts down. This was all student lead. I was amazed at that the students came up with and the evidence that they remembered from the story. Gives me goosebumps re-telling it!

I believe that this is the platform for the real authentic learning to take place and have seen first hand how powerfully this has affected the learning environment. Loving the things I am seeing with SWH! It has been extremely powerful for

ALL students! I think the thing I like the most is the authentic data I can gather on my students. Real learning. Powerful learning.

This is a book about teachers, for teachers, and written by teachers. Teachers who took up the challenge to think differently about how their classrooms were structured and consider how they could be re-envisioned with what we know about learning as the central driving force of the opportunities they created for their students to not only explore the subject of science but to see how it would transform the entire curriculum. This is a book where teachers will tell you about the changes that they made, what they learned from their students, and focus on actual evidence from their own practice to support their assertions.

Overall, the intent of this book is to provide a rich and broad view of the impact of argument-based inquiry in classrooms from the perspective of the teacher. There are two important reasons for such a book. The first is that we as researchers constantly work to present our views of these experiences with the voice of the teachers only being relayed through the perspective of the researcher. We need, as a community, to listen to what the teachers are telling us. The second reason is that as demands grow to provide opportunities for students to pose questions, make claims, and provide evidence, that is, to think critically and reason like scientists, we need to understand what this looks like from the perspective of the teacher. This book brings together a range of teachers from several countries who have used the Science Writing Heuristic (SWH) approach to teach argument-based inquiry. These teachers have all gone through professional development programs and successfully implemented the approach at a high level.

INTRODUCTION TO THIS TEXT

In an earlier volume, we were able to show how teachers new to Argument-Based Inquiry engaged with the many facets needed for being a successful teacher using this type of inquiry. We had introduced teachers to the Science Writing Heuristic (SWH) approach to doing science, and we are keen for readers to explore the struggles, shifts in thinking and joy they experienced in being able to engage their students in a question, claims, evidence approach. Given that there has been a push in many countries to move forward in changing their science curricula to align with current research, there is now much more emphasis placed on science learning that introduces students to the epistemic practices of the discipline – that is, students are being asked to engage in the practices that scientists use to move the discipline forward. We have been lucky to work with research colleagues in Korea and Turkey who wanted to use the SWH approach within classrooms in their own countries.

Through grant opportunities our colleagues Jeonghee Nam (Korea) and Murat Gunel (Turkey) were able to implement a series of professional development activities with teachers who were then able to use the approach within their classrooms. The exciting part of this work was that we were able as a group to begin to look at questions related to what are the similarities and/or differences

for teachers in different countries as they move to implement the SWH approach? Do the cultural differences mean that student engagement in argumentation and argumentative practices would be very different? Do we get similar results in terms of critical thinking and adoption of scientific practices related to posing questions, gathering data, generating evidence for making claims, and locating claims within the disciplinary norms, regardless of the country setting?

In terms of where the respective countries are located in international performances on science tests (Provasnik et al., 2016), Korea is always in the top third of countries (generally in the top two or three countries), the US is the middle third of countries, while Turkey is in the bottom third of countries. That is, the countries described in this book are not from the top tier of countries. We believe that this enables us to begin to look at what are some of the different or similar pedagogical events that need to occur for teachers to have success. Importantly what we do know is that:

- Regardless of country students who are in an SWH classroom have greater rates of critical thinking growth than students who are in traditional science classrooms
- In each country, we are able to close the achievement gap – low achieving students including low SES and special education students have more success using this approach
- As with teachers in the US, teachers in Korea and Turkey take 18–24 months to be comfortable with the approach – that is, this is the time it takes for them to be in a place where they will not go back to old ways of teaching

In preparing this volume we are seeking to highlight some the similarities in how teachers use immersive argument-based inquiry, and to highlight how different cultures implement such approaches.

IMMERSIVE ARGUMENT-BASED INQUIRY – THE SCIENCE WRITING HEURISTIC APPROACH

While there have been a number of different approaches to argument-based inquiry, Cavaghetto (2010) has highlighted immersive approaches as being the most fruitful for use within science classrooms. These immersive approaches are framed around immersion into the language of science where students “live” the language of science. Using Halliday’s ideas of language, Norton-Meier (2008) has adapted the ideas related to learning about language, through using the language as you live the language to help students develop understanding of science through this argument-based approach to learning science. This shifting from more structural environments where the emphasis is on generally focused on information transfer efforts, immersive environments place emphasis on students being the drivers of advancing through the topic. Living the language of science, means that students have to “live” science argument as an epistemic practice – this means they have to be involved in posing questions, gathering data, generating claims based on evidence, and to debate these individually, in small groups and publically.

While the original SWH template was framed around a question, claims, evidence structure, more recently we have focused on the different phases that occur within an SWH learning environment. The reason is because we wanted to think through what are the phases that students and teachers engage with as part of the overall SWH approach. For us, we believe that in each unit of work there are three critical phases involved including the (1) Development of Underpinning Epistemic Framework Phase; (2) the Argument Phase; and (3) the Summary Writing Phase (see [Table 1.1](#)). The Development of Underpinning Epistemic Framework is centered on the promotion of the “big ideas” of the topic, the role of language, the role of negotiation as well as issues related to prior knowledge of the discipline, the structure and practice of argument, and the role of the group in learning. These foci are intended to be engaged with through a unit rather than seeing this phase as phase 1 or a three-step phase approach to argument-based inquiry. The Argument phase is the phase in which learning of the science concepts occurs. This is where inquiry drives the teaching and learning that occurs in the classroom. Students are required to generate an argument based on the question, data, claims and evidence structure put forward as part of the SWH approach. Importantly, emphasis is placed on the private/public negotiations that are critical to the development of argument. Not only are students required to publically negotiate their claims and evidence, they are also required to compare their ideas against disciplinary norms for the topic. These many layers of negotiation are critical in providing students with opportunities to both construct and critique the concepts under study. The Summary Phase builds on the writing to learn research we have been engaged with, and requires students to explain the “big ideas” of the topic to peers or a younger audience. This is critical in that this provides opportunities for students to break down the language of science into a language in which their audience can understand. It is through this translation from science language into their own language that learners are able to construct rich understandings of their own about the concepts under review.

Importantly, the SWH approach is not something that is done to students after they have received all the content knowledge – rather this approach is used as the fundamental teaching/learning approach for science. The concept of immersion is centered on the learners being active participants in setting the direction of the learning pathway, generating questions, claims and evidence, understanding and using the epistemic practices of science, and communicating their understandings to others. Importantly, the adoption of any immersive approach requires that teachers’ orientation toward teaching and learning has to shift from previous information transfer perspectives towards to understanding and implementing cognitive perspectives of learning. This shift is what all teachers experience in adopting the SWH approach (see [Table 1.1](#)).

Learning and International Settings

There has been much emphasis placed on socio-cultural approaches to research within science education. Importance has been placed on the different cultural settings and

DEVELOPMENT OF STUDENTS' LEARNING

Table 1.1. SWH approach – three distinct phases

<i>Development of Underpinning Epistemic Framework</i>	<i>Argument Phase</i>	<i>Summary Writing Phase</i>
Unit framed around 3 “Big Ideas” 1. Science concept 2. Learning is about negotiation 3. The role of language	Generation of relationship between questions, claims and evidence	Canonical version of science “Big Idea” for the topic
Determining what students know and build unit plan form there	Small group work generation of data moving to claims and evidence	Use ideas related to writing to learn theory to guide writing task
Development of rules for negotiation 1. Ideas not people 2. Role of group	Product for review by whole class	Authentic audience of peers or younger learners
Engagement with & discussion of epistemic practices • Generation of questions • Research design • Question-claims-evidence structure	Informal writing in notebooks – audience is self Movement from every day to canonical versions of content Development of construction and critique skills	Purpose is to breakdown canonical version of big idea into audience language
Development of pro-social environment	Alignment to disciplinary knowledge related to “big idea” of topic	

having to examine how best to adapt science instruction to these particular settings. While there is certainly a need for this type of research, we believe it is critical that other perspectives be examined to look at how we can better understand and improve science learning for all.

One of the questions that we have asked at inservice sessions when we get push back on adapting to the SWH approach, is to ask “what does an Educational Psychology 101 textbook say about learning in different cultural contexts?” For us this is an important question, because while we recognize that each culture is different, the concept of how learning occurs is the same in each culture. Learners come into a setting with prior knowledge, we need to provide opportunities to have this knowledge challenge, and there needs to be an opportunity for scientifically acceptable ideas to be constructed. While the language used within different cultural

settings is different and how learners may interact may be different, the essential underpinning idea of learning is similar across any cultural setting.

This view of learning parallels how science is constructed across different settings – Turkish science is not different to Korean science which is not different to US science. That is, the epistemological practices of science are the same across these different contexts. Science is framed around a question, claims, evidence structure – scientists pose questions, gather data, apply reasoning to data to generate evidence in support of a claim, and test these claims against disciplinary norms of the topic. While recognizing that different aboriginal cultures interpret natural phenomenon through a different lens, these interpretations while valid are not science explanations. From our perspective, it is important to see that the epistemological practices of science are aligned to the cognitive perspectives of learning. Both require understanding that knowledge is built from what we already know, involves a process of construction and critique, and must be tested against what is known.

Given this perspective, we have worked with our colleagues in Turkey and Korea to both test this idea, and to follow teachers as they begin to explore using the SWH approach in their classrooms. As we moved to implement the SWH approach in these different settings, and to account for what may be differences between these cultures, we first started with conducting the same introductory workshop with teachers in each country. Essentially, teachers were provided with an SWH experience to understand what immersive argument-based inquiry feels like, ideas of learning were challenged with particular emphasis placed on the ideas of private/public negotiation of knowledge as being the driving of how a learner constructs knowledge, the role of language was discussed particularly in reference to the summary writing phase and the need to have students write to a younger audience, and the need for pedagogy to be adapted for each teachers' own classroom setting.

It is important to understand that we *do not provide* the teachers with a curriculum, we *do not provide* teachers with a series of pre-prepared set of worksheets [which we simply do not believe in], and we *do not provide* a series of pedagogical steps to take. We believe that it is important for us as part of the workshop to “practice what we preach” in that it is the teachers who are going to construct the best ways to implement the SWH approach within their classrooms. What may work for one teacher will not work for another because of the type of learners that they have, each teacher has a different personality which means that each teacher has a different preference for what the classroom may look like, an example is that for some teachers noisy is okay, while for others quiet voices are better. This is the difference between an approach and a strategy – an approach is an orientation while a strategy is a simple set of steps that you follow.

In each setting, we were met with the same type of questions and comments. The response in each setting was interesting because it highlighted for us that fact that learning is learning is learning. Kids can't argue (which is always interesting when you asked the married folk with kids if their kids never argue), you can't

use this approach until students have sufficient knowledge of the topic (then how did scientist get started doing science, and who determined if they had enough knowledge), kids will not talk in my classroom (yet they are quite good at it when they are in the school yard, or when the class comes to and end and they are walking out), and the kids will get out of control if I start doing this (response is when are kids are a management problem when they engaged in something for which they are recognized as having control of). These are just a few of the common comments that we received in each of the different settings we worked in.

In terms of developing pedagogy, we worked with teachers in all the countries to understand that adopting the SWH approach was not a quick fix approach to moving to argument-based inquiry. As we pointed out to all the teachers, it takes 18–24 months to become proficient at using this approach. It does not require the teachers or the school district to adopt a new curriculum; it requires a different orientation to the curriculum. This is critical for teachers – they now have to involve students in helping set the pathway through the topic, they have focus on the big ideas of the topic as the central driving force rather than on the factoid transfer approach, negotiation needs to be the underpinning framework that drives the science experience for learners. In each setting, it is this shift orientation that is difficult for teachers – regardless of which country the teachers were in they all went through the same experiences as they adopted the SWH approach. This is what was interesting to us – that the experiences of the teachers are similar regardless of where they were located. Shifting from a teacher-centered classroom to a student-centered classroom requires shift in how one thinks of the classroom and the pedagogical practices required for success.

How to Read This Book

This book offers up a variety of opportunities to the reader to think not only about argument-based inquiry approaches to learning but also to examine the ways that teachers go about examining and adapting their own practice. When we invited teachers to write for this volume, we provided this loose outline for their writing process:

1. Begin by describing your classroom for the reader. Where do we see science/the SWH in your classroom? What is different?
2. How did you get started with the SWH?
3. Share examples/evidence of what kids can do with the SWH approach at this grade level.
4. Discuss important aspects of your SWH teaching.
 - a. What do you do to provide opportunities for students to negotiate meaning?
 - b. How do you provide embedded language practices for students (for example, reading, writing, talking, and listening)?

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- c. How do you still meet the academic standards and mandated curriculum in the context of argument based inquiry?
5. Summary and future challenges/questions – Where will you go next with the SWH approach?

Each teacher writer had a mentor. In Turkey, that mentor was Murat Gunel. Jeonghee Nam supported the writers in Korea and in the United States, we had a variety of mentors (each USA chapter author team ends with the name of their mentors: Mary Grace Villanueva, Carrie Johnson, Lynn Hockenberry, and Kim Wise).

This book can be read by focusing on each country. Each section begins with a context for this work and a description of the professional development efforts in relation to argument-based inquiry. What follows is four or five chapters written by teachers from that country. Each teacher writing team took up a particular focus:

- Planning
- Role of Big Ideas
- Questioning
- Negotiation
- Role of Language

An alternate way to read this book is to choose one of the focus topics from above and read across all three international contexts. For example, if the reader is interested in the act of negotiation in ABI classrooms, by reading Chapter 5 (from Turkey), Chapter 10 (from South Korea) and Chapter 14 (from the USA) the reader will get three different perspectives on the act of negotiation and the role it plays in learning.

However you decide to go about reading this text, we anticipate that you will find the stories of teacher learning and transformation to be not only informative but inspiring at how the act of inquiry into our own teaching practices can help us focus on what it means to learn across international contexts.

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DEVELOPMENT OF STUDENTS' LEARNING

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SECTION 1
TURKEY

MURAT GUNEL

INTRODUCTION

The beginning of SWH work in Turkey was launched in 2006 right after my arrival to Turkey. Having worked in SWH projects and with schools over years in US, I was devoted to implementing and disseminating the SWH approach in Turkish educational settings. In between 2006 and 2008, the approach was tested in college general science lab settings and with four schools with four science teachers in Erzurum (north-east part of Turkey). As an instructor of physics and physics lab as well as general science and science lab courses, implementing the approach with those students who are heavily instruction based teaching oriented was an important challenge for me. It took around a year for students to feel the importance of having ownership in their learning process and to sense the significance of negotiation in doing science. Slowly but surely, they came to a consensus about the nature, doing and understanding of science as well as learning should be examined in a different perspective. Meanwhile, I had started to supervise a few graduate students who are full time working science teachers. Those science teachers visited my courses to get a glimpse and understand the basics of SWH implementation. Later on, they carried out their own preparation and implementation phases under my mentorship in their own learning setting. I was quite excited to be back in school settings with teachers and students. Furthermore, as in the case of early SWH implementations in Iowa, implementing the approach for the first time with mostly low socioeconomic status Turkish students was a “déjà vu” for me. Forming a research team including colleagues, graduate students and SWH experienced teachers along with having promising learning outcomes within school settings, I decided to scale-up the SWH work across the country with teachers and students in different geographical locations and demographics.

The Scientific and Technological Research Council of Turkey (TUBITAK) funded a research proposal with scale-up idea of the SWH approach in between 2010–2013. There were 30 teachers in 21 states of Turkey and 15 researchers in 6 institutions who formed the first SWH project in Turkish educational setting. Those voluntary participating teachers were selected from school districts and states to sample different school settings, demographics and regions in Turkey. That is, among 21 schools, some of them were high-ranked in nationwide standardized tests, and some were extremely low-ranked, some of them were located urban settings and some were in rural village schools. Furthermore, depending upon the geographical location and socioeconomic level of the neighborhood where the school was located,

the ethnic and cultural background of the students were also somewhat representative of Turkey's profile. On the other side, the commonalities among the schools were all middle school level and using a nationwide science curriculum mandated by Turkish National Ministry of Education.

The teachers that are part of this book were all from different regions of Turkey. Among the chapters, you will find a school and teacher in Istanbul Providence, the largest metropolitan city of Turkey over 20 million inhabitants, in Dikili, a small coastal town of Izmir Providence from west-cost/Aegean Region mostly retired inhabitants, in Findikli, a small town of Rize Providence from a north-cost/Black Sea Region mostly hazelnut and tea farmers, in Siirt Providence city center from a southeast border/Southeast Anatolia Region mostly farmers and finally, in Yaylali, a very small town of Kayseri Providence from an inner land/Central Anatolia Region mostly miner and farmers. Within such geographical, ethnic, cultural and social variation, the principal commonality for the students were in a low or medium socioeconomic status. Furthermore, the other important similarity for those students in different settings was having highly dedicated teachers committed to enhancing student learning as all teachers took part in the SWH professional development project.

All of the participating teachers worked hard to change their pedagogical practices and implement the SWH approach in their classrooms, with very limited travel funding and unpaid labor. They travelled from different parts of the country to attend the professional development activities five days for each meeting, two times in a year, and over three years. The research team not only planned and conducted six PD programs but also travelled to 21 states, 30 schools, two times in a year over the course of the project. In each of the five-day workshops, teachers questioned their beliefs and practices about teaching and learning, experienced different science topics as learners, teased out the trainer's pedagogy, reflected their own teaching practices, formulated effective learning environment and conducted unit planning to be implemented in their classrooms. After the workshops, the interaction between the teachers and team has been continued through online communications and school visits.

In each school visit, an enthusiastic teacher and dedicated team member co-taught a session, evaluated the implementation and planned for upcoming instruction and activities. Since usual PD programs treat teachers as passive listeners in a large group gathering without any on-site support and collaboration, it is highly crucial to highlight the uniqueness of SWH approach PD program and collaboration in the Turkish educational setting. Teachers indicated that creating such a community of practitioners among teachers, providing a different learning experience through workshops, and constructing ongoing partnerships in and out of school including those who were not motivated to be part of the SWH, teachers expressed this never happened in other training programs.

The project was framed around an idea of having an identical control (business as usual) and treatment classes for each teacher to test out the effect of the approach on

students' academic achievement and thinking skills. From a research perspective, this project pointed out that regardless of the grade level, subject matter, sociocultural or geographical setting, students in the SWH classrooms academically advanced more than the comparison classrooms for every teacher. However, students' academic achievement and skills development highly depended upon teacher's implementation competency of the SWH approach.

Being in a heavily test-oriented setting and having a nationwide dense curriculum, it was difficult for teachers to foresee benefits of change for them and their students. Additionally, we have found that, teacher development required shifts in beliefs in learning and practices in teaching and such fundamental shift requires time, practice and collaboration. On the other hand, we have also observed somewhat different obstacles for students to be part of SWH learning environment. Having a passive listener role in their previous learning experiences, students struggled to participate discussion, negotiate the ideas, challenge each other and reflect on their learning process in early stages of implementations. Thus, adopting the SWH approach was challenging and required time for both teachers and students in the Turkish setting. However, when the teachers started to see their pedagogical shift and students realized their deep conceptual understandings, the process of adaptation, change and motivation accelerated.

We generated a portfolio for each teacher to report on their implementation development including students' academic achievement, and thinking skills comparisons and development over the terms. As they have seen the change in their competency development and improvement in their students' learning outcomes, they became more attached the SWH approach. Likewise, participating students became advocates of the approach as they became familiar and took ownership of their own learning, took part in a nonthreatening learning environment, conducted an investigation rooted in their curiosity, and saw success in school based general exams.

The motivating excitement for us was to see those participating teachers using the SWH pedagogy in the control classes after the first year of the project. Although, from a research perspective, such bleed over effects limit the research investigations, we were happy to witness holistic change in teachers' practices regardless of the project. In a similar vein, students' in control classes complained about not having the SWH setting in their learning environments as they got to learn more about what was going on in treatment classrooms.

In Turkey, the greatest motivation for education is about national exams with very little emphasis on teacher development and students' competencies and conceptual understanding. Creating settings where both students and teachers became learners with motivation, deeper understanding and enhanced skills have become a case of an alternative and innovative teaching approach for teachers, policy makers in our reach and parents who are in search of meaningful schooling for their kids. Our findings, teachers' cases, participating school success and students' achievements

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not only motivated us to continue to disseminate the approach with other funding but also, to adopt the approach in different areas and subject matters such as engineering, language arts, mathematics, and social studies. As we work with more science teachers and students, as well as with different disciplines to implement the SWH approach, we will certainly improve our own understanding about learning and teaching.

MUSTAFA DEMIR AND NILAY KESKIN SAMANCI

2. PLANNING PROCESS OF ARGUMENTATION-BASED SCIENCE LEARNING

WHERE DO I WORK?

I work in a town that has a population of 10,000 and is in the Eastern-Black Sea region in Turkey (Figures 2.1 and 2.2). The school has nearly 800 students. The majority of students who come to the school from the villages come by means of transport. Most of the families immigrated to the town from different cities and engage with collecting tea as they are not in good condition economically.

There are two labs where I work. As the lab that I used frequently was an old one, there was a concrete table in U shape. I had difficulties in implementing group work because of this structure.

After a year I met with ABI, I broke that table and put six movable tables in the lab. In this way, students can easily participate in group work activities and we can move the tables as we want. As the students are willing to carry out their experiments at break time and out of school, a different practice than from the past, I let them take



Figure 2.1. Muammer Çiçekoğlu primary school



Figure 2.2. FİNDIKLI/RİZE

their materials and carry out their experiments. When you go to the lab at break time or at the end of the day, you can witness that they are trying to answer the questions with different experiments. They form interesting questions that they research to find the right answer by making experiments for two hours and there is a competition among them. Because there are study times after school for other classes, sometimes other teachers may complain. Now in my classroom, there are concept maps, poems about the topics, letters, posters and mottos as main ideas, all of which were created by students and are in every corner of the lab. Students can take them and change them whenever they want. In [Figure 2.3](#), the pictures demonstrate the situation of the lab taken before and after the introduction to ABI as well as the concept maps prepared by the students ([Figure 2.4](#)).

THE FIRST INTRODUCTION TO ABI

My first meeting with this approach was in 2010 when I was invited to an in-service training program as a part of TUBİTAK (The Scientific and Technological Research Council of Turkey) project. I had participated in so many in-service training programs organized and implemented by MEB (Ministry of National Education) but I was not very satisfied with these in-service training programs. Therefore, I was hesitant to participate in this new training about ABI approach because I had some ideas about them, such as they were not useful. I had 8 years of teaching experience and I was a teacher who likes searching. I used to follow the studies in my field and try to help my students learn better by implementing various methods and techniques. Though

PLANNING PROCESS OF ARGUMENTATION-BASED SCIENCE LEARNING



Figure 2.3. Before ABI (top); After ABI (bottom)

I had negative feelings about these programs, I decided to participate in them with the belief that I can learn something in these seminars. When the formal paper came to the school, there was something called Argumentation Based Inquiry (ABI) in it, which I had not heard so far. I had no idea about what it could be. I thought that a person would come from a university, reflect something on the wall, just talk a bit and leave.

However, I had a different experience in the first ABI in-service programs. I had been to so many local and central seminars so far, but the process was very different from the previous ones. We were students, asked to define what learning is, and we

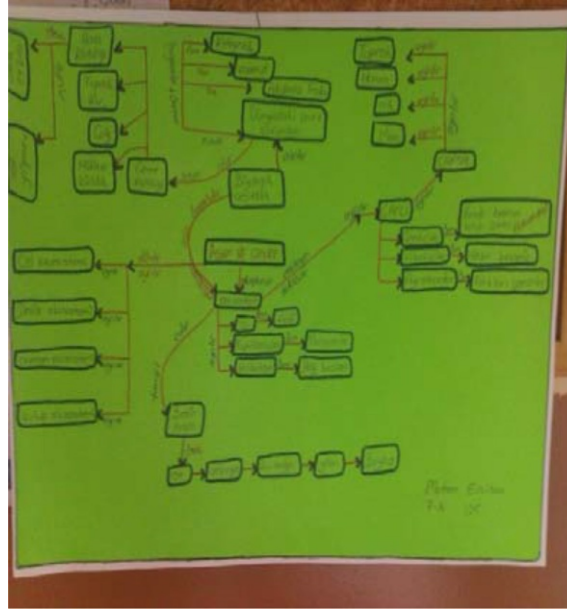


Figure 2.4. Example of concept map

discussed as a group or class. This was the first time I had enjoyed such in-service training programs. There were not quick responses and we questioned our knowledge by forming our own questions. There were some doubts in my mind towards the end of the seminar. There were questions like: “Is it possible to apply this in my real classes? Will I have enough time? Can students form their own questions?” in my mind. Moreover, there was the framework which my students will fill in. I had doubts about its implementation in real classes. I had difficulties in having students write a few lines and it was difficult for them to fill in that framework. I left the first in-service seminar with many questions in my mind but I liked different implementations. I thought and said to myself: “Let’s try it once, if not I can quit it,” and then I decided to apply it. I will share my experiences in the process of the preparation and implementation stages of ABI, which started with my decision, in this section of the book. Examples of the implementation stage and planning of preparation stage given here reflect my thinking style. These examples of the implementation stage and planning of preparation stage can change from teacher to teacher.

ABI PLANNING PROCESS: FROM PART TO WHOLE AND WHOLE TO PART

When I first started to apply ABI, I noticed that this approach required me to adopt a different approach for unit preparation. In my previous preparations for the units, I first looked at the learning outcomes in my annual planning reports and then

made preparations for the related part and topic in the textbook. My planning style changed together with ABI. Now, I plan the unit as a whole. I know that a successful implementation of ABI is only possible with a good planning. I thought that if I applied ABI in the class without good planning, the implementation wouldn't reach its aims. Therefore, after I determine the unit on which I will use ABI, I follow the steps below that I share with you.

The First Step: Preparing a Concept Map about the Unit

I see the preparation of concept maps of the unit as a way for teachers to examine their knowledge on the unit, and I think that teachers should find the concepts in the unit and demonstrate the relationship between the concepts clearly before beginning ABI implementation. With concept maps, teachers have to answer such questions as "What do I know about the topic?", "Where am I?", and "What should I know?" and thus have an opportunity to overcome the deficiencies.

Before I met with ABI I thought that preparing concept maps about the unit is an easy one but when I started to do so, I saw that it was hard work. I noticed that I did not exactly know the relationship between many concepts and had to search a lot of sources in order to overcome this situation. I noticed that in fact I did not know much about the units which I thought I knew a lot about. In my first implementation, while I was preparing concept maps about the units, I studied for many hours and searched a lot of sources. I noticed that this time decreased as I practiced more and more. In addition, I think these concept maps provide convenience during the unit implementation as they help me see the unit as a whole. I could see the unit as a whole after I prepared the concept map and so did not have difficulty in identifying the main idea(s) of the unit.

The Second Step: Identification of the Main and Sub-Ideas

The concept map I constructed was my greatest assistant in the identification of the main and sub-ideas of the unit. Because the main idea covers all the concepts in the unit and the idea to be conveyed, the concept map was my guide in the unit. When I looked at the concept map, I could easily understand the main idea of the unit by looking at the concepts in the unit and the relationship between them. I needed to identify sub-ideas after I found the main idea. Again, the concept map I drew was my assistant in identifying sub-ideas. While identifying the main and sub-ideas of the unit, I took the learning outcomes of the unit along with the concept map. Sub-ideas were the parts of the main idea to be conveyed in the unit when I divided the unit into parts. When I brought the sub-ideas together, I had the main idea. When I couldn't draw a good concept map about the unit, I couldn't have a clear schema about the concepts and the relationship between them and had difficulties in determining the main and sub-ideas. On the contrary, when I form a good concept map about the unit, I could find out the main idea easily, design activities well and guide my students to

get the right message from the unit because for me, it is suitable to get the main idea in group and in-class discussions. Table 2.1 displays some examples of the main and sub-ideas of the units.

In most cases, I shape in-class discussions around the main and sub-ideas I determined before and try to help my students find their way to get this opinion. Otherwise, I have problems in the implementations and notice that the discussions go in other directions. I think the problems I faced in my first implementation are good examples for this situation and I want to share them with you:

The First Implementation and the First Chaos: Finish or Continue?

In my first implementation, I went into the class without considering the main and sub-ideas much. At the beginning of the topic, I couldn't direct the discussions of my students and caused the topic to stray. My first implementation unit was the "Granular Structure of Substance" in the 6th grade. I identified one of the sub-ideas as "The distance between the particles changes according to the states of matter." But I did not take this into account much when I went to the class.

Table 2.1. Big and sub-ideas

Level	Unit	Main Idea	Sub-idea
6	Electricity in our life	Electricity is an energy	• Electrical energy does not pulse through everything. • If contactor changes, brightness of the bulb changes. • Resistance is the power against electrical energy. • Bulb is a resistance.
6	Substance and Changes	All substances consist of granular structure	• Substances consist of the same or different particles. • Some changes change both the internal structure and appearance of the substance while some changes only change the appearance of the substance. • The distance between the particles changes according to the states of matter.
7	Human and Environment	Living creatures and non-living things in a specific region interact with each other.	• Living creatures need each other to feed • Every type of living creature has a special habitat. • There are different types of living creatures in our country. • Environmental pollution threaten the future of the living creatures.

Since I did not have a clear opinion about where to guide my students in the discussions with my students at the beginning of the unit, the discussions were about different topics. While I wanted to get the students to the sub-idea, they got me to different ways with their questions. I both lost time and caused chaos in my students about the concepts. After this discussion, when I put students in groups and wanted them to prepare questions, none of the groups were able to ask a question about the sub-idea that I specifically wanted. I couldn't guide my students to the sub-idea in the discussions and couldn't help them to have a question about the sub-idea and so I had to prepare the questions on behalf of the students. At the end of the implementation, I was unsuccessful in guiding the students to the main idea.

I began to think that ABI was not an effective approach and thought that it requires cognitive skills beyond my students' levels. I decided to revise my implementation process. There were some questions like "I cannot apply this – is there a problem with this approach? Or is it an unsuitable approach for my students' levels?" in my mind. I began to watch the videos I recorded during the implementation in order to find answers to my questions. When I watched the videos, I realized that I did not conduct many of the activities in the lesson I had planned before class. I had identified the main and sub-ideas and prepared activities based on them. When I revised my implementations from beginning to the end, I noticed that I shifted away from the subject in my discussions at the start of the lesson. In this way, I couldn't guide the students for the necessary ideas and because of my deviation, I left my students confused. I realized that the activity I used in order to take students' attention to the subject and to create questions about the sub-ideas in their mind was not effective. In my next implementations, by taking my missing points into consideration, I tried to carry out my implementations with adhering to the concept map I first drew and the main and sub-ideas I identified according to the concept map. The reason for the digression at the start of the lesson resulted from my aimless discussions with the students without adhering to the main and sub-ideas. In later implementations, I began to direct the discussions and carry out the implementations without wandering away from the main and sub-ideas and when students wandered away from the subject, I tried to turn back to the real subject with some questions or their answers to the questions. I observed that students reached the objects as they went on the implementations in this way.

By starting out with the problems I had during the implementations, I find the discussions about the main idea in ABI similar to an object fastened with a string to a nail stuck in a specific place. Here the nail stuck refers to the main idea while the in-class activities and discussions refer to the string. At first, I made the string too long and thus wandered away from the main idea. As I had more experience in the process of implementation and preparation, I see that I now make the string shorter and have activities and discussions with a focus on the main idea.

The Third Step: Identification and Planning of the Activities Aligned to Main and Sub-Ideas

I believe that the activities in ABI process are one of the most important steps in guiding students to get the main and sub-ideas. I think a badly-planned activity cannot attract students' attention to the subject at hand or form questions in their minds. So, I pay attention to the following points in my activities that I planned to teach the main and sub-ideas. The activity should:

- take students' interest to the subject,
- create questions in their minds,
- make it possible for students to compare and contrast the new knowledge by triggering their previous knowledge,
- stress the main and sub-ideas,
- let them find their ways towards the main and sub-ideas,
- make it easier for students to interact with each other in group discussions.

I believe that the other point that needs attention during planning stage of the activities is that every part of the ABI reports that is filled in by students during the implementation time should also be filled in by teachers at the planning stage and I also believe that the implementations will be more productive if teachers answer the following questions at every part in a detailed way:

- What is my real purpose for this part?
- What kind of learning environment should I create in order for students to reach these goals?
- What should students do in order to reach these goals?
- How will I observe whether students have reached these goals or not?

CHANGE IN PLANNING: NOT TO PLAN THE TOPIC – BUT THE UNIT

Prior to meeting with the ABI, I did not spend much time in planning. There were previously prepared plans about the topics in teachers' books and thus I did not have to rewrite a plan. However, if I found the plan or activities in teachers' books insufficient, I could make new plans. So, I used to examine the plans in teachers' books that were related to the topic I would teach. In the activities suggested, I would take and use the activities suitable for students' level and the topic. Sometimes, without looking at the plans in teachers' books, I taught the topic with the presentations or animations I downloaded from the Internet, without looking at the plans in teachers' books by taking the learning outcomes into consideration. I went into the class by making preparations about the related part of the unit. In other words, I did not cover the unit as a whole but I made preparations by only focusing on the subjects in the unit.

After meeting with the ABI approach, my planning style changed completely. While I was preparing my first unit plan according to ABI, I had a lot of difficulties and had to work for hours. The nature of ABI required teachers to plan a unit as a

whole, which was very different from my previous plans. Before ABI, I made plans that are based on topics rather than the unit itself as a whole but ABI necessitates a holistic view of planning. Before starting the unit, I needed to have a good concept map to see the whole unit. The concept map helped me to see the whole unit by showing all the terms in the unit and the relationship between the terms clearly. In this way, I could both easily see the relationship between the terms in the unit and understand the message conveyed. In my planning style before ABI, because I focused on the topics in the unit I might overlook the main purpose of the unit. Thus, I made my plans and applied them without taking the relationship between the topics in the unit into account.

Different from my previous planning style, after preparing a concept map, I had to determine a main idea for the main purpose of the unit. I had worked with concept map before and I was familiar with it but determining the main and sub-ideas of the unit was a first for me. After I drew a concept map, the top purpose that covers all the terms in the concept map needed to be determined. I first had difficulty in determining the main and sub-ideas. I did not pay attention on the concept map while determining the main and sub-ideas. After a while I saw that if I drew a concept map in determining the main and sub-ideas about the unit, I could easily identify the main and sub-ideas with ease.

As I carry out more implementations, I feel more confident in planning. I had problems while I was carrying out my first ABI implementation. As the time passes, I see that I have reached to a certain level in implementation and planning but with experience, I started to see my mistakes and discovered new things. I realized that I made changes in my planning style after every implementation. I think "Tomorrow, I won't like the plans that I made today." However, when I compare the time I started to use ABI and today, I believe I have come a long way in planning. But I don't know what I will discover in my future journey yet.

How Flexible Should I Be?

I believe that the preparations I made in line with ABI implementations are directly related to the success of the implementation. Therefore, in order to talk about the flexibility of the plans or how much to depend on the plans, I suggest that the success of the ABI implementation process should be addressed before the implementation and during the implementation.

For me, what should be done before implementation is to draw the concept map of the unit, identify the main and sub-ideas and design the activity or activities according to the concept map. The more we are careful about the abovementioned planning stages before the ABI implementations, the more productive and successful the implementation will be.

As for the implementation stage, I can say that the main and sub-ideas are red lines for me. Except for the main and sub-ideas, some situations are exceptions. I still remember changing the activities because I believe that what is important in the

implementations is not to wander away from the main and sub-ideas. When you enter the class atmosphere, you may not attract students' attention to the topic with the questions you prepared before or may not form questions in their minds. Discussions can stray. At this point, the main and sub-ideas are your savior and you have to maneuver pedagogically and you can change your questions, and if necessary and you can do it, you can decide to do different activities. However, I believe that we should never ever leave the main and sub-ideas. As teachers' pedagogical capabilities are different from each other, the content and the applications will be different, too. Some teachers can have advanced skills at asking questions and managing discussions and can attract students' interest to the topic and form questions in their minds at the start of the lesson with their effective questions. Alternatively, they can again form questions in learners' minds by attracting their interest directly to the topic with the activities in the beginning. It can also be possible to attract students' interest to the topic by starting a discussion about the scenarios written on papers in the beginning. What you do is not important but whether what you do guides students to the main and sub-ideas is important.

My answer to the question "How much should we depend on the plans?" is as in the following: our destination is always our main idea but we can follow different paths to reach the main idea. What path to follow can change according to the pedagogic knowledge of the teacher and the classroom dynamics. For example, in one of my applications, I prepared what questions to ask the students before the activity but when I entered into the class I saw that these questions were not very meaningful for the students. Sometimes what we consider as important may not be so meaningful on the part of the students. So, I had to quit my questions and I think we must decide in a short time in such cases. I saw that if I trigger students' previous knowledge about the topic and direct the discussions based on their knowledge, the students were more successful.

PREPARATION FOR TESTING AND ASSESSMENT

I think students' previous knowledge about the topic is important for them to learn the terms and the subject studied. Before I met with ABI, at the beginning of the class, I asked students, "What do you know about the topic?" and allowed them to share their opinions in order to discover their prior knowledge about the terms. After doing so, I supposed that I discovered their prior knowledge and went on with the implementation. After I met with ABI, I noticed that detecting students' prior knowledge about the topic is not possible only with some superficial questions because detecting students' prior knowledge required discussing the topic with the students in detail and advanced abilities in asking questions.

Together with the ABI implementations, in order to find out students' prior knowledge about the topic at the start of the implementation, I believe that I need to find answers to the following questions:

- What is their knowledge level about the terms?
- How do they express their knowledge and opinions about the topic?
- How much are they interested in the subject?
- Do they have any misconception about the concepts?

While preparing for the unit, I create unit-based achievement tests in order to test students' success on the related unit. These achievement tests consist of multiple-choice questions that cover all the learning outcomes and questions about the concepts which evaluate learners' knowledge about the concepts in detail. I pay attention on the questions I prepare to test students' advanced cognitive abilities. I apply these achievement tests both at the beginning of the unit as pre-test and at the end of the unit as a post-test. I don't think multiple-choice questions can test students' knowledge level about the topic in a detailed way and are sufficient enough to make decisions based on them. I get important clues regarding students' prior knowledge about the concepts with the help of the questions about concepts. Starting from the results here, I try to direct the discussions by considering students' answers to the questions about concepts in class and group discussions. However, because of time constraints, it isn't always possible for me to plan the activities after evaluating the results of the pre-test. In that case, I try to find out students' prior knowledge about the topic with the help of individual and group discussions with the students at the start of the lesson. Again, in these discussions I try to detect students' misconceptions if there are any and have them face the new terms they will learn.

After students form their own questions, I put them in groups and try to be well informed at every stage by observing what they do. I think the questions students ask in these group work activities and the answers they get from their group partners are very significant for me to follow their development in concepts. The questions students ask each other and the level of the questions give us interesting clues on what students know about the concepts. In order not to overlook any clues, I try to listen to them without interfering in the discussions as much as possible. I consider this as an inevitable opportunity for me to identify the knowledge level of my students.

While listening to the groups, I usually pay attention on the following points:

- Do students ask questions? If yes, what level of questions do they ask?
- Do they express the concepts? How do they express?
- What kind of sentences do they make in their answers? (certain or contingent)
- Do they listen to their friends' statements and contribute with alternative statements?
- Do they express their opinions by depending on the information in the book or with their own sentences, being away from the information in the book?
- Can they make comments about the results they reached at the end of the activities they conducted?
- Are they aware of their own learning?

Based on the questions above, I try to observe the students. I think I can easily examine all students' performances during the process in this way. I had a different point of view for performance tasks that I used to evaluate students' success in the process, too. The performance tasks I used before the ABI were not very effective. I had a lot of students and it was not possible for me to follow each of them. Because I didn't have time for students to present all these activities I did not attach importance to them. ABI frameworks offered me great ideas and I thought that I could use the ABI framework which students fill in during the implementations as a performance task. Therefore, I created a rubric by considering all parts of the framework (Table 2.2).

Table 2.2. ABI evaluation rubric

	1	2	3	4
1.The question group prepared to search (group)	Most of the group members didn't participate in preparing the question. It isn't a searchable question.	Half of the group members didn't participate in preparing the question. The question needs arranging.	Some of the group members didn't participate in preparing the question. The question was prepared well.	The question was prepared well with the contributions of all members.
2. My opinions as the basis of the question (individual)	The opinions as the basis of the questions weren't explained.	The opinions as the basis of the questions were explained.	The opinions as the basis of the questions were explained well.	The opinions as the basis of the questions were explained very well.
3. The experiments conducted by the groups to answer the question (group)	The experiments conducted have lots of missing points. There was no control on the variables. There was no relation with the research question.	The experiments were conducted inaccurately but still serve to the research question.	The experiments were conducted appropriately but don't serve to the research question.	The experiments were conducted appropriately and prepared to answer the research question.
4. The things the group found at the end of the experiment: what I have found (individual)	Results of the experiment were presented inaccurately and unsystematically. There were no graphics and charts in the organization of the data.	Results of the experiment weren't presented Systematically. There are many missing points in the no graphics and charts.	Results of the experiment were presented accurately but there are mistakes in the graphics and charts in the organization of the data.	Results of the experiment were presented accurately and well and the data were given in graphics and charts accurately.

(Continued)

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Table 2.2. (Continued)

	1	2	3	4
5. My claims (group)	The claims were formed without considering the experimental results and have many missing points.	The claims weren't based on the experimental data exactly, were explained incompletely.	The claims were based on the experimental data and explained well.	The claims were based on the experimental data and explained very well.
6. How have I compared my opinions with those of others	There are many missing points in comparing one's own opinions with those of others.	There are some missing points in comparing one's own opinions with those of others.	Comparison of one's own opinions with those of others were done well.	Comparison of one's own opinions with those of others were done very well.
7. What I read (individual)	A source was read but no information was given about the source and there was no comparison between what s/he found and the information of the source.	A source was read, the information of the source was given accurately and compared with what s/he found.	Two sources were read, the information of the sources were given accurately and compared well with what s/he found.	Three sources were read, the information of the sources were given accurately and compared very well with what s/he found.
8. Reflections (individual)	Wrong information about the unit still continues	There are some missing information about the unit	Information about the unit was understood well	Information about the unit was understood very well
9. The harmony between the question and claim	The claim was formed separately from the question	There are some missing points in the harmony between the question and claim	The claim was formed and based on the question	The claim was formed and exactly based on the question
10. The harmony between the claim and evidence	The evidence put forward doesn't support the claim	The evidence put forward supports the claim	The evidence put forward supports the claim well.	The evidence put forward supports the claim very well.

With the rubric I prepared, I started to evaluate the ABI frameworks that students fill in as a performance task and saw that it was very useful because I could directly observe what students do in the class. The main aim of the

performance tasks was to test students' advanced cognitive abilities and ABI reports were very appropriate for this purpose. Performance tasks needed to be carried out in the class in line with the regulation but it was not possible for me to do so before I met with the ABI because it took lot of time and I couldn't cover the curriculum. However, performance task has become very easy for me thanks to the ABI and stopped embarrassing the students because all the teachers gave the performance tasks as homework and this has created a great chaos among students, and thus students are now off their hands. I also started to use the letters students write at the end of the topic as a performance task and worked with the Turkish teacher. In this way, I could connect with other disciplines, which was an opportunity for the students to notice the relationship between this lesson and the other ones.

While planning the unit, I used different activities like preparing a poster if necessary by considering the general features of the subject (see Figure 2.5). In the evaluation of these kinds of homework, I started from the difficulties I had in the past and prepared a poster evaluation rubric to test the process of poster preparation and the posters themselves more effectively. In addition, we prepared a poster framework as a guide to my students at the preparation stage. According to this framework, we decided that there must be a motto in every poster and then we also decided to include the question, the claim, the evidence, and a picture in the ABI framework.



Figure 2.5. Some examples of the posters students prepared

Additionally, by considering the general structure of the activities I plan to implement during the planning process, I now use some strategies like self-evaluation and peer evaluation where students can evaluate both themselves and their friends in the implementation process. According to the observations I made about the implementations in the class, students were more motivated in this way and they took more responsibility for both their own learning and their friends' learning.

I observed that writing in the ABI process played a crucial role in developing students' language skills. I try to have such strategies as creative writing activities like poems, songs, letters, and stories of the students with a purpose to use them as evaluation tools in the activity planning process. While using writing activities, I try to guide them well with good directives. I especially pay attention on writing for a real audience. I believe that these strategies are very important for me to be able to see how students have internalized the concepts at the end of the learning process. Moreover, I get the opportunity to follow the change and development of the students throughout all the ABI implementations like the ABI frameworks, performance and writing tasks, all of which are in files.

Below are the poems the students wrote about the subjects:

My Problem is Different from Yours

What has happened?
The ears on whose auricle
I ran out of breath.
The long feathers of the auditory canal
On which I stumbled.
The games I played by vibrating the tympanum
Where are you now?

Where is my malleus?
Following my incus and stirrup?
The eustachian tube I played with
Where have you been?

Where are my dreams and aims?
My middle ear with which I was happy
When I touched the three bones
I've created a big world on these bones
The sound waves that see cm as km
Who knows where you are?

I used the vestibule as bridge
Passed the middle ear and reached the internal ear
Considered the oval window as my friend
Where are they now?

M. DEMIR & N. K. SAMANCI

Oh, how cute was the semi-circular canal
The stones in it
The balance center including all these
I feel dizzy, where are you?

I took the snail as the wind rose
Reached the brain after passing the nerves
Was considered as sound in the brain
Miss the old days

Nobody talks now
No one can hear now
While people are dealing with their own problems
I am thinking about my own problem
My problem is different from yours...

Here We Have Learned!

First we learned the cell
Then we learned what atom is
Finally, we came to the electricity

With the battery having plus and minus sides
With the cables
Then we turned on the bulb lamp
We watched whether the lamp was on

After the light was on
We looked at the conductivity
We took an iron and
Combined it with the cables

In the end, we looked and
Turned on the lamp again
As a result of this situation
We understood that it was conductive

We also looked at the soap
We tried to turn it on
But we couldn't do it and
Understood that it was non-conductive

Are you conductive?
We are conductive and
In pursuit of conductivity
Look! We have always learned!

What Do Students Say?

I think ABI helps us to study in a productive way a lot. Learning with experiments helps us to understand the topic better. If we do this at home we don't have any friends to discuss, but we share what we have learned with our friends and complement the missing point at school. Writing what we have learned and comparing these with the information in different sources we find when we arrive home contribute to our learning. (Erdal, 7th Grade Student)

I take pleasure for the ABI implementations and enjoy filling out the ABI papers. I learn how scientists work, conduct experiments and draw conclusions. I feel like a scientist while conducting experiments and in group discussions. If we have any mistakes we learn them in our group discussions. If our friends have a mistake we offer a better one and help s/he to reach the best one. I think the ABI papers are also good because some friends couldn't make sense of the teacher's sentences while s/he is explaining about the subject. However, while my friends are working with these papers they can get the point with their own sentences much better. Therefore, every science teacher must use them. (Gözem, 7th Grade Student)

The ABI is a useful activity for me. While our teacher is explaining a topic to me, other topics confuse us but while using the ABI we act as a group in both the experiments and the discussions. What are the similarities and differences between the questions, experiments conducted, initial opinions, claims and proofs in the ABI and my claims and proofs in other sources? Writing some sections like whether our opinions have changed or not helps us to learn. ABI is a useful and effective way of learning. (Kağan, 7th Grade Student)

We were surprised when we started to use the ABI activities. "what is this teacher doing?" we cried and the ABI papers were even more boring. As I use ABI more I understood that I learned better. While discussing we share our ideas and thus we produce better ideas and questions and learn better. We discuss what we write and draw on the ABI papers later, go to the board and present in front of it and thus discuss them with all of our friends and understand the points better which we didn't understand before. We thank our teacher for finding such a learning style. (İbrahim, 7th Grade Student)

I had some difficulties when we started to use the ABI activities and I was afraid that I wouldn't be able to do it. I searched help from my friends. I disliked the ABI papers on which we wrote what we did and I had some problems with it. Now one year passed and I enjoy them a lot. I carry out all the implementations with pleasure and learn better. (Buse, 7th Grade Student)

VOICES FROM PARENTS AND TEACHERS

We were having a meeting about the branch teachers' board at school. All the teachers who were teaching courses based on practice came together. We were talking about the teaching methods used in the class environment. One of the branch teachers said "What are the students doing in science classes? I really wonder about it. When I say something, they ask if I have any evidence and say there may be wrong information in the book, and ask again if I have any other sources that support my claim. So, what do you teach my dear teacher?" He also reproached if students do not believe in what teachers say how we will teach the course? Some other branch teachers agreed with this teacher. I experienced a similar situation at parents' meeting. There was a parents' meeting of the implementation class at school. The teacher of that class insisted me to participate in the meeting because some parents complained about the science classes. I went to the meeting hall with the friends. It was my turn to speak after my friend spoke and stood back. I thanked all the parents for attending the meeting. I said "You said you had some complaints about the science classes." Some of them raised their hands and I allowed them to speak: "Dear teacher, what do you teach these students at school? While discussing a topic at home they always ask if I have any evidence or other sources that support my claim. Our children do not believe in what we say." I smiled and said: "How nice is it? Isn't it what we want? The fact that they don't believe in every information they hear and search the reliability of the information." The parents said: "Dear teacher, you are right but how would I know the evidence or source?"

I ask this question in return, "Isn't it our main purpose at school to have individuals who search and question?"

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3. THE ROLE OF BIG IDEA IN ARGUMENTATION BASED SCIENCE INQUIRY CLASSROOMS

AN INTRODUCTION TO ABI IMPLEMENTATION

In my first implementation, I entered the classroom without considering big ideas and sub-ideas. During the introduction of the topic, I could not effectively manage discussions with the students and this resulted in distraction from the topic. The first implementation I made was two years ago and was embedded in the “Particular Structure of Matter” unit. I determined one of my sub-ideas for this unit as “Look at the distance between atoms, decide the state of matter.” However, when I entered the classroom, I had not paid much attention to it. At the beginning of the unit, while having discussions with the students, I did not have a clear objective in my mind; therefore, the discussions shifted to very different points. While I was hoping to direct students’ attention to the sub-idea, they introduced different topics with their questions. I lost time and this caused students to contradict concepts among each other at the same time. After this discussion, when I divided students into groups and asked them to prepare questions, none of the groups could prepare questions related to the sub-idea I expected. I could not manage to bring the students to the sub-idea and form questions in their minds related to this idea with the discussion. Therefore, I had to prepare the students’ questions myself.

A Section from My Big Idea Oriented Argumentation Based Science Inquiry Implementations: Two Years Later

I was in the 8/A classroom, where I was trying to practice my Argumentation Based Science Inquiry (ABI) implementations. Our discussion within the scope of the big idea was continued, heated, and interesting discussions were arising because of the differences of opinions among students. Student groups were performing activities one-by-one in line with question-claim-evidence and then presenting their claims to the whole class with explanations or evidence. I was observing, as well as increasing the interest of my students in participating in the class. Each group was willing to present their work and share the experiences and knowledge they gained from the activities they performed. During the big group discussion, while one group was presenting their claim and evidence, some students objected to their peers’ claim and evidence. Then, an oral discussion began between two groups. This discussion lasted for approximately five minutes. What was I doing during that time? I was sitting

on a stool in the corner of the laboratory and listening to the beautiful, civilized, respectful, participating discussion and watching my students, who were examining the issue they were discussing thoroughly; without interfering. This happy memory was one of the best moments of my teaching career. I am so glad that I experienced the ABI approach in this way.

With the ABI approach, I have earned positive and enjoyable experiences. In this section, I would like to share the knowledge and experiences I gained during ABI implementations about teacher pedagogy and the big idea concept, which I think is very important for student learning and classroom applications. As a person who has lived the process personally, I hope I can demonstrate through my experiences about the importance of the big idea in ABI implementations, how it is determined, the problems occurred, and the possible solutions from the point of view of a teacher for those who want to experience the process or gain information about how the process works. In this sense, in order to be able to represent my experiences better, I would like to mention my classroom environment, mine and my students' introduction to the process and the changes that occurred in my classroom afterwards.

A GLANCE AT MY CLASSROOM

My name is Yesrip Akbay. I am a science teacher at Atatürk Elementary School in the city centre of Siirt. Siirt, in the Southeast region of Turkey, has a population of approximately 130,000 people and a lower socioeconomic status than the country average. Most of the people living here are on middle income. Agriculture and stock breeding are the two main sources of income in the province. The demographic structure of the province is quite varied. The majority of the population is made up of Arabic, Kurdish and Turkish people. Multiple languages are spoken within the community. People of the same origin speak in their mother tongue to each other, whereas people of different origins speak Turkish to each other.

In our school, there are nearly 850 students. Each classroom is composed of approximately 30–35 students. While the majority of students are children of families that migrated from rural areas to urban areas through different circumstances, there is also a group of students who are children of families settled in the center. Families here generally have an “extended family” structure. Consequently, not all students have their own private room to study in. Most students are from middle income families.

My school and I spent two years on the ABI project. This year, my practice and control classes are each composed of thirty-four 8th grade students with similar academic achievements and socioeconomic statuses. Within these classes, most of our science lessons are taught in the science laboratory of our school.

MY INTRODUCTION AND ADJUSTMENT TO ABI

I am one of two science teachers at our school. I have 16 years of teaching experience. Since the beginning of my career, I have followed educational publications, observed

my colleagues' lessons with their permission, criticized myself, determined my shortcomings, if there were any, and tried to improve myself by focusing on overcoming those shortcomings in order to become a better teacher. Furthermore, because of my interest in my profession, I have followed the latest developments in science and technology and attended in-service training seminars in this area. They have certainly contributed to my development; however, I cannot say that this has been completely satisfying for me in terms of carrying out education, except for an in-service training seminar. In fact, it is incorrect to call it just an in-service training seminar, because this term is insufficient to describe it. This seminar is the ABI approach.

Our meeting with ABI started during a seminar in Van providence when Murat Günel, who seems to be different than other academicians, asked us "Would you like to participate in such a project in the future (8 months later)?" We replied, "Yes, maybe." I had thought that it was a passing question and would be forgotten when the in-service training seminar was over. A couple of months later, I was surprised when I heard Dr. Günel's voice on the phone. When he said an in-service training seminar was about to start, I felt he was serious about his work.

This in-service training seminar was an ABI project as you would understand it. I should admit that at first I thought, "Why did I get into this?" In other in-service training seminars, we had just been sightseeing and gaining a little information and improvement. In ABI in-service training seminars, I experienced certain problems for the first time, but I also discovered the pleasure and excitement of learning. We experienced the activities we were going to perform with students beforehand by acting like students. We laughed and were surprised. It might seem strange to you, but during the traditional in-service training seminars we were looking at our watches to see when it was going to end, whereas in ABI seminars we stayed on even during the night, working voluntarily. With the ABI project, not only my ideas about traditional teaching approaches but also my ideas about traditional in-service training seminars changed substantially. As a result of this knowledge and my studies, I think it is beneficial to share the observations and adjustments I have gained at the end of the ABI activities.

MY CLASSES' INTRODUCTION AND ADJUSTMENT

Before ABI implementation, my practice class was composed of an ordinary student group; after the ABI process, both myself and the other teachers in our school noticed that the students in the practice class were moving in a dynamic way in terms of cognitive development, learning abilities, generating and organizing ideas when compared to the students in the control class. I reached this conclusion with the support of my observations, the inventories I collected from the students (written/oral exams, homework, stories about the lesson, concept maps related to the unit, ABI reports, etc.), the ideas of the other teachers of this class, and the discussion I had with the parents of the students who voluntarily participated in our classroom activities.

When a colleague of mine said “2/A class is asking too many questions, criticizing my words,” I felt that we were on the right track in this process. In addition, I think that the learning environment I provide for my students has also changed. I observed that until now, there had been a teacher-centered environment where students were passive and education moved in a vicious cycle of loading information that would be soon forgotten. However, with the ABI process the students’ and the teacher’s role has changed, a new learning environment has been formed where students are active and willing to learn, enrolled in intellectual activities by mentally processing information and concepts, and expressing themselves.

In summary, the ABI approach has resulted in a positive change. My students are not the only ones who changed during this process; I have also changed, of course. In particular, my procedures for planning and implementing a unit have changed with the ABI approach. In light of these changes, I would like to highlight the big idea, which is the first step of this process. In this regard, I am going to mention what the big idea is, how it is determined, the teacher’s role in gathering students around the big idea and the problems the teacher faces while determining the big idea and their solutions.

WHAT IS THE BIG IDEA?

As Descartes said: “I think, therefore I am.”

Thinking is one of the basic and indispensable elements of being. Behind the most important developments of the world, there are great leaders focused on their big ideas. Their process of orienting their audience to the target points starts with the emergence of big ideas. In order to create an effective learning environment, the teacher, who is the leader of his/her own class, first sets a target and then generates his/her big idea in this direction.

The big idea is the destination point that we expect students to reach and is determined within the context of the unit. The big idea, which is expected to cover the whole unit, is also the intersection point where all the ways/ideas related to the units meet. Sub-ideas are the steps that need to be followed in order to reach the big idea and they are also the main theme of a topic determined within that unit. These sub-ideas are linked to the big idea in principle, but they are also more specialized structures that support the big idea. If the big idea is the end point of a stairway, sub-ideas are the steps that help us to reach them. Both the big idea and the sub-ideas include a clear, comprehensible, meaningful, and short statements.

The big idea has an important place in the ABI process. The big idea, which is related to the unit, makes the teacher active and dynamic during the implementation since it is a practice formed and constructed by the teacher without sticking to a source. At the same time, it helps the teacher to prevent the learning process from breaking down and to keep the students in the focus point by mentally creating a template or map. Furthermore, it establishes a ground for the target learning environment as the ABI process that will occur during the unit that will be planned around the big idea.

How Is the Big Idea Determined?

As I mentioned before in the importance of the big idea section, the target point of a unit for the lesson, in other words the destination point, is the center of the target board. As the possibility of making my students reach this target increases, our willpower to access our target and making it happen also increases. The relationship between the big idea and the unit is similar to the relationship between a steering wheel and a ship. Just as a captain holding the steering wheel can take the ship to the target harbor properly, a teacher who has determined the big idea can make his/her students reach the target point of the unit. Consequently, this process needs to be handled very carefully. For this reason, we need to answer the questions “How are big ideas and sub-ideas prepared?”, “What should we pay attention to during this process?”, etc.

Before determining the big idea and the sub-ideas of a unit, it is important to know the teacher’s content knowledge level, because gaps in the content knowledge make themselves evident while determining the big idea and the sub-ideas. Accordingly, the teacher needs to work on his/her deficiencies. After that, the teacher, who has strengthened their background content knowledge, enters into a mental process by focusing on the characteristics of the unit, its purpose, and its objectives. This process is the first step in the context of preparation of the big idea and the sub-ideas. In the meantime, the teacher might feel a contradiction between these mental activities and the directions like “prepare those for the unit, plan, students should listen, etc.” that comes from the traditional education approach. At the end of this process, the teacher’s own conceptions related to the unit, which is the basis of the big idea and the sub-ideas will arise. This state will lead to the formation of a template of the unit in the teacher’s mind due to the mental activities and data recording. The concepts related to the unit are determined and noted down on paper. The teacher discusses and gives the meaning of these concepts both on paper and in his/her mind. At the same time, by focusing on the unit, the unit becomes an object that the teacher can manipulate. Therefore, after questioning the relationships between concepts, a concept map of the unit can be formed.

The preparation of the concept map is a study of establishing a basis for the big idea and the sub-ideas because in order to prepare and determine the big idea and the sub-ideas, the meanings and missions of all of the concepts they have in the concept map are turned into a judgment with a sentence. Then, these judgments are turned into a basis for determination of the big idea and the sub-ideas. This study is made approximately one week before the implementation of the unit. With these studies, the potential to cover and represent the unit, to guide the students towards the way we desire and to bring students to the point we aimed at is about to be formed. Therefore, from this point, the big idea and the sub-ideas need to have the characteristics of covering the unit, being the focus of the judgments that can be detected from the concept map, being short, core, easy to remember and an intersection point of the sub-ideas. These characteristics made the ABI process more active in terms of classroom management and an efficient learning environment during the implementation.

The mental studies, the conflicts and relationships between concepts, the ideas presented and the efforts related to a different learning and teaching approach, which are experienced from the beginning of the concept map preparation, can be accepted as important factors in shaping the big idea and the sub-ideas. At the same time, they can reduce the difficulties that can be faced during the implementation period of the unit.

During my implementations, preparation of the big idea in the way explained above made my job much easier and helped me to get positive feedback. It was important for me to prepare my sub-ideas in such a way that they can represent one or more topics, their number does not exceed three and they are the most efficacious sentences that correspond to the big idea. These sentences of the sub-ideas should also have the characteristics of the big-idea as explained above. Within the scope of clarifying this, I believe showing my studies related to the units I taught will be more effective; therefore, I present the examples of the big ideas and the sub-ideas in [Table 3.1](#).

When the relationships between big ideas and sub-ideas are examined, it is seen that they correspond to each other and address a unit. As it was mentioned before, it can be said that the ABI process can be prepared and implemented in every lesson by selecting a unit based on one of the branches of the science, physics, chemistry and biology. The research, mental studies, and concepts emerged as a result of the ideas obtained through rigorous and creative thinking, which were made during the formation of big ideas and sub-ideas, and investigation of the relationships between them have a fundamental effect in construction of the concept map. The ideas I mentioned above were written as a result of the concept maps (see [Figures 3.1, 3.2, 3.3](#)).

Table 3.1. Big and sub-ideas

<i>Physics</i> <i>"Force and Motion"</i>	<i>Chemistry</i> <i>"States of Matter and Heat"</i>	<i>Biology</i> <i>"Humans and the Environment"</i>
<i>Big idea:</i> Objects move with the effect of force.	<i>Big idea:</i> Matters change when they are heated.	<i>Big idea:</i> Living and non-living things always have an interactive relation.
<i>Sub-ideas:</i> 1. Liquids and gases apply buoyant force 2. In liquids, the objects sink if they are denser; they float if they are not. 3. Force causes pressure.	<i>Sub-ideas:</i> 1. Heat, which is a kind of energy, can be transferred, while temperature can be measured. 2. Matters make heat exchange and change state. 3. Heat separates matters from each other.	<i>Sub-ideas:</i> 1. Within each system and between the systems there are interactive relations. 2. Living organisms are diverse and this diversity affects the environment. 3. Pollution affects living and non-living things.

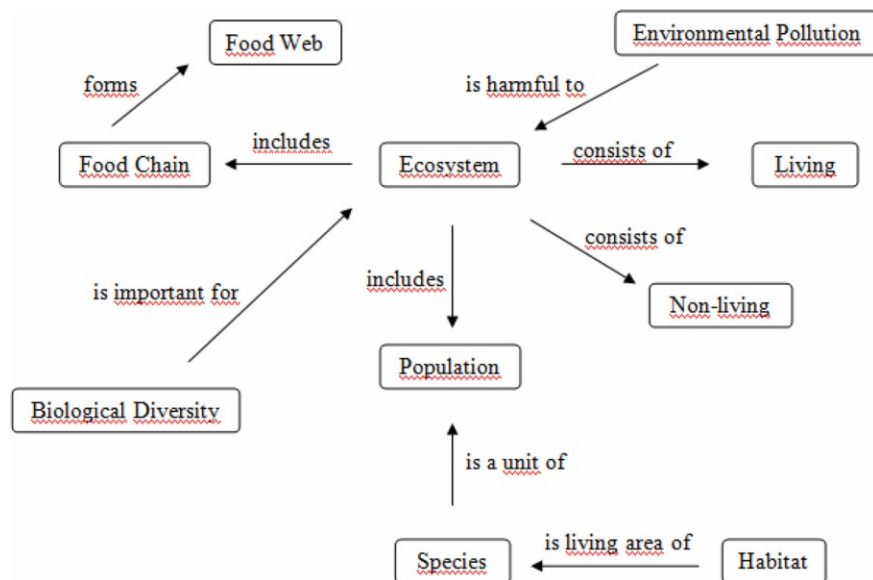


Figure 3.1. Biology concept map: Humans and the environment

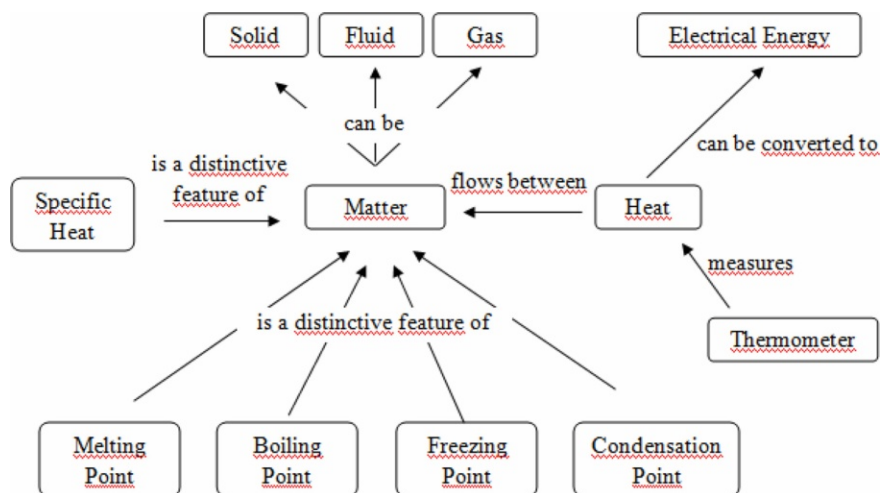


Figure 3.2. Chemistry concept map: States of matter and heat

THE TEACHER'S ROLE

During the implementation, the teacher has an important role in making the lesson comprehensible without losing the integrity of the subject and by providing continuity.

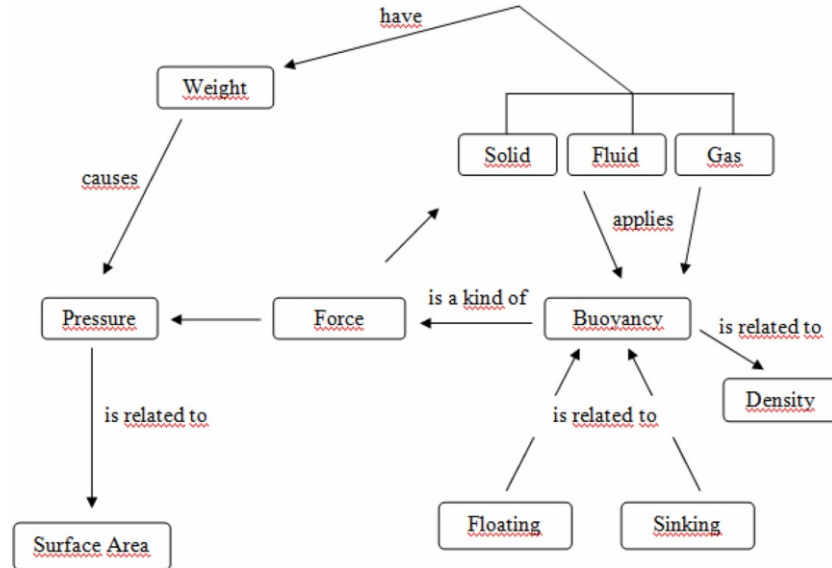


Figure 3.3. The concept map of the physics unit: Force and motion

The most important duties of a bus driver are getting the passengers to the desired destination point safely and being behind the wheel with complete attention so as not to cause accidents. Similar to this example, the teacher's main duties are determining the big idea and the sub-ideas; the focus point of the unit, being careful in ensuring that the process moves in this direction and carrying the students through the desired point. For this reason, while managing the classroom actively to achieve their goal, the teacher should also be able to intervene in the process when she/he thinks it is necessary. Beyond any doubt, these interventions and guidance should be in line with the big idea. Otherwise, we will deviate from our aim, since we deviate from the big idea. Furthermore, we will face difficulties while trying to put together students and carry through the desired point. In such a case, the teacher should realize how problematic the lesson has become.

During the first phases of my ABI implementations I experienced such a situation and problems. In these first implementations, I had trouble motivating my students in the lesson, since I could not provide the meanings of the preparations and the big idea concept. Each student who had broken away from the lesson had gone to another space in the classroom. The students, who did not know what to do, had taken me to an unexpected place with their questions. I had experienced problems in terms of putting them together through my purpose and managing the lesson. Our lesson was swaying from side to side like a ship with an uncertain route. I had thought that my students were about to be drowned in misconceptions. As a matter of fact, they were expressing their argument by saying "Can't we go back to our old lessons?" However, the ABI seminars I attended, the exchange of ideas I made

with the researchers and the teachers in these seminars and the experiences I gained through “learning by doing”; practicing the ABI implementations, which would be made later in the classroom with my colleagues by acting like students, helped me get through this problem. In this way, I had faced the possible problems that might occur during the lessons and gained insight into the precautions that should be taken in order to overcome these problems. With the experiences I gained, it had become easier for me to focus my students close on the big idea and lead the lessons.

In this section, I would like to share my experiences about gathering the students around the big idea. First of all, as a teacher, I always consider the big idea to be able to carry out the ABI implementations in the way it is desired. I try to design the activities efficiently and in this direction, which could be done during the implementations. I think the method that the teacher follows during the implementations of these activities is very important. With the questions I asked and the answers I received, I examine the students’ closeness-remoteness relationship to the big idea both as a group and individually. I focus on guiding students through the big idea by providing them with an opportunity to construct their’ ideas, knowledge, and objectives, and I also try to focus them on the big idea with the help of qualified questions I ask during the discussions and implementations of the activities. During the activities in the classroom, when I realize that my students deviated from the subject and frame of the big idea that the teacher drew in his/her mind, I interpret the student’s questions within the frame of the big idea and ask the students open-ended questions like “What do you think?” or “What is your idea about this issue?” to pull him/her toward the target. Otherwise, there will be a confusion about purpose and misconceptions in the classroom, which is an undesirable situation for a teacher. At the same time, in order to make the students participate into the lesson, I try to use encouraging language and be patient with my students; because this is a process in which the teacher also learns while teaching. Although it looks difficult both for the teacher and the students at the beginning, substantially efficient results will be obtained after the steps of this process are comprehended.

As a result, I can say that the preparation studies I made before starting my implementations made it easier for me to manage discussions better, ask perfect questions, think attentively and in detail, use the language better and reach the targeted point of the learning process. Furthermore, it contributes to creating an effective learning environment by better time management.

DETERMINING THE BIG IDEA

In my opinion, determining the big idea is one of the most important steps of the process of unit implementation, because the big idea forms a basis for the studies that need to be made during the preparation. In this regard, the characteristics of the big idea can be listed as:

- It should be able to cover the whole unit.
- It should serve the purpose of the unit.
- It should be short, essential and comprehensible.

Table 3.2. Suggestions and solutions

The teacher's internalization of the unit, in other words awareness of the purpose and meaning of the unit in terms of preparing students for life, which could make his/her job easier during the preparation of the big idea.

If the teacher feels as if they lack knowledge related to the unit while generating the big idea, s/he can face problems while determining an appropriate idea. In spite of that, if the teacher updates himself/herself continuously, this problem might be solved.

The teacher's noting of the important concepts related to the unit and construction of a concept can reduce any problems related to the determination of the big idea.

The necessity for the big idea to cover the whole unit results in some problems. In this case, it might be necessary to make long sentences; however, as the sentences become longer, they become harder to understand. This problem can be solved by dividing the sentence into smaller, meaningful sentences. Another alternative is determining the sub-ideas in advance and then generating the big idea to cover these ideas, since sub-ideas are easier to determine.

Since the big idea needs to be unique, different from the objectives of the curriculum but also related to them, its formation requires an intense thinking process; and therefore, results in difficult times for teachers. These difficult times can be overcome through acquired experiences.

It is important for teacher to do his/her job fondly and willingly. The teacher's persevering, willing and patient nature can help him/her solve all problems related to this process.

Sometimes the activities might not reflect the big idea/sub-ideas. In this case, the activities should be planned beforehand while determining the sub-ideas. Furthermore, in order to solve this problem, general activities might be chosen that address more than one sub-idea.

- It should be the focus point of the all sub-ideas.
- It should make it easy for the teacher to guide the students during the implementation.
- It should be original and easy to remember (like a slogan).

Since the preparation of the big idea and the sub-ideas is a challenging process for the teacher mentally and conceptually, it is normal to experience some difficulties and problems. In general, it is undeniable that after these problems a good product will be produced and the desired target will be reached. Certainly, with the acquired experiences, these problems can be turned into opportunities. See [Table 3.2](#) for suggestions and solutions to problems addressed earlier in the chapter.

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4. QUESTIONING IN ARGUMENTATION-BASED INQUIRY (ABI)

Students should feel proud that they have a question rather than pleased that they have the answer.

(Janice Szabos)

Teachers who believe that their task is to educate the Socrates within students can make the classroom a place for asking as well as answering questions. Problem-finding will have equal importance with problem-solving. Student questioning is the tool that opens the “window” for effective, meaningful learning.

(Garnet Miller)

MY SCHOOL, STUDENTS, AND WORKING ENVIRONMENT

I am a teacher who lives in Istanbul, which is a great metropolis. Istanbul is in the Marmara region and the biggest city in Turkey, home to about fifteen million. Istanbul, which played an important role in the past and is still playing a crucial role today, perpetually allows people of all backgrounds from all regions around Turkey into its city. The fact that the city is an important center in terms of industry, commerce and tourism is the most important factor in its allowing immigration to flourish. Therefore, Istanbul has a mosaic structure in terms of history, commerce and culture (see [Figure 4.1](#)).

I work at Bayrampasha Primary School in the district of Bayrampasha, which is located on European side of Istanbul (see [Figure 4.2](#)). Twenty-six years ago, I was a student at the school where I work today. Our school, which consists of two independent buildings, was established in 1971 with 12 classrooms. The additional building with its 24 classrooms was put into service in 2005. There are four classes from grades 1 to 8 in our school. In addition, there are four classes for pre-school level and a special class for students with disabilities. Our school has approximately 1,600 students, 50 teachers, and 5 school administrators. There are 45 to 50 students in each classroom on average.

There are 25 schools in Bayrampasha District. Our school is ranked second or third among these schools in terms of academic success in the national examinations. When evaluated within Istanbul in general, our school has an academic success that



Figure 4.1. Istanbul



Figure 4.2. The istanbul bayrampasha primary school

is above the average. Our school is preferred by successful students who live in different regions because of its academic achievement, which can lead to oversized classes.

In my school, generally the students' families immigrated from either the second and third generation Balkan states (Bosnia, Albania and Macedonia) or different regions in Turkey. Most or all students at my school are middle class or more financially established. The families expect academic success from their children

QUESTIONING IN ARGUMENTATION-BASED INQUIRY (ABI)

for the future. In this school, all students are fond of one another as if they were members of a big family, even though they have different cultures.

MY INTRODUCTION TO ABI

I think that the teachers I had in school affected my choice of teaching profession. It has been my general philosophy in this profession to always follow in the footsteps of my teachers whom I look up to as my models and to work in order to be a better teacher. Therefore, I try to participate in in-service trainings during my teaching profession to develop more of my skills.

I was asked whether I want to engage in an education project which was planned by a researcher whom I met during an in-service training. About thirty teachers were chosen among the teachers who wanted to participate in the project like me. I was so happy to be in this group. When invited to the in-service training, I had no idea about what Argumentation-Based Inquiry (ABI) is. My first acquaintance with ABI happened with this education seminar.

The first ABI in-service training lasted for five days and it was so busy! This training was very different from the ones that I participated in before. In this in-service training, which was beyond the understanding of a classical seminar, we performed applications and we were able to discuss and ask questions by taking a student role. We benefited from the teachers' and researchers' experiences during this process. As the time goes by, details about ABI applications began to leave a mark in my mind. The trainings, applications and discussions here were very effective for my professional and pedagogical development. I noticed my weak points and found an opportunity to improve myself in these trainings. I think every teacher should go through such a training program.

My First ABI Application

In our country, science education curriculum changed in 2004. My previous in-class applications were more toward teacher-directed instructional practices, including didactic instruction. Science courses were generally held with the favorite students in the class and there were not many attempts to increase the participation of other students in the discussions. With the new curricula, teacher-student interaction was pushed. We tried to form class environments where teachers and students are mutually active. However, there were still questions in my mind concerning how I could form a more effective class environment.

I got so excited in my first ABI in-service training. During the training, I had an idea that ABI applications might increase the dialogue for student-student and student-teacher interactions and be enjoyable and educative as well. My first opinions about ABI were so positive and I got excited that I would apply this approach in my class.

Before I started my ABI applications I thought that I should change the classroom arrangement (see [Figure 4.3](#)). Our classroom arrangement was a classical one.



Figure 4.3. Original classroom setting

Unfortunately, the seating arrangements, in which students sit in a row and see each other's backs, was not suitable for group work. In order to find a solution, I had students sit in groups where they could see each other's faces, which is more suitable for group work. This new seating arrangement was important for students to interact with each other.

Before starting the first application, I told my students that we were going to have argumentation-based applications and I informed them about the approach. I warned them to obey the related rules especially with time management. In ABI applications, I tried to switch from a talking-teacher to the teacher having students talk. I gave emphasis to support students to interact not only with me but also with each other at the same time. My aim was to create a classroom full of voices, contributing to the shaping of ideas and discussion.

I must confess that my first application did not work as I had planned. I noticed that the processes of asking questions, revealing prior knowledge, starting the discussion within the classroom, and reaching the big idea are not easy at all. I must even say that my students had many problems in listening to each other during the applications. They were not familiar with being responsible for their learning, trying to find answers to the questions, thinking and concluding. In a similar way, I also performed an unfamiliar teacher role in the classroom that they were not used to at first.

Assessing Prior Knowledge through Questioning

In the classroom environment before the ABI applications, I used to ask a few questions in order to increase students' motivation and find out their prior knowledge about the topic. These were generally knowledge or comprehension levels of Bloom's Taxonomy. In general, the answers were not satisfying. There were almost no answers to these questions in some classes. Frankly speaking, I hadn't thought

QUESTIONING IN ARGUMENTATION-BASED INQUIRY (ABI)

much about the importance of questioning in the learning and teaching process before I started the ABI applications.

My questioning style and the quality of my questions have changed with the help of ABI implementation. I benefit from the questions in order to help the students' participation in the class discussions, increase their interest, find out their prior knowledge, help them to link knowledge, understand and develop their opinions about the topic and what they learned. Additionally, I ask questions in the class to guide the students, to start or continue the discussion process. With the implementation of ABI, I started to include questions not only in the knowledge and comprehension levels but also the application, analysis, synthesis and evaluation levels in the learning process.

Students' questions may give hints about what and how much they have learned. I try to understand whether the students have linked the topics or how they connect topics with the help of questions. With the students' answers, I can recognize the aspects that are incomplete or need to be developed. For this purpose, I ask other questions to deepen and explain the students' answers. In the course of time, the students noticed that questions are deepened with other questions in the ABI process. For example, in an application about the force, the student, who said that *power is an energy*, told me that "Now, you will ask what power is, won't you?"

I noticed that the teacher plays the role of an engineer for a locomotive about questioning for the class, steering students in a discussion towards an end point. I have observed the positive effects of questioning on the students during the ABI applications since the first application. I have observed that the more active students' participation in the question-answer process, the easier writing to the research questions. Furthermore, I noticed that all students were encouraged to answer the questions in the course of time. The number of students who participated in the course increased with the ABI implementations. The questioning process has increased both the dialogue between teachers and students and the interaction between the students as well.

I make use of questions at different stages of the ABI application process. I use questions as a means while preparing the beginning questions, starting and maintenance of the discussion process. Below, I share my ABI experiences about using questions and preparation of learning environments, which make asking questions possible.

THE BEGINNING

At the beginning stage, teachers ask good questions that affect students' interest and participation in the lesson in a positive way. If the teacher doesn't lead with a good beginning activity and questions to achieve the goal, you can immediately notice that reluctance and weariness start to emerge in the class. In this case, it will be more difficult to motivate the class for the topic. This situation will cause the following applications to be weak especially in crowded classes like where I work.

I ask my students questions that reveal their prior knowledge and try to have most of my students participate in the process. For that purpose, I aim to ask questions that are appropriate for the students' level, will deepen their thoughts, will help them be away from the expected knowledge and with which they will question their own thoughts. I pay attention to give the students the opportunity to think by giving them enough time in the questioning process. After asking questions to the students I gave them 4–5 seconds to think. In this way, I give them both the opportunity to think and to help them reorganize their knowledge. In my previous implementation before ABI, I used to ask my questions directly to the class, give permission to the person who wanted to talk first, and go on the course in this way. With the ABI implementation, I observed that when I gave my students the opportunity to think, they expressed their opinions and participated in the discussions more. Moreover, I can say that student answers are more creative as well.

While planning the unit, I make a preliminary guide on what kind of questions I will ask while also anticipating the answers of my students which could lead me to ask a question that I didn't plan before. I do not hesitate to ask such unplanned questions. In this process, I include questions that are not only in the level of knowledge and comprehension but also higher level thinking questions such as application, analysis, synthesis and evaluation level questions. The distribution of questions in different levels can differ from topic to topic. I think that teacher should be good at asking questions at the beginning of the lesson in order to reveal students' prior knowledge and have them face with the new concepts they will learn. In my previous applications, I used to ask questions concerning knowledge to some students and go on the course by supposing that I revealed their prior knowledge. After ABI, I saw that revealing students' prior knowledge is, in fact, a very difficult process. I think that especially the level and quality of the questions that are asked to students in order to reveal their prior knowledge are of great importance. In my first application, a discussion environment that I had with my students happened as in the following:

Teacher: What is chemical change? What do we understand when we hear chemical change?

Student 1: The transformation of a substance into a different one. For instance, the growth of a plant.

Teacher: Does a plant turn into a different thing when it grows?

Student 1: No.

Teacher: Then what part changes?

Student 1: Its traits.

Student 2: I don't agree with my friend. Chemical change is when a solid turns into liquid and liquid turns into a solid.

Teacher: Is chemical change limited only with these?

Student 2: No.

Student 3: If water freezes, it becomes solid and when it melts, it becomes liquid.

Teacher: Is this a chemical change?

Student 3: Yes, it is a chemical change, because a solid's atoms turn into liquid atoms.

Student 4: The shape of the substance changes in chemical change.

Teacher: How's that?

Student 5: The transformation from solid into liquid is a chemical change.

Teacher: Then do the atoms change while changing from liquid to solid?

Student 5: Yes. The shapes of solid and liquid are different from each other.

Student 6: Chemical change happens when a substance turns into a different substance with other impacts.

Teacher: What does it mean for a substance to turn into a different substance?

Student: For example, fermentation of milk.

Student: Does milk lose its traits when it ferments? Does it turn into a different substance?

When I reviewed this discussion that belongs to my first application, I believe that the questions I asked to the students were not so good at assessing their previous knowledge. When I ask knowledge questions such as "*What is this?*" to my students, they could define a word which they memorized from books or different sources. They cite definitions without much knowledge about its content. It is important to reveal students' conceptual structure with good questions in this process. Thus, questions should be carefully chosen by teachers. Instead of questions directly asked to judge students, questions that will completely reveal students' knowledge about the concepts should be asked. Knowledge level about the concepts should be brought out with follow-up questions. Different types of questions should be used to follow-up. The prior knowledge should be brought out with questions like "How come?", "What happens if ...?", "What could be the reason of this?" and "What kind of differences are there between them?" and should be faced with the new concepts to be learned.

The stage at which prior knowledge is detected is followed by the process by which students construct the research questions. I think that the questions students ask and the beginning activities which teachers use are important to help students to construct their research questions within the big idea framework. In this process,

I generally plan a beginning activity that will help students to question their current state and want them to form research questions about the topics which will support the big idea. I have them think about the questions they are curious about the topic in groups. While doing that, I want them to write down the questions they constructed. I observed that my students produced a lot of questions in the first ABI applications. I give time to my students in order to construct their questions.

After completing the question construction process, I want all the groups to share their questions with the whole class. For this purpose, I drew three circles one within the other with different radiuses (Figure 4.4) in the first applications. I had the questions discussed in the classroom. I had students read the questions aloud in the classroom and discuss how to test these questions. I wanted them to put the searchable, testable and good questions in the innermost circle. I told them to put the questions whose answers they partly know or that cannot be tested in available circumstances in the second circle. They put the questions which are not possible to be searched in the last circle. I tried to involve the whole class in the determination of the good questions in this process. The students decided on what questions should be searched together with their classmates. Although this procedure took a lot of time in the first applications, the students began to carry out this task quicker and appropriately in the course of time. At the beginning, they had too many questions. However, as they became more familiar with the applications the number of questions decreased but the quality of questions increased. I believe searchable and testable questions are important in reaching the big idea.

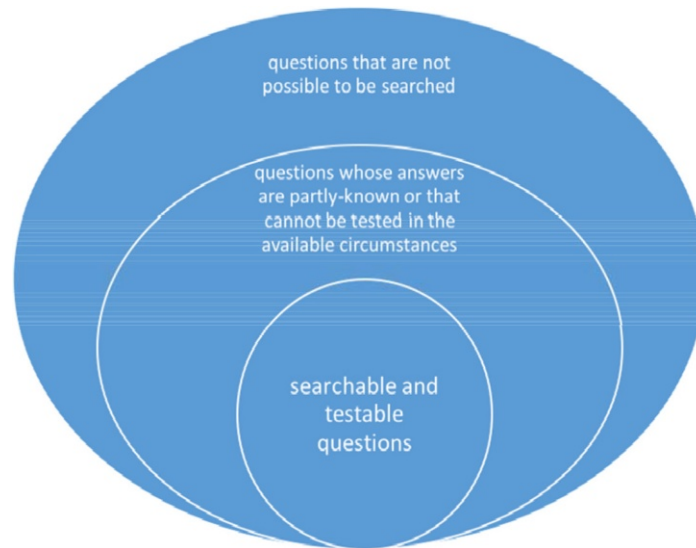


Figure 4.4. Categorization of the research questions

HOW DO I USE QUESTIONS IN THE DISCUSSION PROCESS?

The discussion process is another process by which questioning has an important role in the ABI applications. This is a section which both I and my students enjoy a lot. In the ABI applications, revealing of prior knowledge is followed by the determination of research questions and then by looking for answers to these questions. The question-answer process also works very well among the students in the groups who look for answers to their research questions (see [Figure 4.5](#)).

Student 1: I think it depends on density. Since the sea has a higher density, we can swim more easily.
 Student 2: No, I don't agree with that. I swim in the rivers more easily. Because it is pure.
 Student 3: What is your evidence for saying that? Can you give an example?
 Student 1: I can swim in the sea more easily but I find swimming in the river more difficult.
 Student 3: Is your swimming in the sea more easily related to density? How do you know it? Maybe this results from the amount of water. How can you prove that this situation results from density?

Figure 4.5. Exemplary discussion between students

Each group finds their answer to their research question. This stage which happens within the group is followed by the discussion stage where all the groups participate in. At this stage, my students are ready to share their findings after testing their research questions. We start the discussion process by giving each group equal time. While the groups are presenting, they explain their beginning ideas and research questions. They declare their claims and present their evidences in light of the findings by sharing how they have tested the research question with their classmates. It is crucial to have all students actively participate in the discussion which occurs within the question-claim-evidence framework as much as possible (see [Figure 4.6](#)).

This discussion stage is very important while guiding the students to the sub-ideas and then to the big idea. You need to ask effective questions in order to lead students to the big idea with the help of questions in this process. I must admit that I couldn't manage the discussion process well in my first ABI applications and thus the discussions were away from the big idea.

I have learned to use the discussion process for students to reach the big idea by changing my questions and controlling the questions of my students more effectively in the course of time. When we moved away from the big idea, I said, "This is also an interesting topic and let's talk about it later," trying to guide the discussion around the big idea with new questions.

The discussion process can be defined as the part where student voice in the class increases most. There is an intense student-student interaction at this stage. The classroom management and time management are very important at this stage. It is

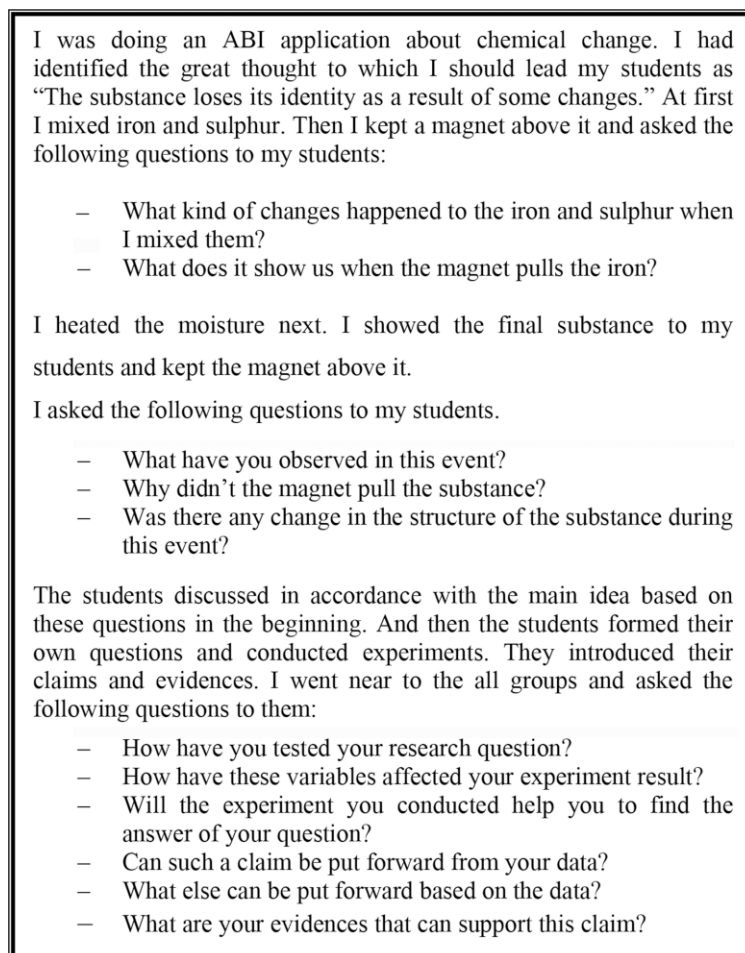


Figure 4.6. An example of ABI implementation

crucial that each group must use their time well and all groups should listen to one another carefully. I also benefit from the questions to increase the interaction among the groups. With the questions like “What do you think about the claim of this group?” or “Are there any evidences that support the claim?” I start the interaction among the groups and sometimes allow them to be free by saying, “You can ask questions to each other concerning what you have done.” While every group defends their own opinions here, I also come across some self-assessments like, “We thought in this way at first but we found what the other group did reasonable. We left those points incomplete.”

The maintenance of the discussion process is as important as the starting of it. The maintenance of the discussion can be achieved with questions like, “What do you

think?” “Do you agree with what your classmates have said and why?” I also benefit from the students’ questions in this process in order to lead them to the big idea. I reflect the question of a student with questions like, “Ahmet is asking this. What do you think about it?” I try to involve all the students in the discussion process actively with these kinds of maneuvers.

After all the groups finish their presentations, I also use questions while finishing the discussion process. Moreover, I finish the discussion process with student answers by asking a question like “What kind of changes happened to your opinions?”

How Has My Questioning Style Changed with ABI?

It can be said that my questioning style was a classical one before ABI. With “classical,” I mean that the questions were in the knowledge and comprehension level questions such as “What is this?”, “How is ...?”, “How did ... happen?”, “When did ...?”, “Which one ...?”, “What does ... mean?”, “Can you explain what is happening ...?”, “What can you say about ...?” I used to start the course by asking a few questions to increase their motivation before the topic and the questions had short or yes/no answers. There was little room for divergence of interpretations and ideas.

I used to ask questions in written examinations to assess knowledge level. The questions we asked in the examinations were generally in the level of knowledge and comprehension. I must say that I had few questions to assess high-level thinking abilities. Furthermore, I used questions in in-class activities for oral exams. I can say that knowledge and comprehension level questions were numerous in the oral exams. This situation was classical for most of my teacher classmates. I rarely used application, analysis, synthesis and evaluation level questions. My students were used to knowledge and understanding level questions, so being challenged with high-level thinking questions was an unfamiliar situation for them. This case was the same not only in my courses but also in other courses.

At the beginning of the ABI applications, there was a long silence in the class when the students came across application, analysis, synthesis and evaluation level questions which are high-level thinking questions. As a consequence of my introduction to ABI and the training I had, I noticed that there was a good chance my students could answer high-level thinking questions such as “What would happen if ...?”, “How would you use ...?”, “Why do you think ...?”, “How is ... related to ...?”, “What evidence can you find ...?”, “How would you test ...?” “Can you predict the outcome if ...?”, “Do you agree with it? Why or why not?”, “What is your opinion of ...?”, “Why is it better ...?” They were used to this situation in the course of time, like I had gotten used to the ABI process. Now they did not answer the application, analysis, synthesis and evaluation level questions with silence.

Another change was about the participation of students whom I define as passive in the classroom activities. Now the students whom I previously described as passive had a more active role in answering the questions. This meant the students’ participation transformed the usual routines over time as they became more involved

and engaged. Now, the students were eager to participate in class discussion and take responsibility in the ABI applications. Students' active participation in the course and observing their development made me happy.

I believe that questioning in the class is an important process for both teachers and students. The changes in teachers affect the change in students. It took time for me to start to use questions effectively in the ABI applications. I observed that my students also adapted to this process slowly. At the beginning, I started my ABI applications by extending a few questions I asked before or asking the same question again and again from different ways. It can be likened to warm-up exercises in physical education. I then had them enter into a deep thinking process by extending the content of my questions. It was much more beneficial and enjoyable to work with the students in my later ABI classes.

I used to frequently ask questions whose answers were either "yes" or "no" before ABI. Together with ABI, I noticed that these questions did not take me or my students to the goal. Today, I barely use these questions. Now I think that these kinds of questions damage the dialogue between me and my students.

I started to use follow-up questions more effectively with the ABI applications. I use follow-up questions to guide my students, deepen their answers and consolidate their knowledge. While asking these questions, I always think about the big and sub ideas to which I want to drag my students and ask my questions according to big idea. Students' answers might sometimes move us away from the big idea but it is possible to take our students to the big idea by using questions.

It is very important for students to ask questions as effective as teachers during ABI applications. Based on my experiences, this is not so easy in the beginning. The students would ask knowledge and comprehension questions before my ABI applications. As the applications progressed, I observed that my students progressed in terms of asking questions, asked more qualified and high-level questions both to each other in group discussions and to me. Students asking questions to each other was not a common event in our classroom environments before ABI. However, students always have attempted to ask questions, discovering their answers since the first stage of the ABI applications.

Students ask a lot of questions both in groups and in classroom discussions. I listen to the questions students ask to each other while walking around the groups during group work and try to understand what they think by asking them some questions. While listening to them, I avoid facial expression and reactions that can give clue to them. Initially, the students were not used to this. Listening to them unresponsively made them have dilemma whether they are doing right or wrong but they got used to it in time. The listening of their answers unresponsively made them defend their idea.

After the groups test their research questions, they create presentations. Using questions during the presentations is important to start the interaction among groups. The group presentations are the time when student-student interaction is the most productive and intense. At first it was not easy for students to follow each other carefully. They adapted over time as they practiced more. As long as they listened to

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and followed each other carefully, they reached the big idea easily. We all together experienced that the discussion stage where students intensely ask questions became very enjoyable and educatory in the course of time. It is a fabulously enjoyable process for a teacher to observe the change in students with ABI.

CHALLENGES IN ABI

It is wrong to say that the first ABI applications in the classroom were very easy and successful. Both my students and myself hesitated a lot in the first ABI applications. It did not take a long time for them to get used to this new learning environment. They showed how eager they were in adapting to this process in such a short time. Both my students and myself got used to this approach after a while. These are some of the challenges that took place over my ABI implementation.

Questioning

I didn't use the questions effectively in the class before ABI. The fact that questions are so important in the ABI process made me feel nervous at first. I asked the questions "What will I ask? How will I ask?" to myself many times. As I gained experience in the ABI applications, my anxiety started to disappear. Additionally, I wasn't used to getting so many questions from my students, either. I must say that I was anxious not to be able to answer their questions many times, but now I take it easy not to be able to answer their questions and try to find the answer with my students. This is probably one of the most important changes in my teaching profession.

Another challenge I had in this process is high-level thinking questions. The students were reluctant to answer these kinds of questions and participate in this process in the first applications. Those students who hesitated to participate in the process in the beginning started to have a more active role. I had students focus on the question by emphasizing the question, rewording the question. I use questions in different levels which will help them to think on the subject systematically. I use low-level and high-level thinking questions according to my purpose.

Management

I would like to share the other problem that I had at the beginning. My students were talking with each other about the topics not related to the course in my crowded classes. This is one of the problems for which a solution was found in time. This problem disappeared automatically when the students got used to group work and began to actively participate in the process. The chatting left their place to the speeches and discussions about the subject. Succeeding in involving all the students in the process as much as possible is the basic solution of this problem.

Another problem I had with the ABI applications was time management. The fact that both I didn't control the process and the students were in a learning

environment with which they were not familiar in the first ABI applications were very problematic in terms of timing. I came across some problems when students weren't able to construct the research questions within the given time, it took more time than expected for students to find the answers of the questions and group discussions went away from the big idea in the discussion process. However, students found better research questions within the given time, planned and conducted their experiments more quickly. As I gained experience in directing this process, it caused timing problems to decrease.

WRAPPING UP

This has been my journey through questioning in the ABI process. I think about the basic questions which will take my students to the big idea while planning my courses. I identify some key questions which will take my students to the great big idea. Certainly, I cannot use some of the questions in the class. I ask new questions that will bring them closer to the big idea by making quick decisions in line with students' interpretations, answers or questions. At the beginning, these kinds of maneuvers were the processes in which I had difficulties. However, I gained experience in concentrating on the big idea while asking questions in the course of time. We should ask the question, "How does my question aim towards the target?" to ourselves at the question-formation stage. Predicting which question will take the students in advance is crucial in terms of directing the process. I try to prepare questions that are relevant to my goal. Questions are effective tools for taking students to the desired point when discussions go into different directions.

Teacher-student dialogue was more dominant before the ABI applications and in the first ABI implications. The sentences generally started with "Teacher." I gave importance to involve all the students in the class, which was possible only with student-student dialogue. I found a solution for this case by posing reflective questions to the class. I ask the questions such as "Your classmate says... 'What do you think?'" "What do you think about what your classmate said?", "Your classmate said... 'Do you agree with that?'" to the other students in the class. In this way, I try to turn this process into student-student dialogue. Group work also makes this process much easier. Student-student dialogue develops naturally in the discussion process that starts among the groups. I try to involve all the students in the process by observing the groups and asking questions to them and to help student-student dialogue become dominant. I especially help shy students to get involved in the process by encouraging them and while doing that I try to balance between the voluntary or reluctant students.

In this process that started with in-service ABI training, my sharing with both academics and my colleagues were very important for me to overcome the problems. The exchange of ideas about the applications and knowing how they handled problems about classroom management helped me to progress more quickly in the process. It is impossible to say that my current applications are perfect. I learn when

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I apply and try to produce solutions for the new situations I come across. It is so relaxing to know that I can get help when I need it, to exchange ideas with my colleagues who carry out ABI applications, and to know that I am not the only one who faces these problems. I always remember that every application is an experience for us and can be developed. The more the applications progress, the better questions students learn to ask, the better they learn to express their opinions and the better research questions they learn to construct.

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SELÇUK OZGUR AND SEVGI KINGIR

5. NEGOTIATION

INTRODUCTION

I was appointed as a primary school teacher at the beginning of my career. It was a combined class with more than one grade level and I was the only teacher teaching at that school. I was feeling like a fish out of water. Eventually, I was a teacher; I was required to guide my students. It took about two months to teach the name of the capital city of Turkey to my students who had never lived outside their hometown. Then, why did it take such a long time? I think, you will find its answer below.

School Context

The school I currently work is in Dikili, which is a coastal city, and a district of Izmir Province in the Aegean Region of Turkey (see [Figure 5.1](#)). Dikili is situated at about 120 km north of Izmir with a population of around 35,000. The city is quite picturesque both along its shoreline and in its interior parts, and is a popular summer resort. The facilities of the school are adequate and parent involvement in the school is at a reasonable level. Socio-economic background of students ranges from medium to high. In our school, student success is not satisfactory, although



Figure 5.1. A general view of the school

it is better compared to that in other cities of Izmir Province. Because our school is located at the shoreline, it is difficult to engage students in classroom activities especially in the summer. On the other hand, due to the test-driven nature of the curriculum in Turkey, both students and their parents have a high-level test anxiety.

First Impression of ABI

Let's talk about how I started with Argument Based Inquiry (ABI) ... One of my best colleagues came to me and told that he was going to participate in a seminar about the ABI. The acronym 'ABI' was not familiar to me. When, naturally, I asked him what the ABI stand for, he responded as 'What?' Then, we laughed together. Now I remember that conversation whenever someone asks me what the ABI stands for.

I have participated in several professional development programs so far. In these programs, a trainer was at the board, reading something from the presentation slides, and we, teachers, were listening. The program was usually taking a few hours. Just after the program, we were discovering the city's main highlights and points of interest. At first, I thought ABI professional development program as an ordinary program, just as the programs mentioned previously. Because the word 'ABI' was interesting to me, I asked my colleague to describe what was happening in ABI professional development programs. Based on my colleague's description, ABI professional development programs were different from the ordinary ones. Thus, my interest in ABI increased over time. An inner voice was telling me that ABI would answer my question: 'How can I teach science concepts to my students in a more effective way?' Therefore, I felt that I should participate in ABI professional development programs. I asked my colleague to talk with the coordinator of the National ABI Project and professional development program coordinator, Dr. Murat Gunel, about my desire to participate in that program. My colleague gave me good news in a very short time. I was going to experience ABI in the next professional development program. However, I was aware of the potential difficulties of this journey because my colleagues were one step ahead of me. That is, they had participated in the first ABI professional development program and started to implement the ABI approach in their science classes. Fortunately, there was a short time period, just 2 months, for the second ABI professional development program.

In January 2011, I became a member of the ABI family with the second professional development program held in Kırşehir, a small city located in the central part of Turkey. However, the activities done on the first day of the professional development program that I took part appeared to be more different from the ordinary ones. I was unfamiliar to the conversations between the trainers and participant teachers about the ABI implementations and the problems encountered during those implementations. I was still trying to understand what the ABI is. For this reason, on the first day of the professional development program, I asked myself, "Why am I here? What am I doing?" My colleague who accompanied me kept an eye on me; he was observing my behaviors and trying to understand my feelings. According to what I learned from

him later; at that time, he thought about me “Selcuk is going to give up the idea of participating in this program.” There were two more new participating teachers on the same situation with me; these two teachers were also thinking the same question. Despite these problems, the ABI became clearer and understandable to me with the help of the consideration of newly participated teachers’ situation, working with the experienced teachers as a group, and support of my colleague who accompanied to me. At the end of the program, the trainers informed us about the process to be followed until next meeting. The trainers mentioned that they are going to visit teachers at least one time during the ABI implementations and provide support to teachers if needed. Knowing that I would be visited and supported by the project team in my ABI implementations made me more comfortable. At the end of the professional development program, I was so excited for implementing the ABI approach in my science classes.

Implementations of ABI and Negotiation

Before I met with the ABI, I was traditionally using the textbook as a main source of knowledge in my classes. I was asking my students to read the related topic from the textbook prior to the class session. During the class session, first, I was explaining the content, and then I was having students watch a video related to that content. Immediately afterwards, I was asking students to take notes. I was also asking students questions to check whether they understood the content. If I got a response similar or closer to what was in my head, I was proceeding to the further topic; but if I could not get it, I was explaining the content again. A few months later, students were taking exams. At that time, I was recognizing that students were not learning the concepts that I previously taught. Therefore, I believed that the ABI implementations would be a solution for these problems. However, students became anxious when I told them the ABI process on the first day of my class session after participating in the professional development program. A reason why students became anxious about the ABI could be because they were doing something different from what students were used to doing. Another reason could be nationwide high school entrance exams. According to many beliefs, being successful in these exams is directly related with having science classes with test-driven curriculum and implementation.

There had been a decrease in students’ anxiety levels as the ABI approach was adopted in our classes. Students enjoyed the science classes over time, because the ABI approach was anticipating active student engagement in classroom environment and provided students opportunities share their own experiences. Each stage put forward by ABI, including a range from identifying beginning ideas to writing reflection, aims students to experience negotiation. I was trying to create an environment in which students could find a chance to experience negotiation.

So, what is negotiation? Negotiation is a process of arriving at a common agreement through a set of discussions in which various ideas about a topic are put forward. During negotiation, all the ideas coming from the students were valued, which was enjoyed by the students. Students were constructing a concept map as

a group by using their current concepts about the topic under consideration. In this group work, each student was saying his/her own concepts and then writing on the paper. Afterwards, they were connecting those concepts as a group.

After students recalled their current concepts about the topic through concept mapping, they tried to state what they wanted to know in the form of questions. Students were deciding on their group questions through negotiating their own individual questions. The students who were not even interested in classes started to become involved in question formulation process over time because they were determining the questions which they want to investigate. Each group, in turn, was writing their investigation questions on the board and then we were discussing the quality of those questions in the classroom. Meanwhile, we determined the criteria for a good question with the whole class negotiation.

Accordingly, a good question needs to be testable through experimentation and observation. A student was reading the question on behalf of the group and then I was asking the rest of the class, "Do you think that this question is testable?" By doing this, I was having students to decide about the quality of the question. If the group's question was not good, I was asking, "So, how can we revise this question to be good?" After the decision for each group's question, I was getting students to explain the procedure that they were going to follow through questioning, "So, what do you think about the procedure that needs to be followed to answer your question?" For example, in electricity unit about the electrical conductivity of matters, a group's question was "Does electric eel conduct electricity?" The group told that they needed an electric eel to answer this question. Then, we, as a whole class, discussed the quality of this question and then we decided that it would be hard for us to bring an electric eel to the class. At the end, this group revised their question as, "Does salty water conduct electricity?" On the other hand, in some situations, the groups were formulating the same questions at the same time. At that time, I was either allowing students to investigate the same questions or guiding students to revise their questions. For example, in a topic related to protection against harmful effects of electric current on human body, two groups formulated the same question as, "How can we help a person suffering from electric shock?" Then, I guided students through questioning as follows, "Then, is it important to know how to avoid getting electrical shocks? Do you think that it is worth to investigate?"

Upon the completion of formulation of questions, the next stage is to test those questions. Generally, students were conducting experiments using simple equipment and materials. Students were bringing materials they have at home. I was providing necessary materials from the laboratory, which were not accessed by the students. I was walking around the groups when they were setting up their experiment, and I was asking guiding questions. For example, in electricity unit, one group was trying to investigate whether a magnet can conduct electricity. I got close to that group and then asked the following questions to guide them, "What are you searching for? Then, how do you do that?, Draw the circuit in your mind" Through these questions,

I was getting students to think about what they were doing and why they were doing that rather than having a cook-book style experiment.

While I was moving around the groups, I was sometimes recognizing that students in the groups were in a difficulty of having a common agreement when setting up the apparatus and manipulating the variables. Students were defending their own ideas as the only correct idea without listening to peers' ideas. At that time, I was joining the group and asking questions to get them think about the procedure needs to be followed again. For example, the group investigating the question, "Does a magnet conduct electricity?", discussed how they were going to set-up the experiment, and drew the experimental setting on the relevant empty space provided in ABI report prior to doing the experiment. Subsequently, students in that group designed the following experimental setting shown in [Figure 5.2](#) to test the electrical conductivity of both plastic and metal magnets.



Figure 5.2. Experimental setting for testing electrical conductivity of plastic and metal magnets

Each group was reporting their observations and data, and then constructing claims and evidence to support those claims. For me, the most difficult part of the ABI implementation was the part of construction of claim and evidence. My students were not only confusing the terms 'claim' and 'evidence' but also, they were using claim to refer to their beginning ideas. When students were stating their beginning ideas before testing their questions, some of them were starting to talk as; "My claim is ...". During one of my class hours in a reproduction unit, all the students came to the board in turn and wrote a name of an animal on the board. Then they tried to identify the animals that were reproducing by laying eggs or by giving birth to babies. For instance, one of my students said that bees reproduce by laying eggs. His claim was, "Bees are so small enough to cope with labor pain". Here, the student supported his idea, reproduction of bees by laying eggs, based on his observations, and used the term 'claim' instead of 'evidence.' Therefore, I was always emphasizing the meanings of claim and evidence in their construction process. I was always explaining the meaning of claim as an inference based on the data obtained from experimentation and observation, and the meaning of evidence as the interpretation of the data to support the claim.

One of the most important parts of the ABI implementation was the presentation of claim and evidence in the classroom. In this stage, each group, in turn, was explaining what they did to the entire class, the rest of the groups were listening to them, and directing questions. All of these activities in this stage were facilitating concept learning. At first, while each group was presenting their claims and evidence; some of the rest of the groups were listening to them, some students were talking about their presentation within their groups and some were talking about things that do not fit the lesson. Then, how can I create an environment to support student-to-student talk and questioning? I could find the answer of this question in the 3rd ABI professional development program. In this program, we, participant teachers and trainers, watched some colleagues' ABI implementation videos and assessed those videos with respect to questioning and negotiation.

In my further ABI implementations, if students did not ask any question to the group presenting their work, I started to ask questions that could grab students' interest. I was planning the questions that may be asked prior to the lesson. I was meeting with two of my colleagues implementing ABI on the same unit just as me on Skype, and discussing about what we were planning to do to teach the relevant topic using the ABI, considering the following questions, 'What are you planning to do in your class in this week? Which questions are you planning to ask?' At the end of the meeting, we were reaching consensus and identifying the common things to do and questions to be asked for the implementation. We were considering those predetermined points most of the time. Because of having such a conversation, we were feeling comfortable in our implementations.

When I asked questions that requires students thinking, the students that have never even talked in the class before were also expending considerable effort to answer those questions. This situation was making me happy. When responding to those questions, some students were suggesting scientifically correct explanations while some were suggesting scientifically incorrect ideas. Moreover, at first, I was asking a good question and when a student gives response to that question, I was immediately evaluating that response, by saying 'right' or 'wrong.' Before having met with ABI, I used to evaluate students' scientifically correct response by saying, 'Yes, your classmate is right.' Like any human being, it was also difficult for me to abandon a habit completely in a short time. My habit of evaluating student response continued in my early implementations. When I evaluated a student response, naturally, different responses were not coming from any of the students. That is why negotiations were not starting in my classrooms in my early implementations. For example, in a topic about electrical shock, I demonstrated a cartoon from the internet and then the following conversation happened.

Teacher: What do you see in this cartoon?

Student A: There might be an improper connection in the cable, a man might touch the cable without taking precautions, and then there might be an electrical shock.

- Teacher: Yes, is there any different idea?
- Student B: There is some water in that place.
- Teacher: Right, there is some water. Do you think that he suffered an electric shock due to the conductivity of water? Or is there another thing?
- Student C: He might touch the cable with wet hands, and then he might suffer an electric shock.
- Teacher: So, what the other man is doing there?
- Student D: He is using a piece of wood to save the man suffering from electric shock.
- Teacher: OK, the man suffering from electric shock might shake. Do you think that the rescuer may touch to the man suffering from electric shock?
- Student E: No, he may touch to him.
- Teacher: Do you think that the rescuer may touch to the other man when he is trying to save him from electric shock? So, what do you think about the first thing the rescuer needs to do before starting to save his life?
- Student A: First, he needs to unplug the appliance.
- Teacher: So, he is saying that he needs to unplug the appliance. That is, he needs to remove the source of electricity, does he?
- Student F: There is not any plug.
- Teacher: There is, here it is. Okay, what is electrical shock? How does an electric shock affect a person?
- Student F: Electricity passes.
- Teacher: Just now, you said that human body conducts electricity.
- Students: Yes it is.
- Teacher: That is, electricity passes through human body. So what does happen when electricity passes through the body?
- Student G: There is an electrical shock.
- Teacher: So how does it affect a person?
- Student G: It applies a force.
- Student H: For example, we did an experiment and when more power (electric current) passed through the light bulb, it blew out. If more power, that is, energy, passed throughout the human body, a person might shake just as the light bulb.
- Teacher: A person might shake. It can damage to cells and tissues, and even it may cause to death.
- Student I: Is there any human body resistance to the electricity?
- Teacher: He is asking whether human body applies resistance to electricity. Because human body does not apply resistance, electric current passes through it. If human body were applying resistance, electric current would not pass. Is that so?

As seen in the excerpt, the classroom talk was occurring between the students and me (teacher). There was not any talk between the students yet. In the excerpt, we can see some traces of negotiation. As I mentioned before, an important reason of the limited negotiation in my classroom lies behind the difficulty in abandoning my habits. For example, in the excerpt, a student asked the question 'Is there any human body resistance to the electricity?' Instead of giving response to this question, I would now direct the question to the entire class.

Day by day, I was not quickly evaluating student responses, although it was not easy for me. My students were stating their ideas about my questions, but in this case, they were waiting for my approval. At that case, I was responding with a question, e.g., "I do not know...Okay, what do you think?" Students were not accustomed to hear such a response, they believed that teacher knows everything and always responds to student question. One day, one of my students asked, "My teacher, how did you get the teacher certificate, because right now you are not giving us the right answer when we ask you a question?"

My students also began to ask questions that has the potential of starting negotiation over time. Student questions have a critical role in starting and sustaining negotiation. A student asks a question when s/he wonders something. Accordingly, student questioning shows an interest to learn new things. For example, in the topic about electric shock, one of my students wondered the reason why birds are not electrocuted when they sit on the wire and then the following classroom talk happened in the class. However, we could not reach a consensus at the end of the talk.

- Student A: May I ask a question? Birds sit on the electric wire. Why do not they get an electric shock?
- Teacher: Right. Why don't birds sitting on wires get an electric shock?
- Student A: Electric gets into one of the bird's foot, and goes out from another foot. It just looks like electric transfer.
- Teacher: There happens an electric transfer. Okay, Gökhan?
- Student B: If a bird sits on the wire with single foot, it gets electric shock, but if it sits with both feet, it does not get electric shock, it gives electric just as it takes it.
- Student C: It does not store electricity in its body.
- Teacher: You just set up an electric circuit, do you? What was happening for a bulb to light? ... It (electric current) was going out from one end of the power supply and getting into the other end of the power supply, was not it? Do you think that it is happening in birds just as this?
- Student D: However, birds' feet are...
- Teacher: Power supply...What we did was to complete the electric circuit. As you see, the circuit needs to be completed for a bird not to be electrocuted, or does not it? Or, the circuit needs to be completed for a bird to get electrocuted? When does a bird get an electric shock?

Student D: Single foot.

Teacher: Do you think that a bird does not get electrocuted when it sits on the wire with both feet?

Student D: It does not.

Hearing good questions from my students was making me happy, but it was still hard to see student-to-student negotiations. Actually, student-to-student talk or discussion was not an ordinary case for my students. Before having met with ABI, I was explaining the topic and then I was asking questions to check whether they understood the topic. I was getting what I explained to them back. Students were just iterating what I explained to them, they were not thinking about the question and its answer, and were not adding their personal ideas and interpretations. This system was easy for me because it was, of course, not easy to promote student thinking.

Negotiations may occur within an individual as well as within a small group and whole class. There were some introverted students in my class as well. Generally, these students do not have the capability of being active in small group and whole class negotiations. Learning occurs through the negotiation of ideas and my ultimate goal is to get all my students learn science concepts. Thus, I was trying to engage students in a reflective writing activity in which students have a chance to experience self-negotiations. I was doing this through investigation reports, which were filled out considering ABI student template shown in [Table 5.1](#).

Table 5.1. ABI student template

-
1. Beginning ideas – What are my questions?
 2. Tests – What did I do?
 3. Observations – What did I see?
 4. Claims – What can I claim?
 5. Evidence – How do I know?
 6. Okuma – How have my ideas compared with others?
 7. Reflections – How have my ideas changed?
-

In the *reflections* part of the ABI student template shown in [Table 5.1](#), students are asked to compare their beginning ideas with what they learned in that class and reflect on whether their ideas have changed. I was asking students to fill out the investigation report at home and bring them for the next class. For example, a group wondered whether a newspaper can insulate heat and designed an activity to search for it. Before the activity, they were thinking the newspaper as a heat insulator just as a piece of wood because newspaper is made up of wood. However, students' ideas changed at the end of the activity. Students thought the newspaper was a heat conductor rather than insulator, and reflected on their investigation reports just as this thinking was challenged.

I was also faced with problems throughout the processes mentioned above. In some groups, some students were not participating in their group work. I was moving around the groups and trying to make them engage in the activity through questioning such as, "What do you think about this issue?" As far as possible, I was trying not to intervene in group work. I was observing the groups and helping them if it is needed. It was not so hard for me to guide students' negotiations in their own small groups. However, I was confronted with some problems in the whole class negotiations, during the presentation of group claims and evidence. While each group was presenting their own group questions, claims and evidence, I was struggling with gaining attention of the rest of the groups to the presenting group. Some students were listening to the presenting group, but some of them were talking among each other about their group work or the issues not related to the course content.

An important problem confronted in whole-class negotiations was students' tendency to state their own ideas without listening to others' ideas. I could not solve this problem completely, but there has been a considerable decrease in the frequency of this problem over time. To tackle with this problem, I was asking questions (e.g., Look! What is your friend saying? Who wants to paraphrase what your friend talked about?), or warning students (e.g., If you do not listen to your peers, they may not listen to you when you are talking). Being an element of language, listening is as important as talking. If students do not listen to each other, it would be hard to engage in negotiations.

CONCLUSIONS AND RECOMMENDATIONS

I hope all of the things that I have mentioned so far describe what I have experienced in negotiation process. But, I would like to remind everyone that this process may differ in the classrooms of different teachers. Teachers' pedagogy has a critical role in supporting negotiations. To understand the importance of negotiations in student learning is closely related to point of view about learning. Until I met with ABI, I was describing learning as *a desired change in student behavior*. I believed that the better I describe the content, the more students will learn. But it was not always coming true; there were learning difficulties even in the concepts that can be easily learned. After having met with ABI, I learned that learning occurs as a result of negotiation and students construct their own knowledge using different modes of language. Our role, as teachers, would be to create an environment in which students can construct their own knowledge rather than transmitting knowledge.

For an effective negotiation to occur, we teachers, need to adhere to the big idea determined in advance of the instruction. Students are easily and likely to depart from the big idea while formulating their own questions and discussing their ideas. In such a situation, we teachers, we may get students to focus on the big idea through simple movements, such as "We can consider and discuss your idea in the further X topic, please take note your idea and remind me in that class session."

Moreover, valuing students' ideas and creating a democratic learning environment in which students can comfortably state their own ideas are essential for an effective negotiation to occur. Our ultimate goal needs to be getting all the students actively participate in their own learning. For this reason, it is important to focus on the students left behind through questioning such as, "What is your idea? Do you agree with your classmate?"

While students are discussing their own ideas, teacher's pedagogy becomes critical in leading students into common agreement. A teacher should not evaluate students' ideas when they are stating their own ideas. Instead, they should act as a moderator, and try to connect the presented ideas to the big idea. Making negotiations needs to be targeted at all stages provided by ABI. So, how can we make a successful negotiation? It is critical to challenge students' minds via questioning and then get students engage in dialogue until they reach consensus. It just looks like removing wrinkles from clothes with ironing slowly. For this reason, we can start negotiation through asking open-ended questions at each stage of the ABI. Seeking answers to those questions urge students to think alternatively, and further helps for negotiations.

Upon asking a higher-order question, possible problems are students' reactions into thinking for that question, and their reproach such as "How this question relates to the content?" and "Is there a relationship between this question and exam?" There may be several reasons for those problems. I think one of the most important reasons is having an exam-driven curriculum. We have nationwide exams and those exams are crucial for my students in entering a high-quality high school. That is why students are always seeking the connection of the classroom activities including questions with the nationwide exams. Another reason is related to the difficulty in changing students' habits because they were not used to thinking about the concepts or questions before ABI was implemented in their science classes. Because thinking requires some cognitive and metacognitive effort, it is viewed as difficult. If students do not respond to your higher-order question, you may try to motivate those students to respond to your question through asking, "What do you think about your friend's idea? Do you agree with your friend?" Such questions may lead students to negotiations. If there were some students not interested in classroom activities, you can ask for their ideas by calling them with their names. As Confucius said, "Learning without thinking is waste of time."

I do not mean that open-ended questions always need to be asked in ABI classrooms. It is easy to start negotiations with open-ended questions, but after asking a close-ended question, probing questions (e.g., Why ...?) can be asked to start negotiations. In sustaining negotiations, it is critical to ask moderating questions and follow-up questions. In some situations, negotiations may take much time. Because of having limited time for science courses at school, teachers may be required to spend effort in ending up the negotiation with consensus.

ABI, a kind of student-centered implementation, anticipates active student participation in learning process. For this reason, ABI implementations are congruent

with the recent elementary and middle school science curriculum. Unfortunately, many teachers interpret student-centeredness as “The students will do everything in a student-centered classroom, so it is easy for me” However, teachers need to exert much effort for actively engaging students in classroom activities. It is not easy to moderate students talking altogether, and get them listen to each other and respect their peers’ ideas. This problem may be overcome by warning and motivating students, and with experience and patience.

I also had trouble at the beginning of my ABI implementations. The reason why I encountered problems is closely related with becoming progressively weaker in teacher pedagogy because of adopting a teacher-centered approach for a long time. Now, I think that implementing ABI in my classrooms is enjoyable despite having some difficulties in adopting ABI. Moreover, I did not understand how time elapsed in some of the days. Monitoring my students’ progress in learning science concepts day by day is motivating me to exert much effort in improving my ABI implementations.

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6. THE ROLE OF THE LANGUAGE IN ARGUMENT BASED INQUIRY (ABI)

MY SCHOOL

I teach in a school in Yahyalı with a population of 20,000 in the Kayseri Province. Most of the population makes a living as a farmer or a miner. The people in the city have just begun to understand the importance of education and want their children to pursue education. There are 40 teachers, 3 administrators and about 800 students in the school. Our class sizes are about 25–30 students. Even though there are students whose parents graduated from two- or four-year colleges, most students' parents are less educated; therefore, they cannot guide their children in terms of education. There are even illiterate parents. Some families struggle financially. However, this does not stop students pursue their career because local authorities, officials and school administration support these students' education. In general, our school participates in social events such as sports, poetry, reading competitions, art, etc. The relationship among parents, students, teachers and administrators is very strong.

MY ENCOUNTER WITH ABI

We participated a professional development program called ABI (ATBO in Turkish) for a week in a small seaside town. While I went in with an open mind, I left the seminar with many confusing thoughts. It was a dense program. I did experiments that were unlike any I had done before. There was a transparent, plastic fish; we put in our hands and watched its tails curling up. We counted several reasons such as hand moisture, heat, etc., as to why it was twisting. For example, I saw a sea snail very first time. As the other groups and trainers asked questions about our experiment designs, I realized I struggled with theoretical knowledge. With the upcoming questions, we always thought our knowledge and results were certain. This was the most thought-provoking dilemma I had ever faced: “knowing but not explaining,” or should I say, “not knowing what I thought I knew.” After a five-day training, all of my theoretical knowledge was a complete mess. I finished the program with many questions.

When I started the first implementation, all I knew was to “have the kids argue.” “Yes,” I thought, “I could actually do this.” I did at first. But there was chaos in my classroom, as my students did not know how to argue. They perceived argumentation

as fighting with each other. For them, the potential wrongness of their ideas was an unacceptable thing. The big idea was important in ABI implementation as it sheds light in front of the teacher. However, I couldn't follow the big idea in the first implementation. It was tough for me. Students talked about everything. Students were also not accustomed to group work and writing. They wanted to work alone. After the first implementation, full of struggles and problems, I understood that my problems had just started. Lucky for me, there were my colleagues and researchers with whom I could share my difficulties and search for solutions with them. During the second implementation later that year, I often got in touch with the teachers who were teaching the same unit. Communicating with other teachers was crucial because they might have had the same problems and we could get together and search for solutions.

AN "A-HA" MOMENT!

I found my answer to the discussion problem in the first implementation with the idea that "we argue the ideas, not the personalities!" We could now argue, with less students resisting group work. I was creating well-organized lesson plans and the students gave me good feedback. I was happy when I realized that most, if not all, students never wanted to return to the old way of teaching. I thought, "I am doing something right!" My problems started to change as time continued on. As I was struggling in implementation in general at the beginning, I now thought about things such as having groups listen to each other, giving equal speech time to students, choosing appropriate writing activities, etc. We are very happy doing our lessons with ABI. The only problem is not having as many flexible class hours: We want to do our experiments whenever we want. Too much to ask for!

THE CHANGE

I have changed some of my behaviors with ABI. I thought I was always fair to my students but then I realized I wasn't always treating everyone the same. I asked the bright, successful students to talk all the time. However, there are other students in the classroom. I never thought having them talk, never asked for their opinions because they did not know what I wanted. During the ABI implementations, I realized that those shy students, who did not want to talk, had something to say.

Student: Everyone says their opinions. Some classmates say something wrong, but nobody says anything; in other lessons, they say "wrong" right away.

With the writing opportunities, the students used unique methods, cartoons, poems to express their ideas (see [Figure 6.1](#)). I now care about their thoughts and this helped quiet student progress. They had been used to not raising hands for speech but with ABI implementations the number of hands raising is much more.

Student: *Discussing with classmates and you asking me questions caused me raise my hand.*

Of course, this gives me a headache; when all students wanted to talk, it was hard to choose who would talk. My classroom sometimes got very noisy. But multi-voices (polyphony) made me happy – hearing 24 different ideas is incredible!

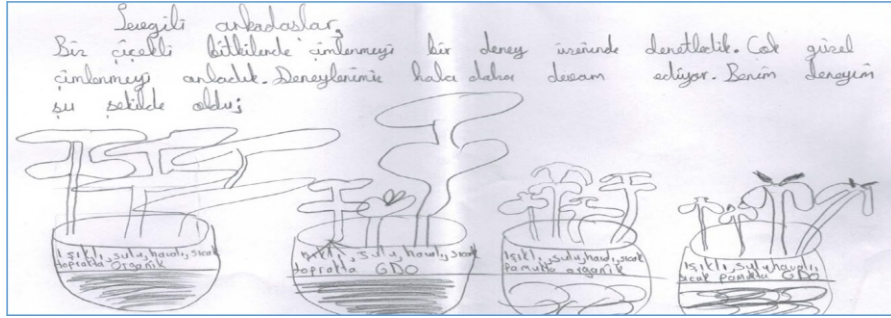


Figure 6.1. Different designs for germination

In the ABI implementations, you find opportunities to get to know your students in various ways. It is possible to sum up the changes in my students in two major points.

BEHAVIOR

The first one is the changes in students' behaviors. Some of my students wanted a task in which they knew everything by using their knowledge that they had learned from private tutoring lessons. They also went further saying that others not understanding the subject was their fault; they tried to humiliate when others asked questions. For this reason, most of my students did not want to ask questions. However, in the ABI implementations, those who were seen as bright and wise needed to ask questions to me and their classmates when facing some problems. They started to struggle and realized that they needed to listen to their classmates' ideas. They understood that people could have problems that were hard to solve and find solutions by arguing with each other. Therefore, wise and bright students stopped the act of "knowledge bullying" to their classmates because questioning is in the human nature. This caused students to produce solutions for the classroom on their own.

Students at first did not listen to each other during the discussions and we continued this way for a while until students became used to the process. One day, a group, when came up to the board for presenting, explained: *"If our classmates listen to our presentation without making any noise till the end, we will too."* The whole

class listened to them and the other groups promised they would follow their lead. Students raised their voices, yet it was always in a productive manner.

One of the best things I observed was the low achieving students' eagerness to participate in class discussions. Something was affecting their talking, writing, and listening. Those who did not want to talk started to talk, those who did not write began to write; even without my saying, they brought me what they had written during the weekends.

In the beginning, the low achieving students did not talk but started to express their thoughts as time went. I persistently asked for their ideas and never judged their ideas as right or wrong, I just accepted it as an idea. This reflected on their listening. Compared to the previous lessons, they listened to their classmates actively because they asked questions. This was an indication of their listening. I think this is because of the democratic situation in the classroom; not saying the ideas as right or wrong, everyone having equal rights, and discussing with classmates in groups.

LEARNING PROCESS

Another change I observed in my students was the change in their learning processes. They did not see themselves different than scientists; they even thought that the scientists could be wrong. The biggest change to me was that they argued the ideas. They could create their own knowledge through argumentation; there is no need me telling them. They could set up experiment designs, they could draw pictures and they could evaluate their research during presentations. They had started to understand how scientists work.

Student: I was doing observation last year but this I am doing more. I also learned, this year, that I could prove my thoughts better).

Even they could change the definitions in their books:

Student: "The wrong definition of insulator" in the book pushed us to question whether our findings are true; we say "we have to first try and then read").

This increased their self-confidence as well:

Student 1: You feel like a scientist, we've changed the definition of isolator.

Student 2: I feel like challenging scientists.

Truthfully, students could think without limits as long as we don't put them in a box. Not only did we study during the lesson, but we also continued to discuss after the lesson. We could easily see that learning was not just in the classroom. In this regard, I saw that my students were reading science books more consciously:

Student: I did not read science books given earlier because I could not understand. Since we started doing lesson in this way, I more often read such books. For example, I preferred to read my astronomy books at nights so that I could observe and also take notes while reading.

I could see that they were reading with purpose.

THE ROLE OF THE LANGUAGE IN ARGUMENT BASED INQUIRY (ABI)

RIGHT TIME, RIGHT DEFINITION

Science learning requires learning various concepts at the same time. I used to teach these concepts in this way: I would give the definition of the concepts and have students write them in their notebooks. I also asked students to repeat the definitions that I thought they had learned. Honestly, I did not know how learning occurred in students' cognitions. However, I realized that in the ABI approach, we should not give the definitions up front because students face new concepts they have never seen before. I think my students could not make connections to the concepts. However, in ATBO, we did not give definitions. They started to make connections with daily language through class argumentation and they argued in their daily language. In this way, they knew what they were talking about and filled in the concepts because it was their way of using language to make meaning.

This was the most exciting thing in ABI implementations for me. I did not do this on purpose but I saw it was effective. I realized my students had fun and I watched the lessons becoming more fun. Why was this? My students' making scientific definitions on their own, without leaving their daily language behind, made science learning more engaging every day. These are some examples of their language and how it shaped their learning experiences.

CONNECTING CELL TO CUBBY

We were investigating living things through microscope. Students labeled something, "cubby," or what they saw and we talked about these cubbies. "Are there cubbies in other living things?" We saw that all living things we looked at had cubbies. We wondered if there were cubbies in the non-living things. We looked at them; we were expecting hundreds of cubbies, yet we saw none. My students called cells, "cubby," as a room in their houses. It was better and more real to speak in their language instead of mentioning an invisible concept.

OUR RESISTANCE CONCEPT

Electricity is a hard topic to learn. We cannot see it, but we know and observe its effects. The question in my students' mind is: "How does the electricity travel?" "Why does every matter behave differently?" My students found a solution for this one. First of all, they found that the reason electricity travels faster through some materials was that the material had a *slippery substance* in it. Something in the material makes electricity move faster.

"What was the reason for slowing down?" There were two reasons for this; either there was less slippery substance or there was a non-slippery substance in the material. If there is a slippery substance, our first reason was true. "What if there was no slippery substance?" There was then a non-slippery substance and this prevents the electricity travel. We did not use the word "resistance," but slippery or

non-slippery substance. In time, my students felt that they needed to use “blocking substance” instead of non-slippery substance.

Students: *There is no substance that does not move electricity, even a small amount of electricity travels through every material... if we call it preventing substance, then the blocks can be removed or reduced.*

Therefore, they explored that the resistance can be adjusted. In other words, they explored the rheostat. If I had told them “rheostat,” I am sure, they would have understood something else; they even hardly read the word. I did tell my students the words resistance and rheostat, but long after they had explored the concepts. They were even amazed when they heard the name resistance, “Was the resistance this?” They were expecting a “fancy, sciency” complex word; they liked the idea that they found by thinking.

OUR INSULATOR DEFINITION

We were confused about electricity. Some materials were conductors and some were isolators. In our books, the ones that transmitted electricity were called the conductor, and the ones that does not transmit the electricity called the isolator. The water with sugar was an isolator, according to our sources. One of my students made a circuit using led lambs and showed us sugary water transmitted the electricity. We saw it right in front of our eyes. We could not believe it at first and thought, “The book made a mistake.” Three different groups tried again. Yes, it transmitted the electricity. However, we knew that the book had told us it would not happen. We had to try with the water without sugar and with lots of sugar. We conducted the experiment and saw it transmitted energy. We would even try it with pure/distilled water and we added sugar into the pure water.

What were we going to do with sugary water, was it conductor or isolator? What if the books were wrong? We, as the class, found a definition for an isolator: “*isolator is a material that transmits electricity at a very, very, low [current] that does not shock us.*” From now on, the sugary water is an isolator for us. We are happy that we could classify the sugary water. This was a wonderful process for my students because the books can be wrong or the scientists can be wrong. Through argumentation and experiments, my students saw that some sources could give wrong information. In this way, they realized that information they collect may not be true and they started to read the information in the books more consciously and critically.

All this showed me that my students easily understand the concepts and communicate with each other using their own language, the language they use to communicate with others outside the classroom. The whole class constructed the ideas about scientific concepts, and communication was easier. What about the scientific names of the concepts, don’t they need to know them? Of course they do. After learning the concepts, I told them the scientific names. To me, as long as they learn the meaning of the concepts, the name does not matter, it is just a tag. I can give the names, or they can find in the books.

THE ROLE OF THE LANGUAGE IN ARGUMENT BASED INQUIRY (ABI)

INTERDISCIPLINARY CONNECTIONS AND WRITING AS AN EVALUATION TOOL

When I first started to implement ABI, I did not think that I would need to focus or include literacy. I never thought that science and literacy were connected; science was more related to mathematics and should be taught with mathematical expressions. I realized the importance of language use in learning over time. My students were thinking during writing and could argue what they had read. At the beginning, they might not write completely their ideas; sometimes they copied from the books or they literally read the information they gathered. Over time, they realized that they had to read on their own and understand the concepts so that they could argue in the classroom. We concluded that plain reading from the book or the paper was boring. They also understood that instead of writing directly from the books, it was important to write what they had learned. In fact, I first cared about their writing, knowing the content would follow as they wrote more. I now look at the content and see how they blended science and literature. In the end-of-unit-writing, they used the definitions and concepts they had explored.

This is a song that my students wrote and composed. They were like a pop star while singing.

“It is the air
The master of the isolation
Use and use it
Have a tough isolation
Because the particles
Away from each other
That way, the heat
Barely escapes.”

CONNECTING ABI TO OTHER COMMUNITIES

A city in the east part of Turkey was hit by a big earthquake and school had to be postponed. I asked my students to write a letter about cells at the end of the unit to someone they knew. One of the students came to me and asked, “*Teacher, what if we wrote our letters to the students in Van so that they learned the subject they have missed. Let’s help them in this way, shall we?*” I liked the idea. I called my colleague in Van who was in the same project (ABI) with me and told him we would like to write letters to them. He was happy as well.

After sending the letters, we were looking forward to receiving our responses (see [Figure 6.2](#)). My students were always asking whether the responses had arrived yet; they were really curious to hear back. The letters finally arrived. Sending the letters to the real people and receiving response pushed them to write again so that they could respond the critiques to their ideas. We wrote and sent the second batch of letters. What struck me in the process was that my students used all forms

of language for their purpose. They used visuals within the text accompanying explanation so that the readers could understand. This showed me to what extent my students understood the concepts (see Figure 6.3).



Figure 6.2. Students reading the letters from Van

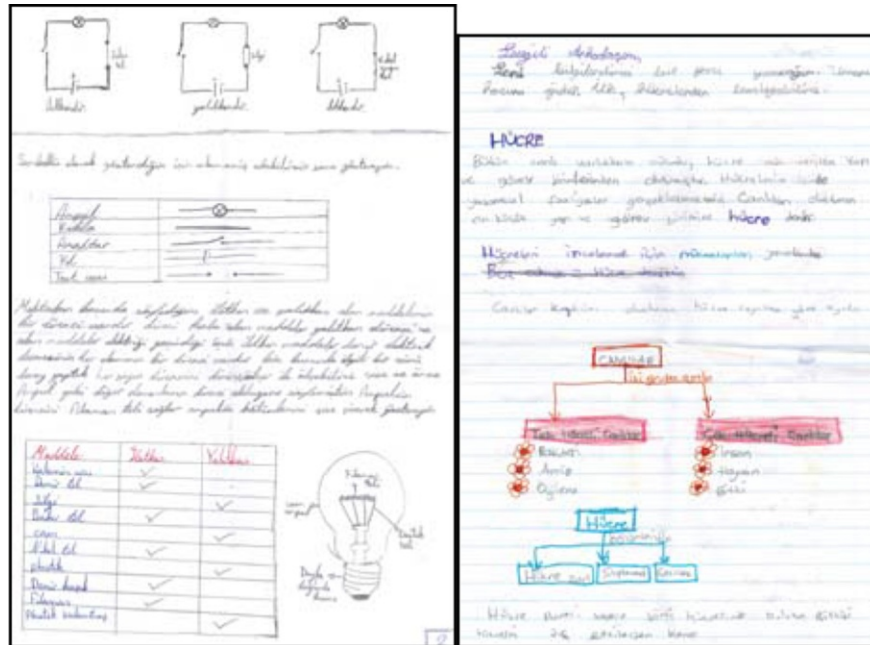


Figure 6.3. Samples of letters to Van

MAKING A JOURNAL AS AN END-OF-UNIT ACTIVITY

For the heat unit, I asked my students to form a heat isolation company as groups. They were going to convince me about which materials I should use for the isolation for my house. As the groups were sharing their ideas with the whole class, a student said, “Our group wants to make a heat isolation journal and to publish

our classmates' ideas as well." They started to take notes of presenting groups' ideas and to ask questions. Let's listen the rest of the story from my students:

The lesson ended, all the ideas of the groups were noted. Now, it is time to decide what is going to be in the journal and what message we should give the readers. We got together and discussed, and then made a draft. However, it did not look like a journal; what should be in a journal? How should we prepare? We thought that we had to talk to Turkish Literacy and Technology teachers. During the breaks, we talked with them and asked our questions. Our literacy teacher gave us ideas about the contents of the journal, and she corrected our writing mistakes. The technology teacher showed us how to make a cover for the journal. We had to be assertive. We started to work again. We sometimes showed the teachers the steps of the journal. We talked to our science teacher about the contents of the journal. Within two weeks, we finished our journal and presented to the whole school. We gave information about the importance of heat isolation.



Figure 6.4. Students working on the journal

During this process, my students were so excited. They explained to me what they had done every day (see [Figure 6.4](#)). They learned to cooperate and to make decisions together. They asked for help from other teachers for science lesson. They researched, asked questions, and explained what they wanted to do. They even gave the teachers information about the heat isolation and tried to convince them about the isolation. I think this was the thing we wanted in our education system; that science is not independent of other subjects. Initially, I thought that scientific information in the heat isolation journal is related to the science teacher; writing is related to the literacy teacher; and the pictures, visuals and the cover are related to the technology teacher. It was good that teachers from all areas helped children within their expertise.

I had my students write all the time during the ATBO implementations but I did not grade their products. When talking with a teacher in the ATBO project, he said

that we could use ATBO templates and letters as performance evaluation and shared his ATBO template evaluation rubric. The research team also suggested a rubric for letter evaluation. In this manner, everything students had prepared turned into a portfolio so that we could use for evaluation purposes. This was a process evaluation within the process. My students also liked this idea such that their performance was evaluated as they were learning.

WRAPPING UP

Before I met ATBO, I used to use multiple choice, right-wrong, fill-in-the blank, and match questions to measure students' performance. This happened at the end of the units, there was no chance to go back. In ATBO, since the evaluation starts at the beginning, the concepts students bring into classroom are always discussed and mistakes were corrected in the process. Concept maps were the biggest help with this practice. We create a concept map at the beginning that stays visible to students and they may change connections if they want. Most of the argumentation is about such changes. Students question each other in this process to understand the concepts flying around. The questions they asked give clues about students' understanding of the concepts. In order to pick up these hints, I prefer to listen without involving myself in the argumentation. I think this is a good opportunity for me to evaluate students' conceptual understanding. In addition, we had an activity of "the slogan of the day" as the end-of-the day reflection. Both as group and individually, they wrote the striking sentences on the cardboard which stayed up all the time. This way, everyone saw what had been written. They sometimes corrected their classmates' misconceptions or grammar mistakes. Therefore, they took responsibility in each other's learning. They even went into other classroom and checked their slogans. *"We wonder what the other class wrote as slogans, what the focus of their discussions was."* They started to care about others' ideas (see [Figure 6.5](#)).



Figure 6.5. Student artifacts

THE ROLE OF THE LANGUAGE IN ARGUMENT BASED INQUIRY (ABI)

I get excited when I start implementing ABI each year. I wonder what ideas will come out, whether the new students will like the ABI approach. Yet, after beginning the lessons, I see that my worries are senseless and unnecessary. What if I implemented ABI in the same groups over time – would I notice a perfect lesson in my students? I would want to do ABI in the same groups as the last year. I am sure my students will create wonderful ideas and critiques. This excites me even before we start. On the other hand, I would also like to start with a new group so that I challenge their minds and get them to know about ABI. Hearing new and different ideas excites me more. My students' acceptance of the ABI approach makes me happy.

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SECTION 2

KOREA

JEONGHEE NAM

INTRODUCTION

I had a meeting with five middle school teachers who were my former graduate students in 2007, which was when I came back from the US where I spent almost one year of my sabbatical year. I met Brian at the University of Iowa during my stay in the United States. He invited me to the professional development workshop of the SWH which was held in a small town. That was the first moment I got involved with the SWH. During the PD workshop, I wondered if the SWH approach could work in Korean science classroom.

We had five middle school science teachers when we started implementing the SWH approach in a Korean science classroom in 2007. They were all enrolled in a graduate course. Three of them were Ph.D. students and other two teachers were Master's degree students.

Before we started, we asked these two questions: first, does the SWH approach work in Korean science classrooms? Those that were going to implement the SWH approach in their classroom said 'NO.' Three of them had more than fifteen years teaching experience at the secondary level. The other two teachers had two years teaching experience. The next question was 'Why?' Five teachers gave several reasons for that, such as time constraints, curriculum coverage, and a lack of students' ability and experience for argument and writing. We have the national curriculum developed by government and have to cover the curriculum in an academic year. The national science curriculum is comprised of content and more concept-oriented. So, the science teachers felt that there was a lack of time to cover the curriculum. They also considered their students might not be able to argue and write with their own idea, as they have not experienced argumentation and writing at the classroom. That was the starting point and how we started to work together with the SWH approach.

Somehow, we were fortunate in introducing the SWH approach. At that time, there was a big movement in science education in Korea. National curriculum emphasized discussion and argumentation in science classroom were newly launched. This movement was triggered by the report that was revealed in 2008. The report by the Korea research foundation indicates that most teachers utilize student discussion or argumentation less than ten percent of class time. Afterwards, the Korean Institute for Curriculum and Evaluation reported that only thirty percentages of class time in Korea was spent on student talk, discussion, and argumentation about the topic while the average percentage of OECD countries was about eighty-one. Korea science education has devoted their efforts to improving the quality of teaching and

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learning science during the last two decades. Many aspects of science classroom environments in Korea elementary and secondary schools however have not been changed. There have been rare opportunities for Korea students to be engaged in argumentation in science classrooms.

Five science teachers and I had a weekly meeting to get used to the SWH. They participated in the professional development workshops prior to implementation of the Science Writing Heuristic (SWH) approach. The first workshop was to introduce the SWH approach. The teachers were asked to discuss their ideas about the teaching and learning of science, and were introduced to the teacher and student templates of the SWH approach. At the second workshop, the teachers conducted several activities using the SWH approach, that is, they were required to complete activities using questions, claims, evidence, and reflection structure of the SWH approach. The third workshop provided the teachers with an opportunity to design their science lessons using the SWH approach. The teachers were able to develop lessons for the same topics as all the teachers were required to cover the same science content as determined by the Korea national science curriculum. The teachers collaborated to design their science lessons using the SWH approach on four topics in 8th grade science curriculum through a weekly meeting over one semester.

All the five teachers also collaboratively developed 8-topics of lesson plans. These five teachers became an expert as a teacher and supporter to expand the SWH into Korean classrooms. They all have been working with science teachers to help them for implementing the SWH.

We were fortunate to work with inspectors at the local education board to expand the SWH approach from individual school level to district level. Since then, more than 60 schools from middle school and high school level and at the university were involved in the SWH research project and more than 6000 students from 7th grade to 10th grade were experienced the SWH approach in Korea. Importantly we have been also working with pre-service science teachers in introductory chemistry at the university. They are going to be science teachers and use the SWH in their teaching. That would make a big change in science classrooms in the future.

We have been working with the local education board for the past five years. The local education board organizes fifteen hours of a professional development workshop for the SWH approach from elementary level to secondary level every year.

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7. PLANNING

A Change from Content to Concept

INTRODUCTION

A teacher can play a meaningful role for students in various aspects. Of those many aspects, the most important is a teacher's role as an instructor. To become a good instructor, a teacher has to thoroughly prepare a planning stage prior to teaching. A teacher's thoughts about teaching have a great impact on planning lessons. The ABI approach required me to change my focus of planning from 'the content transferred by the teacher' to 'the concept constructed by the students.' However, my thoughts changed very slowly because of internal factors such as belief about teaching, and external factors such as curriculum and assessment of Korea.

THE MOST DIFFICULT CHANGE IN PLANNING

I was so confused when I first encountered the ABI approach because it shook my belief about teaching. I was asked a question, "What do you think about teaching?" at a professional development workshop introducing the ABI approach to secondary science teachers. My answer was the following: Teaching is to clearly transfer well-organized content to students through using clear language. I had thought that the requirements for good teaching were learning content well-organized by a teacher and teaching skills. Initially, it seemed to me that the ABI approach was superficial, because instead of the passing of content from the teacher to the students, the ABI approach emphasized the students need to construct their own "big idea" themselves through a negotiation process such as inquiry, writing and argumentation. I agreed that this approach reflects the constructivist learning theory emphasized in recent science education. As a teacher, however, I was not comfortable with skipping over the processes of knowledge transfer and verification, and really worried about whether or not the students could learn well using this approach since Korean students were not familiar with argumentation and writing in general.

EDUCATIONAL ENVIRONMENT IN KOREA: SCIENCE CLASSES

Science classes in Korea are mainly didactic lecture. Students fill in the blanks in a worksheet distributed by the teacher after listening to the teacher's explanation. It is a

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common scene that one can see in science classes in Korea. Teachers use worksheets as a learning tool, which consist of summarization of content and blanks that require students to fill in with a suitable word or concept. It hardly provides the students with an opportunity to argue and negotiate since the teachers spend most of the class time explaining content. Although teachers try to ask thought-provoking questions in order to evoke students' response and participation, the students just respond with a short answer. A worksheet provides students with an opportunity to write only one word. Therefore, students do not have a chance to look back and express their own thoughts. In addition, even though inquiry is emphasized in science class, most of the experiments are conducted to reconfirm the content that students had already learned. Students write a laboratory report that consists of observations, solving formative evaluation problems, or a brief impression from the experiment. Thus, students are not familiar with presenting logically and expressing their own thoughts in oral and written language, since there are no teachers who spend much time on arguing and writing in the general science classroom. I didn't have an opportunity to argue and write when I was a student because the educational environment was still the same as it is now. I was really surprised that these two elements – writing and argumentation – are essential for implementing the ABI approach. Changing my thoughts about teaching and learning was essential.

Teaching is not about conveying science knowledge to students. The teacher's role is to help students construct concepts by themselves. For this to happen, the teacher has to create an environment where students think critically about the learning content. One of the ways to do this is to make students speak and write science. Writing and argumentation for learning results in an abundant use of the language, and these will become a catalyst that stimulates the learner's thinking.

EDUCATIONAL EVALUATION IN KOREA

As mentioned above, our students are not familiar with argumentation and writing. This educational culture is due to educational evaluation. The exam administered to each grade school is an important evaluation process to all students, parents, and schools, and the results are used to advance to the next level (from middle school to high school, from high school to university). The National Assessment of Educational Achievement in Korea is used to provide relative evaluation of the schools, and the results are reflected in the achievement of schools and teachers. Teachers are sensitive to the results of the evaluation, and they feel responsible when they don't teach the questions from the exam or the students' grades go down. Therefore, teachers experience a great pressure to teach all of the content suggested by the national curriculum. I had difficulties planning the ABI approach after reconstructing the closely packed teaching schedule. I recognize that constructing the "big idea" is closer to the nature of learning than conveying a lot of the content through a teacher-led class. However, I was worried whether or not the students could learn a concept well through this approach and that this could affect the results

of the evaluation. I couldn't entirely be free from outside pressure such as evaluation and national curriculum (a lot of learning content), and I also couldn't be convinced of the success of the ABI approach because of my incorrect beliefs concerning the teacher's role and that the teacher could control students' learning.

PLANNING THE CLASS AND UNIT

Implementing the ABI approach for an entire unit didn't fit the educational reality of Korea. If teachers implement the ABI approach for an entire unit, they would find that the teaching content and time will be limited because the teacher has to put more class time on it than a traditional class. Therefore, we decided that students would consistently have ABI activities for a year after choosing the most suitable topics from each unit for the ABI approach. We implemented the ABI approach after choosing 6 or 7 topics from March until December. The ABI approach usually consists of 2 sessions, where 1 session is 45 minutes. We developed a students' template and teacher's guideline for ABI and a plan.

DEVELOPING A STUDENT ABI TEMPLATE

I received help from my fellow teachers when I chose a topic and developed a template. We had a regular meeting (once or twice per week) that consisted of 2 science educators and 10 secondary school teachers. Our main concerns were to set a problem context and to design an experiment. A problem context is intended to help students have a question related to the 'big idea,' and includes 2 or 3 pictures, videos, and results in the problem context. We chose an easy and typical experiment for solving a question that students could directly design. We had a meeting again when a pre-template based on the activities was developed. We modified the worksheet after predicting a question that may come from the problem context and exchanging opinions concerning points to remember when students conduct the experiment. We developed a students' template (see [Figure 7.1](#)) and a teacher's guideline for ABI in order to inform how to use a worksheet.

After several discussions, we realized that there are some topics that the students are not able to directly design and conduct an experiment. In those cases, we tried to help the students solve a question by providing inquiry data, a video, or additional resources. In addition, we developed a condensed form of ABI since several teachers said that they needed a lot of time to implement the ABI approach. We developed three types of templates after reflecting upon these needs. The feature of each type is as follows.

- ABI Type A:
 - Students are engaged in all steps of question-test-observation-claim and evidence-reading-reflection.
 - Students design and conduct tests by themselves.

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- The teacher allows a lot of time for debating in class.
- It takes 2 or 3 class times (or class period)
- ABI Type B:
 - Although the students are engaged in all steps of question-test-observation-claim and evidence-reading-reflection, each step is shortened.
 - Sometimes, the teacher can suggest test procedures.
 - The time for debating in class is shorter than that of ABI-A.
 - It takes 1 or 2 class times
- ABI Type C:
 - Students are engaged in the steps of question-inquiry-data-claim and evidence-reading-reflection.

Science Writing Heuristics (탐구적 과학 글쓰기)	Name(이름): _____ ID#(번호): _____	Period(반): _____ Group (조): _____
▲ Situations		
1. Drop two balls that have the same size but different mass into the water. (크기가 비슷한 철구공과 알루미늄 공을 물에 넣는다.) (Picture)		2. Drop two objects (a chip of wood and bolt) that have the same mass. (질량이 비슷한 나무도막과 볼트를 물에 넣는다.) (Picture)
▲ Questions		
My questions (나의 질문) 		
Small Group questions (우리 조의 질문)		
Whole group questions (학급의 질문)		
▲ Description of investigation (실험설명) Materials (재료): Electric balance(전자저울), Ruler(자), Fish tank(수조), a chip of wood(나무도막), a chip of metal(금속조각), paper clips(종이집), Styrofoam chips (스티로폼)		
▲ Observation (관찰) 		

Figure 7.1. Template for ABI

PLANNING

- Instead of directly conducting experiments, the students infer the results from inquiry data (result of tests and video provided).
- The time for debating in class is shorter than that of ABI-B.
- It takes 1 class time.

PLAN FOR IMPLEMENTATION

We planned for the ABI approach to be implemented in about two class periods. The first class time consists of creating a question from the context of the problem, designing and conducting tests, and making observations. The second class time consists of writing claims and evidence individually and in groups and debating in class after. There is a time gap between the first and the second class time because our school does not have a block time system. We assigned the phases of reading and reflection as homework so that the students can have sufficient time to complete these processes.

SHOWING FLEXIBILITY FOR A SUCCESSFUL PLAN

I had prepared a lot for the Science Writing Heuristic approach during the winter vacation before the beginning of first semester. First, I tried to change my beliefs concerning the teacher's role in order to be successful in this approach. Then I maintained cooperative relations through regular meetings with colleague teachers. We discussed the episodes that happened in class and created a psychological and physical environment that would allow for a great class.

CHANGE IN BELIEFS REGARDING TEACHER'S ROLE

I used to plan the lessons in the same order as the table of contents in the textbook until now. However, I had to restructure the units in the textbook for implementing the ABI approach. This is because a great amount of time was devoted to the ABI approach, and thus, we had to teach after integrating and restructuring the rest of the topics. I realized that I have conveyed too much knowledge to the students for my own satisfaction as a teacher. Moreover, I realized that it is more important for the students to recognize the main concepts and the relationships between those ideas by themselves than for the teacher to convey the knowledge. My confidence regarding teaching was also increased because I clearly understand the big ideas related to the major units. The pressure associated with the problem of educational curriculum and the progress of lessons vanished when my beliefs about the teacher's role changed. From this point on, I was more concentrated on the ABI approach.

COLLABORATION WITH COLLEAGUES

I wanted to receive concrete help and advice in order to successfully implement the ABI approach. I discussed the meaning and the role of each phase of the ABI

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and teaching strategies with several teachers when I participated in the professional development workshop related to the ABI approach held in Pusan National University. In particular, the discussions that we had after watching the video of other teachers' classes using the ABI approach were very helpful in preparing for my classes. Discussion from the professional development workshop includes the following:

1. How do the students express their own thoughts freely?
2. How much does the teacher assist the students when they design an experiment?
3. What should the teacher do to help the debate, discuss, and argue?
4. How can the teacher intervene when there is a conflict of opinions among students?
5. Do we have to provide feedback related to the students' writing?

In addition, we had a mock class by taking on roles as teachers and students. By approaching the learning material from the students' perspective, it was easier to predict the students' responses and I was able to conduct the classes according to the students' level.

CREATING AN ENVIRONMENT FOR NEGOTIATION

I thought about how I could get students to participate in class better. For this approach, it is necessary to make a learning environment that encourages students to think and negotiate. I was not a strict teacher in class. The students had somewhat regarded me as a comfortable and mild teacher. I had tried to create an atmosphere of freedom in class before beginning this approach. I usually encouraged students to express their own ideas in class and avoided directly evaluating the students'

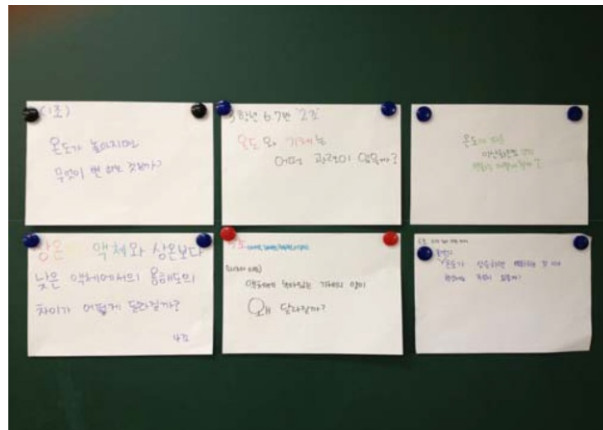


Figure 7.2. Examples of group presentations about 'Beginning Idea'

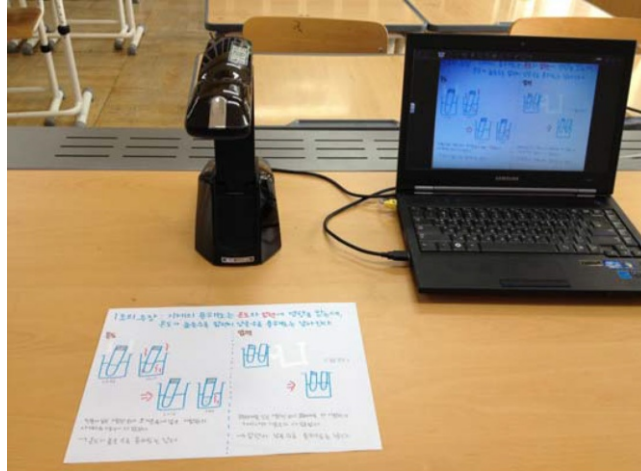


Figure 7.3. Showing a presentation by using the document camera

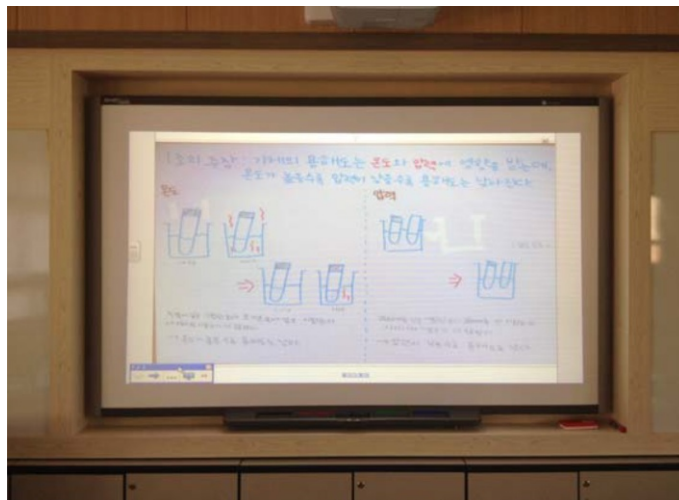


Figure 7.4. Showing a presentation by using the Smartboard

ideas. I impressed upon the students that it is an important process to logically speak their own thoughts based on objective grounds such as the result of an experiment in science class and to negotiate with others through debate and discussion. After about a month, students who were just seated, listening to the teacher's lessons, began to talk. Students who used to just mention their thoughts using words started to confidently speak in sentences.

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MAKING AN ENVIRONMENT FOR AN EFFECTIVE CLASS

Although I prepared for my classes with lots of effort, it was not easy to implement the ABI approach well. The more I taught the class, the more I prepared in order to have a more effective class. Even though each phase of the ABI was important, I wanted the whole-class discussion especially to go smoothly. When I implemented ABI at first, I got the students to speak by sticking the paper where they wrote down their question, claim, and evidence on the board and having them present (see Figure 3). However, the students couldn't see the content of the presentation and concentrate on the class very well since there were too many students in the class, which is composed of 35~37 students.

I thought about how to make all students participate actively in the whole-class discussion. When the students wrote down their speaking content on an A4 paper, it was shown to students through TV or a smart board after being captured on computer by a document camera. (Figures 7.3 and 7.4) Interest in debate increased because all the students could see the claim and evidence of other groups. Moreover, it saved time for preparing the presentation since the size of paper that students wrote on was reduced, and the teacher could assign more time to the discussion.

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Busan

SUNDUK LEE

8. FOCUSING ON THE BIG IDEA

CHANGING FROM MEMORIZING TO UNDERSTANDING

Implementing the ABI approach provided me with a chance to rethink about what teaching and learning are. There were many problems with implementing the ABI approach at first. In fact, I have a long teaching career so I was quite confident about teaching, but after the implementation of the ABI approach I found that the students' product quality was very low and it made me nervous.

HOW HAS THE SHIFT TO EMPHASIZING BIG IDEAS CHANGED WHAT YOU DO AS A TEACHER?

I experienced the biggest change as a science teacher while implementing the ABI approach. That came from my viewpoint of learning. I did not understand the concepts of teaching and learning clearly when I was a beginning teacher. Thus, I usually used a lecture-led class which is based on a textbook to transfer more scientific concepts to the students, and for the topic that required experiments, I usually used cook book style experiments, meaning students just followed its procedure. After experiments, I just induced a conclusion based on the students' results.

I have implemented the problem-solving learning in the local education institute for the gifted since 2003. Based on these experiences, I learned how to interact with the students and considered the thought that giving them a chance to organize their own thinking may be important in science learning.

By using the ABI approach, students were engaged in generating the question from observing a provided problem context, designing procedures to solve the problem, and participating in the investigations and discussions. I think those steps changed my class to a student-led class. I learned that students understood scientific concepts more deeply and specifically through these learning experiences. In addition, I recognized that the teacher's role is providing an environment that allows student participation in the process of knowledge construction and helping students engage in the thinking process.

The seminar and Master's courses provided a theoretical basis for my awareness transformation. Implementation of the ABI approach provided a more detailed framework for teaching and learning. I was involved in the professional development workshop for the 'Science Writing Heuristics' as a presenter and staff member. These experiences were also factors that made me change.

I was uncomfortable and anxious while implementing the ABI approach for the first time because I didn't understand each phase of the ABI approach in detail. I tried to ask other teachers and thought deeply in order to solve this problem. I often needed a consulting group for solving problems about each class and step. However, I couldn't do my best in solving these problems because of having a lot of work in the school.

As time went on, the theoretical basis for teaching and learning became more and more evident and it offered a more specific way to understand the philosophy of the ABI approach. I became more familiar with asking my students to find meanings. I finally began to like the ABI approach which facilitates the learner's thinking from the first step to the last step of the class.

In the problem context (where students changed the big idea to the form of the question), I understood the importance of thinking about their own thoughts and it made me more comfortable when I was waiting for a student's answer. I also facilitated discussions which had a form of 'My question is ... because ... What is your question? Why?' for making questions in small groups and in whole-class.

At the beginning of using the ABI approach, I couldn't implement this ABI approach correctly since I didn't know how to change passive students to active learners. After this failure, I could recognize and emphasize the importance of discussing and presenting students' own ideas in the interaction between students and the teacher in classroom.

The students' thoughts are reflected as much as possible by encouraging their thinking and having them create questions when we decide a whole-class question in the classroom. It is frequently observed that students who have passive attitudes have trouble thinking for themselves and they just copy answers from another student's work. The use of students' own thoughts in creating a classroom atmosphere is also one of the important elements of ABI.

It is hard to use the ABI approach without active participation attitudes of the students. Students' attitudes can't change with a single teacher-student interaction. They also don't think actively by asking one, single question. In order to facilitate a learner's active thinking, a teacher needs to construct a certain atmosphere in class related to their thoughts about the science class and a point of view about important things in science education. I facilitated interactions between the teacher and students in class that allowed the students to host and organize the class.

In the ABI approach, one of the principles related to the big idea is giving the students an opportunity to think for themselves rather than providing feedback on propositional knowledge. It looks hard to do but it becomes easier after recognizing its necessity. If the teacher provides propositional knowledge about the big idea or experimental design, it will be difficult for learning to develop. Students can learn the big idea and improve their thinking abilities when they are involved in every step of the ABI activities faithfully.

The teacher's deeper understanding about tasks and their values in the ABI approach guide the activities and the level of meaning to their students. The teacher

should introduce to the students how to organize these processes. It is necessary for students to change their awareness so they can accept the unstructured situation and lead the class. The considerable number of students who participate in the ABI approach enjoy the fun and excitement that come from the active aspects of this approach.

WHAT HAVE YOU HAD TO CHANGE TO HELP DEVELOP THE TOPIC'S BIG IDEAS?

I think that guiding students to find their own answers is the most important thing to develop the big ideas of a topic rather than the content. I helped students generate a classroom question, design an experimental procedure to solve the whole-class question, and analyze observed data by themselves within the unstructured situations.

In the early part of the ABI implementation, I tried to facilitate the students' activity in making an ideal whole-class question by using the big idea, which made me very nervous. Unfortunately, I forced my students to use my opinion because poor questions usually made poor conclusions, which is far from the big idea. I also couldn't implement the ABI approach very well because I did not know how to help students change from passive learner to active students who have ownership in their learning.

I recognized that there was sufficient possibility to come close to the big idea through the discussion about claims and evidence of the group, although the whole-class question was not ideal. I could use students' opinions more often in the class and I also recognized that non-ideal whole-class questions could make more discussable topics. Of course, more time is needed, but these aspects are effective in developing the students' big idea.

Another important point in the class for developing a deeper understanding about the big idea was discussion among students. It didn't mean just giving more time without help. I tried to encourage students to discuss between group members, reconstruct their opinion scientifically, express their opinion with reason, ask students to express their opinions, and to ask other students to encourage others to participate in the discussion as members of learning. I encouraged discussion between group members for performing the task of making questions using the form 'My question is ... because ... What is your question? Why do you think so?' and I designed experiments where the students think about how to experiment based on the classroom question and apparatus and state these thoughts. I led them to write their thoughts by themselves rather than just copying other students' work. I used the same method in the process for drawing claims and evidence of the group, which emphasized reconstruction based on the opinions of the group members.

The most commonly used method for developing the big idea was to facilitate students' forming the group's claims and evidence. In this method, I encouraged students to express their thoughts as much as possible because I think my role is facilitating discussions among students rather than providing the right answer. First, one group presented their claims and evidence. Before their presentation, I asked the

other students in the class to find good points and reasons in the presentation and why those were good. I gave students a high score when they found a significant good point about the presentation of one group and I didn't say that it was wrong immediately. I asked other students' opinions again to help them find and change their misconception for themselves when I judged that it was a really misleading situation. The students tried to find any weaknesses in the presenting group's claims and evidence and asked why they thought that way. Sometimes the group could not answer the questions asked. I gave the person who posed the challenging question a high score and I reflected that result in the attitude score in the performance assessment. The presenter had the responsibility to answer the question first. If the presenter couldn't answer the question, I asked the presenter's group to answer that question. If they also couldn't answer, I asked all of the students in the class to answer that question. If there was no student to answer the question, I gave a hint to the students to find the right answer themselves. They asked for a spokesperson who can provide more information when they had some trouble understanding the questions and answers of other students. I engaged in that discussion to explain what they said when there was no one who could answer. As time passed, I recognized that the whole group presentation and discussion process about their claims and evidence is the most important thing. Providing a delayed feedback rather than an immediate one is a good way to elicit the student's own opinions. Students asked other students to represent their data scientifically and to be objective in their observations. The following is an example.

Presenter 1: Our group's claim is 'The volume of the gas is changed when the temperature increases or decreases.' This is because the piston goes down slightly when we put the syringe in cold water and the piston goes up slightly in hot water.

Questioner 1: I understand that something is changing but I don't know how it changes in cold and hot water.

Presenter 1: As I mentioned earlier (*pointing to a paper with written evidence of their group attached to the blackboard*), the piston goes down slightly when we put the syringe in cold water and the piston goes up slightly in hot water.

Questioner 1: In that case, isn't it better to use this content as a claim than an evidence?

Presenter 1: That is why we decided on 'volume of the gas is changing' as the claim of our group.

<Silence for several seconds>

Teacher: Does anyone have another question?

Questioner 2: This graph is not suitable to describe the whole range because we experimented only within a narrow range of temperatures.

Presenter 1: Based on the result of our experiment, we assumed that if we increase the heat, the volume of gas expands constantly and if we reduce the temperature, the volume of gas contracts constantly.

Questioner 2: But it is a contradiction to explain the whole thing using a small experiment because there will be a variable.

Presenter 1: I'm really sorry.

Questioner 4: Just writing "Change" doesn't explain how it changes.

Presenter 1: That is why I wrote the evidence in the paper.

Questioner 4: What?

Presenter 1: That is why we used the results of the experiment of our group as the evidence.

Questioner 2: In short, just saying "change" does not clearly express your thinking so I think a clearer expression is required.

Presenter 1: I see.

Teacher: Does anyone have a question about this graph?

Questioner 6: It seems that this graph doesn't show how the volume is changing.

Presenter 1: Could you tell me more specifically?

Questioner 6: From this graph, it is impossible to understand how the volume is changing.

Questioner 2: We should be able to see a flat part in the graph when the temperature decreases.

Presenter 1: I see.

Teacher: What is the target of our observations?

Students: Gas.

Teacher: Gas. Did the state of gas change when we heat it up and cool it down?

Students: No.

Teacher: Therefore, if we consider that the state change did not happen ... What will happen next in that situation?

Questioner: If the gas keeps its phase, it will continue.

Teacher: Then can you understand?

Questioner 2: Interpretation about the piston's movement depends on the individual so I think a more accurate representation is required.

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Presenter 1: It is hard to identify how much the piston goes up. So I think “slightly” is a more accurate expression.

Student: In that case, I think that using “between A and B” is better than just saying “slightly.”

Presenter: (*silence*)

Teacher: What do you do when you are listening to other friends’ conversation?

Students: Think.

Teacher: You should think. As Yeonghwan mentioned, “between scales” is a more accurate scientific expression than “slightly.” Can you understand? Through other group’s presentation, it is necessary to try to understand and compare your own thinking with the scientific thinking of other students. Can you understand? How about finishing group one’s presentation so other groups can present? Next is group five.

Students requested reasons and clear statements from the presenters about their vague claims during other groups’ presentations. Presenters revised their opinions about that point on the spot. They often modified their claims on the blackboard before their presentations. This behavior is commonly observed. These are the results of the feedback from other groups during the discussion. The students learned to have a careful attitude when they do an experiment and learn how to represent their data, rather than use unclear expressions through the discussion about individual misconceptions and their claims based on their carefully observed evidence. From the beginning to the end of class, they discussed the same topic about the big idea over and over again in all the steps such as making question, designing the experiment, discussing with their claims and evidence, and so on. Through this process I think they can gain a deeper understanding. However, it is necessary to prepare more detailed teaching strategies to generate interest about the science class for most students who have a passive attitude during debates and are less interested in science. They require more attention because they tend to maintain their passive attitude in all steps of the ABI approach. In retrospect, I think I should have taken care of these students more.

I always want to spend sufficient time to discuss the claims and evidences of the all groups, but I think that is almost impossible to do within the national curriculum of Korea. Thus, only 1–2 times a year, I spend all of an hour to discuss about the claims and evidence of the groups. Students who found the debates fun were inconvenienced because there was not enough time to debate in every ABI approach. I was happy because it was a good chance to identify students’ thinking as a teacher when I implemented this step in the ABI approach.

DOES FOCUSING ON BIG IDEAS HELP STUDENTS LEARN BETTER?

Focusing on the big ideas is helpful for student's learning. There is more possibility to learn well when the learner participates in each phase using the ABI approach seriously. Students who participate in the ABI approach can understand the big ideas and develop the ability to think because each phase of the ABI focuses on the big ideas and progresses continuously. The teacher should support students' active engagement in each stage. Teacher training is required for success on these aspects. If the teacher understands the educational value about the aim of the ABI approach and they learn the instructional strategies for realizing that value, implementation could be more easily achieved. The ABI focuses on big ideas and is more effective for student's learning. The ABI approach often presents more of a burden to Korean teachers because there is a lot of content to teach. The teacher is limited in using their own thinking for the assessment, and there are so many administrative tasks to complete and many students in each class. Thus, application of the ABI approach in Korea requires teacher's flexibility about reorganizing the textbook base on big ideas and changing passive students who are familiar with instructor-led class to learners who think actively.

HOW LONG DID IT TAKE ME TO FEEL COMFORTABLE
IN THE PLANNING PROCESS?

I have now implemented the ABI approach for six years. This approach brought a lot of changes for me. If I had not encountered the ABI approach, I would have become a teacher who prefers lecture-led class. I was confident in the ABI approach and taught by introducing the ABI approach in the general class. This transformation appeared two years after I implemented this approach. I was happy teaching because the students became the host of the class and there were more frequent interactions between teacher and students and students and their classmates. I get excited when I plan the ABI approach after choosing a new topic every year and when I imagine the teaching scene. However, it is true that I have to prepare for the ABI approach more than I would for an instructor-led class. We still spend much time making templates, designing experiments, and starting the debates and discussions. I know that the ABI approach has different effects depending on the teacher's ability and effort. That is why I still don't feel comfortable with the planning process, but continue to try.

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9. QUESTIONS

Creating Questions to Help Learning

INTRODUCTION

Questions are very effective in various aspects of learning. From the constructivist view, learning is reorganizing pre-existing concepts or experiences, and questions play an important role in the learning process. Questions can help identify main ideas in learning, facilitate reorganization of knowledge by connecting pre-existing concepts with new concepts, and reveal the individual's knowledge structure and cognitive level. Questions also help students become active, self-directed learners, improve their problem solving abilities, and shape their thoughts. Students can understand the nature of science through inquiry-based learning using questions from observations. Accordingly, in the ABI approach, we created questions, which is one of the learning strategies.

Creating a question is the first phase in the ABI approach. In creating a question, the teacher provides the problem context and the students make questions based on what they know and what they want to know. Therefore, the teacher can identify the student's knowledge structure and level of understanding and the students can find deeper meanings of the concepts and connect new ideas to their familiar concepts. The questions made by the students also make them more active in the class because they are related to the students' interests. Therefore, creating their own questions and improving their questions is one of the good ways to improve effectiveness of the learning.

WHAT STRATEGY DO I USE TO HELP STUDENTS CREATE GOOD QUESTIONS?

Creating questions in the ABI approach is a step that allows the students to understand the learning goals and find the direction of the learning based on the given problem context. In most science classes in Korea, the teacher provides everything to the students, such as the learning goal, experiment procedures, ways to interpret results of the experiment, and solutions to the problems. Thus, students limit their thoughts and have misconceptions about science. In order to solve those problems that arise in the class, the ABI approach focused on providing opportunities to the students to find learning goals themselves through creating questions. However, it was hard for students who have participated in science classes with a passive attitude to elicit

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questions. But the students were able to make various questions after the orientation of the ABI approach.

문제상황

①. 물을 사이다 병에 가득 넣은 후 냉동실에 넣어 두었더니 병이 깨져 있었다.

②.



(My Question)	Why does the quantity increase? Why does the bottle break when water freezes? Why did the bottle break?
----------------------	--

Figure 9.1. The ABI template with the problem context and students' questions about the changes in mass and volume during phase changes

After seeing the problem context shown in Figure 9.1, the students made questions such as, "Why does the quantity increase?", "Why does the bottle break when water freezes?" and "Why does the bottle break?" You may think there are no major problems in these questions. However, the phase of creating questions in the ABI approach is a very important step, because it decides the direction of the whole activity in the class. Creating questions in the ABI approach can be viewed as the step that includes observation-question-hypothesis. Therefore, questions must meet the following conditions:

1. Question that includes all of the problem contexts
2. Question that begins with 'what,' 'how,' or 'why'
3. Testable question
4. Question that clearly differentiates between the variables and shows the relationship between those variables

Given these conditions, the students' questions in Figure 9.1 seemed not to be good questions. Given that the difficulty level of the problem contexts is low, the students did not exactly understand the conditions of good questions. There are two strategies

that can be used in order to guide students to make high level questions. One strategy is the teacher's appropriate intervention and the other is discussion with the students to develop the students' own thinking. There are limitations to creating good questions through discussions with other students in the early implementations of the ABI approach because Korean students are not familiar with discussions. Therefore, the teacher's appropriate intervention is important. Appropriate intervention is leading the students by asking them questions, rather than giving them the right answer. As shown previously in the effects of the questions, students who are asked questions can think again and find the meaning of the concepts and try to connect new thoughts to their familiar concepts. As a result, the questions asked by the teacher help students think more deeply.

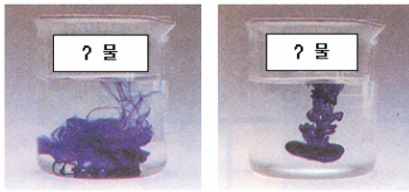
When creating questions for the first time, students commonly make the mistake of including just one of the contexts rather than all of the contexts in their questions.

문제상황

1. 늑대는 만화와 같은 꾀를 내어 돼지들을 유인하는데 성공하였다.



2. 아래 사진은 비커 두 개를 준비하여 한쪽에는 더운물을 넣고, 다른 한 쪽에는 찬물을 넣은 다음 검은 물감을 떨어뜨렸을 때 나타난 현상이다.



<i>My question</i>	Why did the smells diffuse a long way? How did the watercolors diffuse in water? How did the smells and watercolors diffuse?
--------------------	--

Figure 9.2. ABI template – problem context and student's questions about diffusion

From the problem contexts shown in Figure 9.2, students often made questions that included only one problem context such as, “Why did the smells diffuse a long way?” and “How did the watercolors diffuse in water?” Even when they integrated

the problem contexts provided, they just combined the words together such as, “How did the smells and watercolors diffuse?” At this point, the teacher asks the students the following question in order to guide the students to generate questions that include all of the problem contexts. “Do your questions include all of the problem contexts?” After that, students are given the chance to find similarities or differences in the given problem contexts, or find the term that can express all of the problem contexts. Instead of ‘smell’ and ‘watercolors,’ the students will think of the term ‘matter,’ which includes both gas and liquid states, and the term ‘diffusion,’ which expresses that these things are spreading.

When the students make their questions for the first time, they usually create questions which can be answered only with “yes” or “no.” For example, in the problem context in [Figure 9.1](#), the students made yes or no questions such as, “Does volume increase when water freezes?” and “Does glass crack when the temperature falls?” Many teachers in Korea currently use these types of questions in class and I think students also tend to copy such questions.

<i>(My Question)</i>	Does volume increase when water freezes? Does glass crack when the temperature falls?
----------------------	--

These questions above might make students’ thinking and inquiry abilities limited. Therefore, teachers should help students to make questions that include what, how, and why, increasing the possibility for inquiry and creating a space for students to solve their questions themselves through experiments. The following is a dialogue between a teacher and student while creating questions.

Teacher: What is your question?

Student: “When I freeze water, does its volume increase?”

Teacher: What do you think the answer will be to that question?

Student: “Increase” or “yes”?

Teacher: Why do we make questions in this class?

Student: To do experiments.

Teacher: Then do you think your question is suitable for an experiment?

Student: No.

Teacher: Then, how can you change your question?

Student: I have no idea

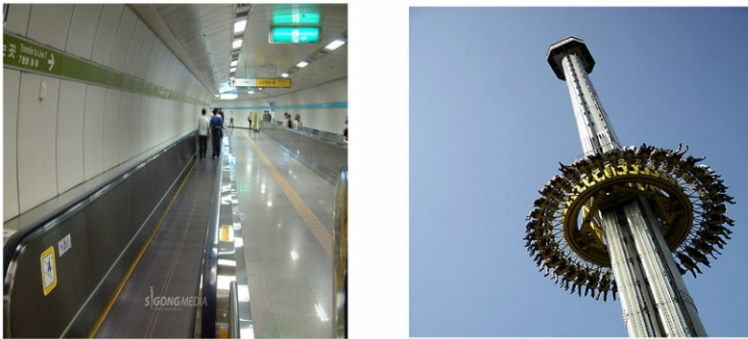
Teacher: Why don’t you include interrogatives such as what, how, and why?

Student: Ah!

QUESTIONS

Students solve their questions through the experiments they design. While a traditional inquiry-based learning consists of (a) creating a question through observations, (b) creating a hypothesis about the question and (c) verifying the hypothesis, the ABI approach seems to include all three steps. The question should be testable and clearly differentiate between the variables and show the relationship between those variables. In other words, teachers need to help their students to make higher level questions that are testable. Students' questions are usually too specific to include all problem contexts, and it is hard to identify what the variables are in their questions when they do the experiment.

문제 상황



My Question	What factors can affect velocity of the object?
-------------	---

Figure 9.3. ABI template – problem context and student's questions about force and velocity

Some problem contexts represent the variables clearly, but problem contexts like the ones in [Figure 9.3](#) do not. However, if students understand the conditions of a good question, they will be able to find a relationship between variables by relating it to their pre-existing concepts. As shown in [Figure 9.3](#), one of the student's questions is, "What factors can affect the velocity of the object?" and it doesn't represent the relationship between the variables clearly. Before learning this topic related to force and velocity, the students already learned about force and how to classify movements of the object (speed and direction). Students can formulate a hypothesis about the factors that affect velocity if they make a connection between these topics. The following is a dialogue between a teacher and student:

Teacher: Can you experiment based on the question you made?

Student: Yes.

Teacher: How?

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Student: Um...I have no idea.

Teacher: What makes it not possible to experiment immediately?

Student: I don't know what factors affect velocity.

Teacher: How can you change your question to make it testable?

Student: Um...If I find some factors that affect velocity, I can modify my question. But I don't know what those factors are.

Teacher: Can you think of the content that you learned in the past?

Student: Um...

Teacher: What was the first thing you learned in this unit?

Student: I learned about force.

Teacher: What happened when force is applied to an object?

Student: The shape of movement of the object was changed.

Teacher: Then how about connecting that content with the problem context?

Student: Ah!

Teacher: Then how about including the relationship between variables in your question?

Because the students need to solve their questions through experiments, the teacher should encourage students to think about what conditions should be included and what variables should be changed to see which results. If students relate what they already learn or their prior knowledge to the problem contexts as they make a question, the effects of learning can be shown through creating questions. This is one of the desired effects of creating questions. At first, in the ABI activity about force and velocity in [Figure 9.3](#), the students often made questions such as, "What is the difference between velocity and direction?" However, this question is related to the concept that the students already learned in the previous class. In this case, the teacher needs to guide the students to review concepts from the previous lesson and use them as the basis for eliciting new concepts. This can be done by using questions such as, "This is what we have already learned, isn't it?", or "What should we investigate further based on the things we know?"

Until now, I have discussed how to lead students to create good questions using examples. In [Table 9.1](#) are questions that the teacher can ask to help the students make good questions.

Once the students have understood the conditions of good questions through these strategies, the teacher should encourage students to create more advanced questions through discussions with other students. However, in classrooms where there are many students as those in Korea, it is a great burden for teachers to lead

*Table 9.1. Questions to ask students**Tips for Creating Good Questions*

1. Does your question include all of the problem contexts?
2. Is it a question with interrogatives that cannot be answered simply by yes or no?
3. Is it a testable question?
4. Is it a question which includes the relationship between variables and can distinguish between the different variables?
5. How can we connect this question with what we have learned previously?

the class by providing proper questions to all students every class period. Therefore, teachers should encourage discussions among students for creating good questions. To achieve this, the phase of creating a question of the ABI approach in Korea is designed to develop the questions through discussions, and is composed of three steps which includes my question, group question and classroom question.

Discussions with their peers in the class can have a greater effect than the teacher's explanations because the students are able to use language that they can understand easily, and the discussions are occurring at the students' level. However, in the case of Korea, students do not have lots of discussion experiences and they are embarrassed when they are asked to have discussions with other students especially in the science class. Therefore, it is necessary to begin by showing the students that discussions can occur even in science classes and allow them to get used to having discussions.

In order to hold lively discussion activities, the groups were organized into heterogeneous groups after taking into consideration the personalities and grades of the students. Each student in the group was also given a role so that everyone could participate in the discussions. The leader of the group was responsible for facilitating the discussions by creating a comfortable atmosphere where all members were able to present their opinions more easily and by reminding them again about the conditions of a good question. The roles were chosen by the group members themselves.

In the ABI approach, the role of the teacher is important as the whole class discussion takes place after the group discussions. The discussion within a small group of students is relatively animated but in many cases the whole class discussion is not, because the students don't want to be laughed at by asking questions that reveal their own ignorance or chaotic state. Therefore, making students comfortable asking questions during the whole class discussion is a high priority. At first, I gave rewards to all students simply for asking questions in order to create a comfortable atmosphere for students to ask questions. In the early discussions, the students asked mainly about ways to present the question, the style of handwriting and effective ways to express their question, and by rewarding such questions, the students' fears about discussions decreased, and as time passed, I gradually gave rewards only for students' higher level questions which helped to promote student discussions.

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The following is the students' answers to the question about the significance and advantages of creating questions when compared to the initial ABI classes.

Teacher: What has changed in creating questions when compared to the initial ABI classes?

Student 1: Creating questions gives me a chance to think about my own thoughts.

Student 2: I can have a chance to think about the answer in the process of finding the question while comparing the similarities between the problem contexts.

There are many students in each class and teachers usually use teacher-led lessons in their classes in Korea. Therefore, the teacher needs to intervene appropriately in the activity and encourage student-led discussions in order to facilitate question-making, which can turn students into active learners and is effective for learning. Teacher's interventions decreased gradually as these experiences were repeated and the level of students' questions became higher as their discussions became more developed. As a result, the students recognized that these improved questions they made can help them think deeply about their own thoughts.

HOW DO YOU FACILITATE THE TRANSFORMATION FROM RESEARCHABLE QUESTIONS TO TESTABLE QUESTIONS?

Young children who start talking ask about certain phenomena, such as "Why is the sky blue?" and "Why are these flowers here?" This can also apply to most of the students. These are questions that students cannot solve through experiments at their intellectual level. These are researchable questions that can be answered by researching, analyzing, and integrating huge amounts of data. There are many researchable questions that come up during the creating questions process of the initial ABI approach because the students make their questions using their knowledge and interests about the problem context. However, the purpose of the ABI approach is solving questions through experiments done by students; therefore, testable questions that can be solved by experiments are more suitable than researchable questions for the ABI approach. That does not mean that a testable question is always the right question form and is better than a researchable question. It depends on the context; therefore, I try to prevent students from having that bias. However, I tried to facilitate the change from a researchable question to a testable question. In the case of researchable questions, I encourage the students to solve those questions during the self-reflection stage that occurs at the end of the ABI activity.

I thought that one of the good ways to change the researchable to the testable question is making sure that the students correctly understand the significance and the methods of the ABI approach. The following are the researchable questions made by students based on the problem context in [Figure 9.4](#).

문제상황	
1. 소주병 입구에 동전을 올려놓은 상태에서 뜨거운 물에 담궈 놓으면 동전이 된다. 	2. 얼음물에 고무풍선을 끼운 페트병을 담궈 놓으면 풍선이 오그라든다. 
3. 뜨거운 물에 고무풍선을 끼운 페트병을 담궈 놓으면 풍선이 커진다. 	4. 비닐과 얇은 철사줄, 알코올, 솜을 이용하여 열기구를 만들면 하늘위로 떠오른다. 
My question	Why does the volume change depending on the temperature?

Figure 9.4. ABI template – problem context and student's questions about Charles's law

The questions made by the students were, “Why is there a difference in the way the paint spreads depending on the temperature?” and “Why does the volume change depending on the temperature?” These questions show that the students want to know the reasons behind the differences in the diffusion speeds and the differences in the volumes depending on the temperature. However, these questions are difficult to test at the students' level. The teacher can ask the student who makes such researchable question about the steps that take place after creating the question, such as “What step comes after creating the question?”, “Can you get the answer to your question through an experiment?”, or “How can you get the answer?” These questions are helpful in leading the students to make testable questions.

Teacher: Is this your question?

Student: Yes, my question is, “Why does the volume change depending on the temperature?”

Teacher: How can you get the answer to this question?

Student: By doing an experiment?

Teacher: How will you experiment?

Student: I don't know.

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Teacher: It seems that your question is too hard to solve by doing experiments at our level. As you mentioned, if you are to find the answer to the question using an experiment, how about changing your question to a more testable form?

Student: Then, how can I get the answer to this question before changing it?

Teacher: I think you can get the answer through reading or during the self-reflection step.

USING YOUR QUESTION TO FOCUS ON THE ANSWER

The students find the answer to the question through the experiment. They design and carry out an experiment for solving their question and write claims and evidences, which are the answers to the question, based on the results of the experiment. During the initial ABI approach, students tend to design an experiment or interpret the data from their experiments without considering their questions. In these cases, finding the answer to the question is not easy. Sometimes they consider answers that are not related to the question. The purpose of creating questions is to help the students understand the learning goal on their own. Even in regular classes, the teachers continuously remind the students of the learning goal in order to check how much of the goals they have achieved. This is also the case in the ABI approach. When the students are aware of the learning goal, their learning become more effective. Therefore, it is necessary for the students to understand the importance of the question. To achieve this, the teacher should encourage students to remind them of their question in each stage. Once this has been accomplished, the students become aware of the importance of the questions and keep their questions in mind during designing and conducting the experiment and while writing their claims and evidence. We could identify these changes in the students through their interviews. The following is the students' interview:

Teacher: Why do we create a question?

Student: I think it is a step for finding the aims of the experiment for when I do the experiment.

Teacher: What are the advantages of creating questions before the lesson?

Student: Questions can make our experiment easier, because they provide a purpose for us to follow. If we have no purpose, the experiment will not go the way we want.

Teacher: Is your standard of judgment for the experiment design just the materials for the experiment?

Student: The fundamental standard of judgment is the question. Based on the question, we design the experiment using the materials for the experiment.

QUESTIONS

Therefore, we judge whether the design of experiment is right or wrong based on the question.

Teacher: What aspects do you consider when you write your claim and evidences?

Student: I write the evidence based on the result of the observations from the experiment and the claim based on the evidences. I also integrate the results of the experiment with the question when creating my claim.

Teacher: Is it hard for you to write the claim and evidences?

Student: It is not hard for me. I just write the results of the experiment according to the question.

Teacher: Do you know what the reason is for creating questions?

Student: I think it is for the step after experiments. Figuratively speaking, creating questions is similar to laying the foundation work when we build a house. Its role is to provide a shape for the larger framework.

Teacher: What do you mainly write for the claim and evidences?

Student: I combine the experiment results with the question when I write the claim and evidences. Sometimes I cannot suggest a good claim when I forget my question and focus only on the experiment results. However, it is not very difficult for me because I generally write my claim and evidences based on the experiment result.

As you can see from the student interviews, the students came to understand the meaning of the question exactly during the activity and they did not feel burdened in finding answers to the questions. If the teacher explains each step to the students before carrying it out in order for students to adapt quickly to the activities and make even a slight effort to prevent them from forgetting their question when they move on to the next step, the students can easily find the answer to their question.

HOW CAN CHANGE PROMOTE YOUR OWN LEARNING IN THE CLASS?

Teachers in Korea usually provide the learning goal to the students in the beginning of the class. Teachers then use instructor-led classes or experiments to achieve this goal. The learning goal is very important to the students because it provides the direction of the lesson and is the ultimate objective of the class. However, the students don't understand the learning goal sufficiently because the teacher provides them to the students in a one-sided manner. Because of this, the students don't remember what the most important thing in the class was and lose interest in learning. Teachers also try to teach the students according to the learning goal; however, they don't spend much time identifying how many students are aware of that goal and whether

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or not they are getting closer and closer to that goal. However, in the ABI approach, the students, who realize the learning goal on their own through creating questions, participate actively in class, and because they need to review their initial question before going on to the next step, they are able to get a deeper understanding of the big idea and these are effective in learning. These results are found in the student interviews below:

Teacher: Which is more helpful – creating questions or the teacher providing aims for the class?

Student 1: If the teacher just provides the questions to us, it feels boring. On the other hand, it seems that we can collaborate with group members well when we make the question ourselves.

Student 2: If I think about the reasons for the occurrence of the phenomena in the problem context while creating the question, I can do the experiment in the direction that I thought of. Then, I try to experiment again and again because I become curious.

Student 3: We can think again and share thoughts with the group members when we make the question instead of using ideas that the teacher provides. This helps us to learn.

As these student activities progress, the level of their questions also increases. This improvement leads to deeper understandings and creating connections between existing and new knowledge in the students' cognitive structure; therefore, they can learn how to study themselves. These changes that occur during creating questions are the results of teaching how to use knowledge with the students instead of cramming students with knowledge. In the ABI approach, the teacher does not need to transfer the learning goal to the students and check constantly to identify whether or not the students have reached the goals of the class using short-answer questions. Therefore, the teacher can spend more time interacting with the students, helping students expand the scope of their thinking, and develop critical and integrated thinking abilities. These can help change a teacher-led class to a student-led class where students have the ownership for their learning.

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10. NEGOTIATION

WHAT IS NEGOTIATION?

I first encountered Argument-Based Inquiry (ABI) five years ago. The most impressive yet unfamiliar term in the ABI was “negotiation.” What do I negotiate about? Who do I negotiate with? I had thought that negotiation was only conducted between countries, companies, or politicians. Negotiation is a term that Koreans don’t use every day; moreover, I had never used nor heard about it in Korean education. I have heard of terms such as discussion and debate and I wondered why the term “negotiation” was used instead of those other terms. I also wondered why I couldn’t call it debate. I had been implementing debate, in science class 3 years before learning about ABI, and I had the pride and confidence of doing something no one else was able to do. I thought that there would be no difference between the two terms. But I kept thinking that there must be a certain reason that the term negotiation was used instead of debate. I kept thinking about that while I was reconstructing the curriculum and developing the syllabus to apply ABI, and I just thought that it should be okay if I just conducted the class with discussions. I realized why the term of negotiation was used once I implemented the ABI in class.

Students began to negotiate while trying to form a question in the problem context. That was clearly different from discussions. Even in the same problem context, the students were curious about different things and they came up with different questions. No question was better or worse than another. This is because I know that students have a variety of questions. Negotiation begins when you acknowledge that everyone has a different question. When choosing the best question among many questions, the students needed to present clear evidence for their own claims. At the same time, they needed to recognize the pros and cons of others’ opinions and realize that negotiation was needed in this process. Negotiation did not only occur between students, but also between students and teacher. The teacher tacitly decides the question for the lesson while planning for the class. However, in most cases, the question does not get decided upon as the teacher intended during the student-led negotiation. In these cases, the teacher cannot force upon the students the intended question of the lesson. Therefore, the students have to decide on the best question through negotiation. Just like other teachers, I have never reflected on the students’ opinions when I set a learning objective, so this process was at first very disconcerting. I thought that I first needed to break out of my own mold in order to lead a good negotiation among the students. This is because negotiation occurs in

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the teacher's and student's mind. Students change their own thoughts and negotiate with themselves while they decide from the individual claim to the group claim and from the group claim to the class claim. I felt that this step of the ABI should not be expressed simply as a discussion, but as a process of negotiation among students, students and teacher, and with their own minds.

DESCRIPTION OF ARGUMENTATION COMPONENTS

I sometimes explained the components of argumentation and its function in order to have higher-quality debates. Students practiced debating with examples and explanations about claim, data, warrant, reinforcement, rebuttal, request and response, and meta-cognition, which were the factors deemed necessary for high quality suggested by Toulmin's (1958) argument structure and Kang et al. (2004) components of argumentation:

- *Claim* is a valuable or a convincing conclusion and data are facts to support the claim.
- *Warrants* are reasons, laws, and principles that are presented in order to justify the connection between the data and the claim or the conclusion.
- *Reinforcements* are the basic assumptions that are provided about certain data. The conditions for when the claim is not true are expressed as rebuttals.
- *Request and response* are questions regarding the claim and data, re-explanation of the problem context, or explanation about the terms and answers to those questions.
- *Meta-cognition* is reflective thinking or awareness of one's own thinking process, and it is important in improving one's thinking ability. The teacher, as a mediator, asks questions such as "What kind of difficulties are you experiencing with this problem context?" or "Why do you think that?" and allows the students to discuss how they overcame the difficulties with the problem context, and by doing so, prompts meta-cognition.

NEGOTIATIONS DURING QUESTIONS AND GENERAL CLASS CONVERSATIONS

When I asked students to debate for the first time, the students didn't talk to each other or just repeated their own opinions. In many cases, the students were not able to explain what was wrong with others' claims or show clear evidence regarding their own claims. Students just replied with a short answer, even when the teacher asked some questions during the general class (not the ABI class) and they were not familiar with explaining the reasons for their answers. Furthermore, the students only stated that someone else's ideas were wrong without explaining the reason. For example, when the teacher asks, "What happens if you increase the temperature in an air balloon?", the students easily answer, "The air balloon will rise." When asked, "Why does the air balloon rise?", the students answer, "Because it becomes light." However,

when the teacher asks, “Why does the air balloon become light?”, the students are not able to answer or they mechanically repeat, “Because the temperature increases.” I think that the students simply repeat what they learned like parrots because they do not know how to provide evidence or reason to support their claims. This type of example comes up repeatedly in classes. I thought that the students first needed to get used to speaking their thoughts and claims with reasons. In general classes where ABI is not used, I asked a lot of questions such as “Why does it become that way?”, “Why do you think so?”, and “Why do you disagree this claim?” in order to make the students express their thoughts and explain why they supported or disagreed someone else’s claims. Moreover, I created a situation where the students provide their opinions through 5 minute group discussions about a brief inquiry problem. Through these processes, I tried to have the students realize that they must have a lot of discussions during science classes. Now, my students always provide their claims with evidence even when they give brief answers.

LEARNING GOAL NEGOTIATION

In most cases, the teacher sets the learning goal for the general class. I also took that for granted until 1 year ago. However, I realized that the students feel pride when they set learning goals themselves while they decide on a whole class question and solve it in the ABI class. The students who had been learning passively in science classes developed an interest and felt happy to actively lead the class through negotiations between students and between students and teacher. Even in the general classes, I thought that learning through active negotiation would be effective so I got the students to set the learning goal themselves. I have the students set a learning goal after reading the textbook and negotiating the learning content beforehand. This process motivated the students to participate in class with a sense of purpose. The students began to feel that they were leading the science class instead of the teacher.

STAGES OF NEGOTIATION

Negotiation does not only occur between others and me. Depending on the subject and the stage of the process, there are various types of negotiation. These are negotiation with oneself, negotiation in group, and negotiation in class.

1. *Negotiation with oneself*

Negotiation with oneself is a negotiating process for making one’s own claim about a new situation through the conflicts within an individual’s cognitive structure.

2. *Negotiation in group*

Negotiation in group is a process for forming the claim of the group by comparing one’s own claim with those of other group members and by agreeing with or refuting other’s ideas.

3. *Negotiations in class*

Panel

Negotiation by panel is when the representatives of each group debate with each other while others watch the debate. Instead of passively watching the debate, the students in the audience can participate in the argument or ask a question when the representatives can't answer or they have a different opinion. The strength of this method is that the students who are not able to logically speak well or give evidence or those who do not know how to speak their thoughts well can learn new content and experience satisfaction vicariously through the representatives who have excellent academic performances and superior debating abilities.

What happened was that the students said, "Ah! That is how you say it!" or "That word means that!" and they even applauded the students who spoke with logical and scientific evidence. Negotiation by panel was very effective when the results of the inquiry were very different for each group or when there were opposing claims. For example, concerning the question, "What do you think affects friction?", the claims of the groups were "roughness of surface," "incline of bottom surface," "weight" and so on. Various evidences came up as well depending on the inquiry method. In such cases, the students had a chance to learn by listening to the claims of other groups and their various inquiry methods through negotiation by panel. It also provided an opportunity to be able to refute the inquiry methods or the evidence and claims of other groups.

Presentation

Negotiation by presentation allows students to ask questions, refute, and compliment the good points of the presentation after each group posts their claim and evidence on the blackboard and gives a presentation. All of the groups post their claims and evidence first, and the other students freely go up to the board to look and take notes. Once this is done, the discussions begin. The advantage of this is that the students gain time to think of questions or rebuttals. It is also a good method to give students different colored post-it notes and have them post those memos after writing questions, rebuttals, and compliments about the claims and evidence of other groups on different colored notes. This way, the students who have a hard time expressing their thoughts by talking can take part in the debates, and they are able to take an interest in the discussions because it is easy to see which group received the most rebuttals or compliments. Negotiation by presentation is effective when the claims of groups concerning the whole-class question are almost identical. When the claims are very similar, it is difficult to conduct a panel discussion. Thus, it is more useful to use presentations type where the students could learn the pros and cons of each groups by discussing the groups' different inquiry methods, each group's presentation methods for evidence, or the usefulness of graphs and tables of each group. For example, in the ABI task of inducing Boyle's Law from the relationship between pressure and volume of gas, most groups use similar inquiry methods and obtain similar experimental results, so all of the claims are that the "pressure of

gas is inversely related to the volume of gas.” In this case, it is not possible for a panel discussion to proceed well. However, when the discussion is held through presentations, the students are able to praise another group because they present a condition such as “at constant temperature,” or they are able to point out that it is better to state that “the pressure of gas is inversely related to the volume of gas” rather than claiming that “the volume of gas decreases with increasing pressure” because the former statement shows the relationship between the two variables. The students stated that showing concrete experimental results as evidence seemed more credible and that it is also easier to understand when tables and graphs are used instead of just text. The students also distinguished between tables and graphs that were more systematic or structured than others. In particular, the students have often drawn graphs since elementary school, but some didn’t know how to draw them well. But they were able to learn about how to draw good graphs through negotiation with themselves by comparing graphs of other groups. Through this process, the students were able to make their claims more persuasively and learn better methods of presenting the evidence and thereby, gradually progress.

Encouraging Students to Negotiate

The most difficult aspect is that some students, especially those in higher grades, are often afraid of speaking even though the teacher instigates arguments according to the students’ dispositions. At first, the students are unfamiliar with debates and are shy about doing it especially in a science class. It is no easy task for the teacher to engage these students in the debates. The shy students especially became intimidated when others refuted their claims, and in some cases, they never spoke again. In these cases, the teacher’s role is important. The teacher has to emphasize the importance of respecting each other’s opinion when the students are arguing. The teacher has to make the students realize that they should not ignore other’s opinions, and that an opinion is someone’s own thoughts and thus is neither right nor wrong. They should accept any opinion as long as there is good evidence to support the claim. The teacher should also impress upon the students that it is important to persuade with evidence and negotiate when there is an opposing opinion. Even when students present a wrong claim, the students should state, “That opinion is good, but let’s think in another direction” rather than saying, “That does not seem right.” It would also be nice to encourage students who suggest good ideas by making statements such as “That’s a good idea,” or “Let’s commend him.” If students become used to doing these things, they are able to make judgments about good claims and evidence and exclaim “Wow!” or they applaud or encourage each other even without being told to do so. Giving points to students who express their own opinions a lot or make good presentations is another good way for leading a debate. There were cases where students who avoided presentations tried to competitively participate in the argument after seeing other students gain many points. In these cases, I encouraged the students to take part in the argument even more actively by giving points for

participating although they suggested wrong opinions. As students became familiar with debates and negotiations in this way and received lots of praise from the teacher, they gradually gained confidence and self-esteem and began to enjoy such class periods. Such responses from the students helped me to continue this teaching method.

EXAMPLES OF NEGOTIATION

The following illustrates cases where negotiation occurs in a variety of problem contexts. This is an example of a case during the processes of “generating a question” and “making a claim and evidence” where negotiation occurs in the group and in the whole-class (see Figure 10.1).

1. Temperature change that occurs at the freezing point

문제상황

1.



에스키모인들은 추운 날 마을로의 온도를 높이기 위해 바닥과 벽에 물을 뿌린다고 한다.

2.



미국의 오렌지 과수원에서는 기온이 너무 많이 떨어지면, 오렌지가 얼지 않게 하기 위해 오렌지 나무에 물을 뿌려준다고 한다.

Figure 10.1. Case 1

The first case that came up during the process of generating a question about the two problem contexts is as follows.

나의 의문	오렌지가 어느때 왜 더 오렌지에 온도가 더해질까	사례1
우리조의 의문	폭설을 때 물을 뿌리면 왜 따뜻해질까?	
학급의 의문	온도가 떨어날 때, 온도가 어떻게 변화하는가	

Figure 10.2. Case 1

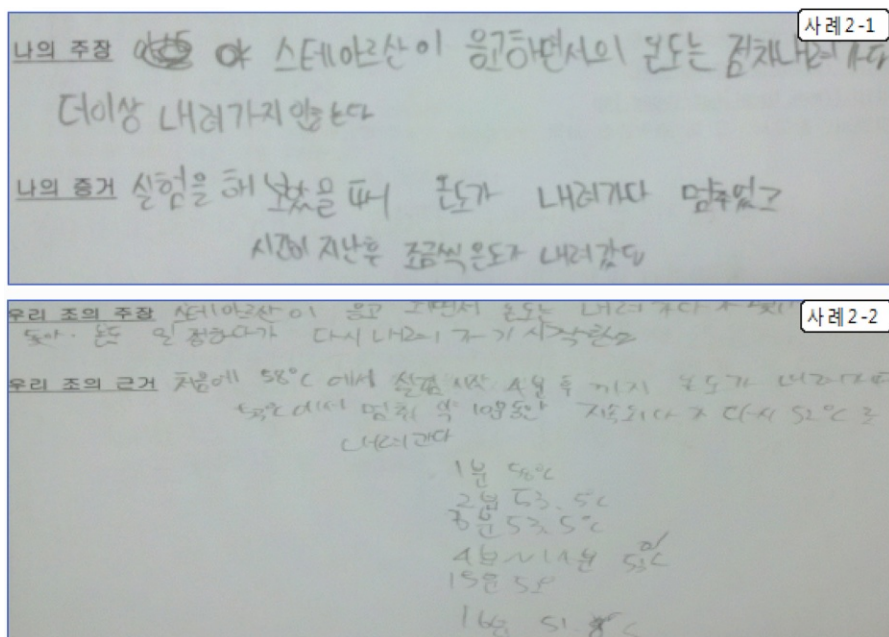


Figure 10.3. Case 2

In the case of this student, although two problem contexts were suggested, he made a question by focusing only on the orange (see Figure 10.2). This student found through negotiation with the group that both problem contexts indicated that the increase in temperature was due to sprinkling of water. Lastly, the students negotiated on investigating the temperature change that occurs during freezing during the whole-class discussion process.

Case 2 shows a situation where a student's claim was almost equal to the group's claim but for the evidence, this student simply explained the result of the experiment in one sentence (see Figure 10.3). After discussing with the group and negotiating with other students, the student tried to be objective by using concrete data as the evidence (see Figure 10.4).

2. Flame reaction

The case about generating a question and making a claim in the problem context of flame reaction is as follows.

In case 3, the student made a question in the specific context of the combustion of a toothpick and steel wool for an individual and the group's question (see Figure 10.5). Through a whole class discussion, the student generalized this situation to a chemical change and used "how" instead of "why." In such cases, the teacher needs to enlighten and negotiate with the students that a question about reasons and principles is not a

문제상황

1. **물결**이란, 파도와 급속의 **변화**를 **유한**하여 조장한 것에 **물**을 붙여 인식되면서 타트러질 때의 소리나 **물결**의 색, **물결**을 감상하는 것이다. 따라서 **물결**을 할 때 여러 가지 아름다운 색깔이 나타난다. **물결**이 **물결**을 감상해 보자. **(물결 감상 제시)**



- [illegible]



블루소 전문가의 묘기

Figure 10.4. Case 3

나의 의문	이슈사태와 감정심을 터무니 없이 절감되 변화는가? 반한다면 왜 변화는가?	사례 3
주리조의 의문	이슈사태와 감정심을 터무니 없이 절감되 어떻게 변화할까? 만약 변화하지 않는다면 왜 그럴까?	
학급의 의문	항상 변화가 일어날 때 직감은 어떻게 변화할까?	

Figure 10.5. Case 3

나의 의문	태연후 강철종의 <u>관</u> 은 어떠한가?	사례 4
우리조의 의문	연소와 연소전 질량은 어떻게 다를까?	
학급의 의문	화학변화가 일어날 때, 질량은 어떻게 변할까? 연소 < 닫힌 - 연소나뭇, 질량은 연소 - 질량감소, 산소 감소 [전자 계를	

Figure 10.6. Case 3

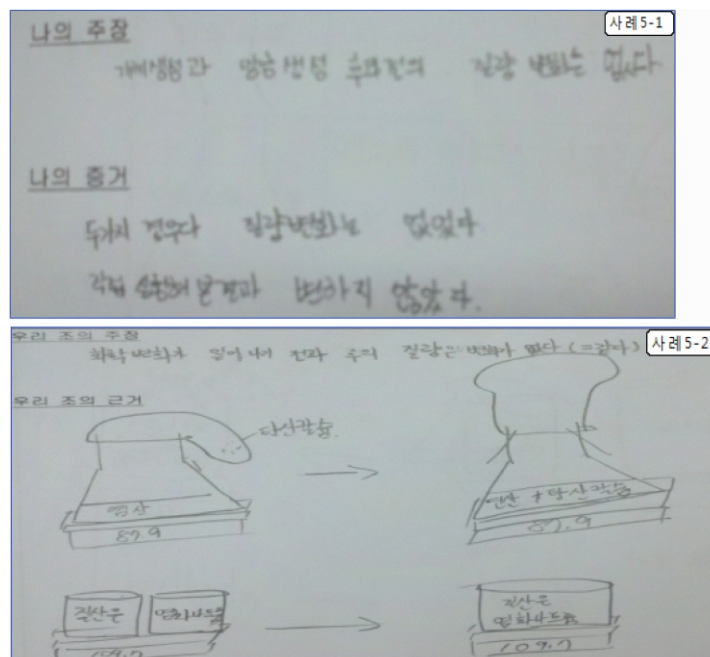


Figure 10.7. Case 4

wrong question but it is a hard question to address through experiments. It is a question that can be answered through a literature search afterwards (see Figure 10.6).

In case 4, a gradual generalization from “the steel wool is burning” to “combustion” to “chemical change” occurred through the process of negotiation about my question, my group’s question, and the class’s question. In this process, the student realizes the concept of combustion and chemical change through negotiation with colleagues (see Figure 10.7).

In case 5, the student stated his claim: “There is no change of mass after generation of gases and formation of precipitation.” However, through discussion with his group, he realized that he needed to make a claim that is related to the topic question and negotiated with other students and changed his claim to, “There is no change of mass before and after a chemical change.” In the case of evidence, the student only expressed himself simply through one sentence but after discussing with the group, he realized that in order to present a more persuasive evidence, figures or concrete data were required (see Figure 10.8).

In case 6, the students negotiated and realized through group discussions that tables with data were required for presenting more persuasive evidence. Through this, the students could learn the importance of tables or figures in successfully persuading other students with their claims and evidence (see Figure 10.9).

나의 주장 화학변화가 일어날 때, 질량은 변하지 않는다.

나의 증거

- 염화나트륨 수용액과 질산은 수용액을 섞으면 흰색 침전물이 생기지만 전체 질량은 변함이 없었다.
- 탄산칼슘을 염산에 섞으면 기체가 생성되어 풍선이 부풀어 오르지만, 질량에는 변함이 없었다.

사례6-1

우리 조의 주장 화학변화가 일어날 때 질량을 변하지 않는다

우리 조의 근거

물질	질량	반응 전	반응 후	
염화나트륨 수용액 + 질산은 수용액		118.4g	118.4g	두 실험 모두 화학 반응 전후의 질량을 재보았을 때, 질량변화가 있음을 알 수 있다. 따라서 반응물과 생성물의 질량의 총 합은 같다.
탄산칼슘 + 염산		96.9g	96.8g	

사례6-2

Figure 10.8. Case 5

■ 문제상황:

접촉하는 두 면 사이에서 물체의 운동을 방해하는 힘을 마찰력이라고 한다. 다음은 여러 가지 상황에서 마찰력을 이용한 생활 속의 예를 나타낸 것이다. 일상 생활에서는 마찰력이 커서 편리한 경우도 있고, 마찰력이 작아서 좋은 경우도 있다.



Figure 10.9. Case 6

3. Frictional force

The case where the students created a question and made claim in the problem context related to frictional force is as follows in [Figure 10.10](#).

나의 의문	우리조의 의문	학급의 의문
1. 작은 공이 왜 갑자기 멈출까? 2. 더 작은 공이 빨리 멈출까?	마찰력의 크기는 무엇에 의해 달라질까?	마찰력의 크기에 영향을 주는 요소는 무엇인가?

Figure 10.10. Case 7

In case 7, the student realized that this was a concept about frictional force and presented the question, “Why does a rolling ball stop?” and after realizing that that occurs due to frictional force, came up with the follow up question, “How is frictional force created?” However, he could not choose between the two questions and presented both. Afterwards, through the group discussion, he modified his second question and negotiated on focusing on the change in the size of frictional force rather than the principle of frictional force. Lastly, the student began to use specific words such as ‘impact’ and ‘element’ through whole class discussions.

4. 나의 주장 (왜 주장할 수 있는가?) 사례8-1
나의 주장은 바닥이 거칠거칠했을때와, 물체의 무게가 많이 나갈때와 다른바닥을 밟을때에 마찰력에 영향을 미쳤다.

5. 나의 증거 (그러한 주장을 한 이유는 무엇인가?, 왜냐하면)
1N의 힘이든다. 1N의 힘이든다. 3N의 힘이든다.
사포를 잡고 끌었을때 2개의 나무젓가락으로 댔을때 1N이 들었어.

6. 우리 조의 주장 사례8-2
우리조의 주장은 무게가 많이 나갈수록 마찰력이 크다.

7. 우리 조의 증거
4N 1N
무게가 많이 나갈때 (나무젓가락) 무게가 적게 나갈때 (나무젓가락)
4N의 크기보다 1N의 힘이 나감
무게가 많이 나갈때 마찰력이 커지므로 쉽다.

Figure 10.11. Case 8

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In case 8, both the claim and evidence were changed after the group discussions. In the case of this group, the result of the experiment was inaccurate (see [Figure 10.11](#)). They realized through the whole class discussion that their claim had a weak point because their group didn't conduct the experiment well. However, in the case of this group, the teacher needs to commend the group's effort to draw a graph that other groups haven't tried in order to present good data so that they do not lose their confidence in the negotiation process.

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SECTION 3
UNITED STATES

BRIAN HAND

INTRODUCTION

The original work on the Science Writing Heuristic approach (SWH, now known as Argument-Based Inquiry, ABI) started with one teacher, Lynn Hockenberry, with her grade 5 class in a small rural town in Iowa. Lynn was keen to try the approach, and so we used polycom technology for us to interact with each other. Sitting in my office at Iowa State University, I was able to watch her teach and then spend a few minutes after class discussing how the implementation was going. This was an incredible opportunity for both of us in building our understanding of what the ABI approach should look like when used in “real” classrooms.

From this small start, we have been fortunate in obtaining a number of grants that helped us expand from this single classroom to work with 300 teachers and over 20,000 students across Iowa. This work involves teachers from K-12 and at the college level. Importantly, we have been able to research what works across these different education levels and what is different when dealing with the “little ones” in kindergarten and what we have to change when working with the “big kids” in freshman chemistry at the university.

The teachers that are part of this book were all from rural Iowa schools. Iowa is predominately an agricultural state with an emphasis on the production of corn, soybeans and hogs. While the state has a population of 3 million, it has over 300 school districts. This means that there are many small districts with the elementary, middle and secondary schools all within the same building. Unfortunately, this means that there are many difficulties facing these schools. Many of these schools struggle with finances because they are funded through the local tax base and these areas are struggling with movement away from rural areas into the cities.

While these difficulties exist, we have been able to work with a really dedicated professional group of teachers, who have greatly advanced our understanding of what the ABI approach looks like and can achieve when implemented within school classrooms. Importantly we have tried to understand what are similarities and differences between grade levels, regional settings, and across different discipline contexts. All the teachers from the US setting have been through a summer workshop program that had additional follow up time during the school year. We were able to provide the funds to support teachers (as they are not paid during the 3-month summer vacation) and as such this helped us provide them opportunities to continue with their own professional development in adapting the approach to their own classroom settings.

B. HAND

In terms of the types of classroom within our projects, our teachers will be from a school with a single section at each grade level, to others who will form multiple sections at each grade. We have seen through the various projects that there is a consistent pattern of performance in terms of what are the things the teachers struggle with, and the pedagogical skills that they find easier to implement. However, what has been consistent across all the schools and teachers we have interacted with is that it takes time to become skilled at high levels of implementation of the approach. Teachers and their students have to make an adjustment to what is traditionally seen and done in the classroom. These rural US children do take some time to understand what is being required of them but then very quickly settle in a new and different way of operating in the ABI environment.

Shifting what is required of them pedagogically has meant that the teachers have had to give up some their perceived control in the classroom and to negotiate more with the students. Across the different schools that we have been working within Iowa, we have seen a consistent pattern of teacher and student excitement as they become familiar and comfortable with using the ABI approach. While the rural kids, like all students, like to hear their voices being heard, we have found that the rural kids are very good at listening and caring for their fellow classmates. To ensure that we are able to make sure that this idea of negotiating has been able to continue within the communities the schools are in, we have spent time working with the parents.

In Iowa, there is a great emphasis on local control, where the school board has the power to set direction for the school. As part of the research process we have constantly worked with these boards. This has helped us to work with parents as we educate them about what is happening in their children's classes. This has been important because science no longer looks like what the parents experienced. For us, this support from the local communities has been critical and enabled the teachers, students, administrators and board members to have confidence in moving forward with the ABI approach. We have struggled to have the same support when we move to the larger districts, and this has meant that we are more cautious in working with the "systems" involved with these large districts.

We continue to work with the rural communities of Iowa because of their willingness to be involved in the professional development and research aspects of the partnership with the university. This means that we can continue to a much richer understanding of how to improve what we do, and to improve the learning of the students.

LYDIA GATTON, MEGAN HACH AND
MARY GRACE VILLANUEVA

11. PLANNING

Shifting from Content to Concepts

INTRODUCTION

The Science Writing Heuristic (SWH) approach to teaching science was not an easy road for new 4th grade teachers, Lydia and Megan. The approach was one of many new things they needed to learn and understand the year we began SWH. It was Lydia's first year out of college and Megan had only taught primary grades (two years of preschool and two years of first grade) prior. To say they had 'bumps along the way' would be an understatement. Nevertheless, their "we'll try anything" attitude coupled with their determination and dedication to student learning was exactly what they needed when tackling the SWH approach in their classrooms. In this chapter, Megan and Lydia reflect on their challenges and accomplishments along this bumpy road. They also provide insight for new and experienced teachers on how to plan for learning.

Megan: In the Beginning – Our Fantasy World

To understand our approach toward planning for SWH, it is important to understand us as teachers. As colleagues, we both felt very lucky to be the two fourth grade teachers in the small, rural community school where we taught. We had a great working relationship and spent many hours together before the start of the school year to make sure our classrooms were organized and that we were ready to be the best fourth grade teachers we could be. It also helped that we had very similar "Type A" personalities that lent to endless hours on weeknights and the weekends to organize and plan very detailed units for the subjects that we would be teaching that year. Similar to most hardworking teachers, we had the mindset of, "As long as we know exactly what we need to teach, how we were going to teach it, and when we were going to teach it, we were going to be amazing fourth grade teachers."

Before the school year started, we did as all good teachers were taught to do: We sat down with our teaching manuals and planned out extensive, cross-curricular units, projects, and lesson plans for each subject for the first part of the school year. This was also the same summer that we experienced our first two-week intensive crash-course on teaching science using the SWH approach. Given our tenacity to do

well, we felt extremely ready and prepared for anything that was going to come our way that year; however, it wasn't long before we realized that all of our well-laid out plans and great ideas for our science units were not going to be suitable if we were to actually implement the SWH approach with a framework of learning, science and language. All of our extensive planning and unit writing was fine and dandy until we actually taught our very first SWH science unit. At that point, we quickly found ourselves realizing that our nicely laid out plans had no correlation with actual student learning.

Lydia: A Step Back – A Look at Our Science Training Before SWH

Although several years apart, Megan and I were both graduates of the same College of Education undergraduate program. It was at our highly regarded university that we both completed our required "Methods of Science" course for elementary school teachers. According to the course objectives, the focus was, "to provide students with specific scientific inquiry opportunities and to teach students to record their observations, findings, and summaries in a science notebook." And true to the course description, we were given "fun" science activities that we could use with our future students. We also enjoyed learning from our professors, but once we began the professional development (PD) program for the SWH approach, we realized how little we were taught when it came to teaching science in a truly student centered, inquiry based way.

Throughout our first SWH PD's, we both reflected on our undergraduate science training as "not very applicable" to the real world of teaching. We remembered that our science professors stressed time and again that our science instruction had to be "student centered," but in comparison to what we learnt in our SWH PD, we never felt we were taught how to successfully do that in our own classrooms. We knew that our science education had told us to, "provide scientific inquiry opportunities" for our students, but the way we had been taught to do that was essentially completely teacher directed. In other words, it was our understanding that the teacher planned and directed the science lesson, and that the students' role was simply to follow these pre-determined steps. We left college knowing the conventional "how-to" of elementary science: (a) write a lesson for a science concept, (b) gather materials, (c) present them to students, (d) help students collect and record the data in teacher-created diagrams, and (f) form whole class conclusions based on the inquiry lesson. And according to our understanding back then, if students were allowed to do the investigation with their own materials along with everyone else or in small groups, it was considered student centered because it was hands-on.

It was only after extensive SWH PD did we realize that this attempt to be student-centered-that-ultimately-is-teacher-centered method was simply not going to be viable for meaningful student learning. This method does not equate to actual student learning because all we would be doing as teachers would be hoping and praying that our students would forever remember the scientific facts we had covered in the

teacher led science investigations. Instead we bought in to the SWH approach. (We use the term “bought in” because, similar to purchasing a new product, one buys the product with the understanding that it will serve its purpose, but its actual quality can only be determined after being used.) Theoretically, we understood that our previous perceptions of teaching did not exactly equate to good student learning, but practically, we were both novices in engaging in a truly student-centered approach. We wanted to teach in a way that would actually allow students to be engaged in the process of learning science, let their ideas and interests guide the way, and afford students opportunities for students to take ownership for their learning. We felt that if we could truly teach in an SWH way the students would internalize what they were learning because they were asking and answering their own questions through scientific investigations rather than teacher determined/teacher led investigations.

We bought into the SWH approach and we saw its potential to create wonderful learning opportunities for our students. However, in a lot of ways, it clashed with our strong desire to plan, plan, plan! It quickly became clear once we attempted to begin teaching our first unit that the way we planned for other subjects [this phrase is somewhat tricky. Someone may say, “If your approach to teaching and learning is really student-centered, then wouldn’t you plan the same way for all subjects?” How is science different from the other subjects?] was not going to work with the SWH approach – if you are going to let your students’ interests and own questions guide the path of learning, then you can’t expect to stick to the path you laid out in your teaching notes. The route you laid out for the unit may not be the route the students lead you down once the unit begins! This, in a nutshell, became our personal struggle with planning and the SWH approach.

The Gold Star Phenomenon

Fairly early on we realized that in order to be successful with this approach we would have to change our teaching mentalities significantly. Being young, novice teachers, we considered ourselves open to trying new things, and thought that we could tolerate not being “perfect” since now we too were the learners. We could have easily said that our styles of teaching were *already* student centered and inquiry based, but it wasn’t until we began evaluating what that meant and were being held accountable through our SWH trainings and observations, that we realized we weren’t as flexible as we had thought. We believed that those elements were the most effective ways of teaching, but releasing control to a room full of nine year olds was frightening! We had yet to understand the delicate balance between a student-centered classroom and a well-managed classroom. Although we thought we could tolerate it, the fear of not being “perfect” and constantly trying to save face when didn’t allow us to be open with the kids or with this approach. It wasn’t until Brian Hand first spoke of what we like to call “The Gold Star Phenomenon” that we finally wrapped our heads around how we had been acting as adults. Just like our students we wanted to feel like we were doing a good job, and we needed that praise from

the SWH team with whom we were working with. We needed that gold star. But that wasn't what the SWH approach was about. If we were going to be successful we had to knock the chips off our shoulders and show our students that we are all learners, and sometimes a setback is the greatest set up for a comeback.

We began our first unit with a class discussion. Looking back, maybe it was just another way to try and save face, but we thought that talking to our students about the changes we'd all be experiencing this year in science would help prepare them for this new experience too. We talked about teachers as learners and as a source of information, much like other sources of information. We admitted to not having all of the answers (which I'm pretty sure they already knew), and that that's how questions become investigations and research. Our goal was to have our students see us as another human being, as a fellow scientist, and with that there would be no gold stars.

As we started to embrace our forth-comings, we soon realized many other things about our teaching style had to change. We would be spending less time on detailed lesson plans, because we didn't know how each day would go until we were experiencing it with the kids. We felt unorganized and that we were barely surviving day by day. But among those difficulties we began seeing the benefits of letting go of the strict structure we were used to. We noticed that even though we felt scattered, our students were taking it in stride. There was no other way to get started than to just jump right in.

Planning Step One: Determining the "Big Ideas"

So, with the strong desire to plan our entire first science unit ahead of time, we set out to teach following the true SWH approach. Therefore, the most planning we could do before starting a unit was not so much planning as it was preparation.

Before we began planning any of our science units that year we first had to come up with what would be our "Big Ideas" for each unit. However, we couldn't determine what our Big Ideas were going to be in fourth grade until we met with the third and fifth grade teachers to determine what concepts they were going to be covering in science. (It is important to note here that the third through fifth grade teachers in our school were all a part of the SWH grant, SWH trainings, and were on board to trying to teach science using this method). This initial "dividing up of the science concepts" amongst the third through fifth grade teachers was a long process, but a necessary one to ensure all of the science concepts that were laid out in the Core Curriculum were going to be covered adequately in our school in the third through fifth grade. It was also important for all of our upper elementary teachers to meet to make certain that we weren't overlapping on some of the science concepts and teaching the same concepts in multiple grades. Through several meetings the summer before we all set out to teach using the SWH approach, we were able to determine the four "Big Ideas" each grade would teach in science that first year. In the end, we were confident that all science concepts laid out in the Core would

be covered and that there would also be no major overlap of concepts in our third through fifth grade classrooms.

The “Big Ideas” we created using the Iowa Core Curriculum included:

- The Earth is constantly changing
- All water on Earth goes through a cycle
- Energy comes in many forms
- Forces affect motion

Selecting the exact wording for each of our “Big Ideas” wasn’t always easy, but brainstorming with other colleagues and graduate students from the University of Iowa, helped us formulate a statement that largely encompassed the goals set forth in the standards. We weren’t always comfortable with the language used in our “Big Ideas,” but in order to get started that first year we didn’t dwell too long on the wording knowing we could change it the following year if we didn’t like how it worked the first year. We learned immediately that having these conversations and discussions with our colleagues and SWH graduate assistants was pivotal for us to move forward confidently and quickly since we always seemed to be second guessing ourselves throughout the process. We spent many hours in the beginning focusing on the semantics of getting the perfect worded “Big Idea,” but realized with time that everything with this approach gives us the flexibility to change it and make it better later if need be.

Planning Step Two: Concept Mapping

The next step in our planning process once we had our four “Big Ideas” laid out was to create our own teacher concept map for the first “Big Idea” we would be teaching that fall. The students would later do this too. Doing a concept map together allowed us to reflect on our own knowledge of the content area. At times, this was very enlightening to us, because as two beginning 4th grade teachers, we soon realized there was much to learn. There were times when we felt incompetent to teach the material because as we sat down to do our teacher concept map we realized how little we actually knew about the concept at hand. We no longer had the science kit telling us how to teach the concept as well as teaching us the necessary background material on the concept at the same time. As teachers, I think we felt like we should know it all, so again this was a moment when we had to check our pride and realize two things: (1) we needed to have a stronger foundation in knowing and understanding the content before we can help our students, and (2) if we didn’t know all the answers, which we didn’t, then it would create a perfect learning opportunity for our students to show them the steps we took to get informed.

For us, every time we hit a roadblock and became frustrated with the feeling that we simply didn’t know enough content to teach fourth grade science without a manual, we were reminded why we had decided to embrace the SWH approach in the first place. These roadblocks were real life examples of how little we actually learned in

science class during our own years in public education and even our science classes in college. Clearly the way we were taught science hadn't worked for us, because we either couldn't remember or never learned the concepts we needed to know to teach fourth grade science to our students. All the years we had spent as students listening to our teachers "teach" us science and doing teacher led investigations hadn't really taught us science because here we were fifteen years later and we were still unclear just exactly how the rock cycle worked or how to correctly explain the changes of the seasons. Therefore, our frustrations often reminded us why it was important that we stick it out and make an honest attempt to teach using the SWH approach.

After constructing our concept map with no resources other than our own knowledge, we took a step back, looked at the standards again, and added concepts that we hadn't thought of but were necessary to include if we were going to ensure all the necessary standards were going to be covered in this unit. Once we had a better understanding of what we knew, and what skills the students would need to learn, we began educating ourselves. We checked out countless books from the library, that would later be used in our classrooms for the unit, and started doing Google searches to find kid friendly websites that broke down the concept in easier to understand terms that we could use to help teach our students. We began researching hands-on investigations that we could use if those topics came up in our classrooms. We organized a binder full of prompting questions and mini activities in the event that we would need them. Most importantly, we asked for help. We emailed fourth grade teachers from other districts that were participating in SWH and asked to hear their "Big Ideas," got lists of books they were using to research with, gathered the questions they used to start off their units, learned of investigations they were doing to answer their questions, etc. Again, this part of the planning process took a lot of time and energy up front. We spent a lot of time educating ourselves and thinking through the possible paths the students would want to get into when it came to this concept. Although we still felt in many ways that we were being asked to reinvent the wheel, we did know that there were lots of resources out there to help us; we just needed to keep a positive mindset and do the work.

Planning Step Three: Centralize Your Resources

We also prepared a few other things before the school year started, to make sure that as much as we could have ready, we'd have ready. Each student had a science notebook that they used like a real scientist to collect, document and organize their data. We also prepped a small storage room in our school that we began calling "The Science Closet." With the help of the other upper elementary teachers, we began bringing in any materials from our homes that related to our "Big Ideas." Items from home (and from around the school) that we began collecting right away included plastic containers, coffee filters, ice cream buckets, rolls of string, jars, cardboard tubes, cardboard, pieces of wood, old measuring devices, heaters, balls, toy cars, boxes, etc. We also started purchasing items with the grant money we had

acquired for taking part in the SWH program. We gathered any science books and non-fiction books that pertained to any of our “Big Ideas,” organized them into bins, and labeled them by topic. We added videos and DVDs relating to science in the closet as well. We collected just about anything and everything just in case we would need it. We knew that we would be asking students to bring in their own materials for the investigations they would be designing, but we also knew that often times things were going to get left at home so we did our best to have a wide variety of materials on hand just in case. Creating the Science Closet was a way to get organized and keep ourselves busy since there wasn’t too much more we could do before that first science day.

Planning Step Four: Begin Teaching!

Once we felt like we had prepared as much as we could, we hesitantly began day 1 of science. We spent some time up front teaching students about concept mapping. We used a short example to demonstrate the process. This could really be done using anything, because the idea is to flush out prior knowledge and get a good starting place for the unit. We chose to concept map. After we felt like students knew how to begin, our tentative plan was to organize the days’ lessons as follows:

Day 1: Mapping

- Students are presented with the “Big Idea.”
- Students use their science journals to construct a list of words or phrases that come to mind when they read the “Big Idea.”
- Students use the words from their list to independently construct their own concept maps in their science journals.
- Once students have had time to work independently, they are placed into groups of 4 or 5 (depending on the class size) and asked to bring their individual concept maps together. They do this by going around and verbally sharing the ideas from their notebooks. They take their ideas and begin placing them onto a large chart paper. We tell students that every one’s ideas are valued and so therefore every idea gets placed on the small group map, even if someone disagrees with it. Negotiation will happen later. As a teacher, this was the time we used to walk around the groups and listen in. We carried our teacher concept maps with us to compare what we wanted to see students come up with, to what their maps really said. This way we could have quick conversations with a group to probe them a bit farther with some of their ideas, and ultimately get everything we needed to see on one of the groups’ maps.
- After the groups have had time to discuss their individual maps and create a combined map, the teacher begins to bring the groups’ ideas together to create an even larger classroom concept map. Before drawing out a detailed and clean map on chart paper, that will be used in the classroom the whole unit, we start writing

students' ideas up on the board. We learned after some experience with this, that doing it on a white board first allows for us obsessive teachers to make it look pretty later. This way we focus on the content and not the design. We learned that this also helped our students sort the information more clearly, and boy was there a lot to sort! More often than not, our students came up with a lot of what was on our own teacher concept map, as well as ideas we hadn't even thought of. Along with that, we also received ideas that we still can't figure out where in space they came from, but students were sharing and that was the important part.

- As we began to help students sort all of these ideas, we eventually found language that seemed to work really well with our kids. We talked to our students about baskets. We told them to imagine the bigger bubbles on their concept maps (that branched off of the "Big Idea") as a basket. Broader concepts deserved their own baskets, and items or ideas that went with them, fit inside. Again, every one's ideas were placed up on the board, but we continued urging students to come back to the "Big Idea" in order to stay on track. For those that couldn't let go of their idea, and we certainly had a few of those especially at the beginning, we placed off beat ideas in the "Parking Lot." This was a way of showing students that we valued their ideas, but because they weren't related closely enough to the "Big Idea" at this time, we'd try to come back to them later. Did we always? Absolutely not. There just isn't enough time in the day or in the school year for that, but the important thing was that all ideas were validated and no idea is a bad one.

Day one was always mostly spent organizing all of the ideas students have for the "Big Idea." When certain topics we want on the class map because of state standards weren't approached, we as the teacher continued to work on prompting, not providing, those ideas by asking questions or posing scenarios. Let me tell you, this wasn't always easy! We tried to avoid the "guess what's on the teacher's mind" game, but until we had enough practice with SWH, we definitely weren't perfect ...once again. But when the map felt complete that first day, and occasionally on the second, we started to work as a class to link ideas together using "linking words." We do a separate mini lesson on linking words, and talk to students about how and why they're used, and which words make for good linking words. We place arrows at the ends or beginnings of our connections, so the pathways start to form sentences off of the "Big Idea." This way students can see the map as a whole, and not as a bunch of disjointed baskets.

Day 2: Questions

- Throughout Day 1 we start to hear our students ask questions. Many times, we've found ourselves rushing behind our desks and saying, "Hold on! Hold on! Let me type this all out!" Our students have never had much trouble with asking questions. The quality of their questions on the other hand, is probably for another chapter, and for many lessons. When our students began asking each other questions, and ultimately beginning the negotiation process, we started a running document on our computers to get them all down. Again, no matter the question.

- After we've gathered sometimes 25 to 50 questions, we began sorting them as well. We had three categories: Testable, Researchable, and Parking Lot. We talked to our students about the difference between all three labels, but in fourth grade they were pretty good about knowing what they could and couldn't do within the classroom. That's really how we defined testable anyway for our purposes; what could we investigate in our classroom.
- While formulating the questions list and during the sorting, we almost always found one area that students would get hung up on. There would usually be one question that they wanted to negotiate more than the rest, and they wanted to start researching right now. There were times when I had to tell a student or two to hold off on grabbing the dictionary or other books I brought in, because we'd get to researching soon. But wow, what did this tell us as teachers? Students can be motivated by science, and *intrinsically* motivated!

But as teachers we had to really learn to listen to our students. That's how we were able to plan for the next day. We had to listen to hear them say what they were the most interested in finding out first, and as long as it fit the "Big Idea" we would address it.

Day 3 and so on ...

On day 3, we found ourselves already jumping into investigations with students. We planned either to address one question as a whole group, or break students into smaller subgroups so that more of their questions could be addressed. We placed students in groups mainly again by listening. During all of the discussion we'd had the past two days, I had a pretty good idea what each student was interested in testing or researching, and I grouped them accordingly. At the beginning, we did a lot of whole group questions so that I could better manage the entire class on an investigation. Our plans from there on out were to follow what we knew of the approach and figure things out as we went. Students answered the question with an initial claim, set up a test or began researching, collected data, often changed their claims, gathered evidence, and prepared to present their findings to the class. Sometimes questions changed throughout the process, and many times we stopped in order to focus on behavioral and management issues. Please don't assume that by our nice organized list things went all that smoothly. The above was always our general "plan" but plans changed continually and the more they did the better we were able to cope with the whole process.

Behavior Management Planning: We Just Couldn't Move on Without It

As soon as we felt successful with one area of teaching SWH, our fourth-grade personalities always threw us for a loop. Although the approach kept students more engaged in science than previous years of teaching traditionally, at the end of the day we weren't working with University of Iowa graduate students anymore, but real life 9 year olds. No matter the circumstances students have to be taught how to behave appropriately, and with that, as scientists! We immediately got on the same page

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regarding classroom management and began planning how to address problems we were having with students, even after using the SWH approach. We definitely had to set the stage for this process to be successful with students. Much of this approach has students working in small groups, negotiating in a large group setting, and being active listeners. These things didn't come naturally to our fourth graders, partially because we hadn't allowed that kind of freedom in the past. Our kids were used to raising their hands in order to speak and being given directions. It was unusual for them at first because we were asking them to lead the classroom discussions. We modeled correct behaviors with them and constantly reinforced the positives we saw with students when doing the approach. It took a while, and for some students all year, but soon they realized that we *wanted* to give them the reigns. The SWH approach became even more successful for us and our students when we all got onto the same page.

CONCLUSION

After two years of participating in the SWH process, we are very much aware that it is a process. Google search says the definition of a plan is a detailed proposal for doing or achieving something, and is decided on and arranged in advance. Defining the SWH approach to planning is no easy task, and as teachers we are reluctant to release control of our lessons and our students, because having those plans often keeps us afloat. But what we have discovered is that if we change our mentality toward teaching and how we perceive students as learners, we may be more successful as teachers. We'd like to believe that every teacher went into the profession to help children learn. If that is our main objective, we have to be open to the possibility that perhaps there is a different way, and it may not feel comfortable at first, but our comfort is not the priority. When we started to plan less, we began to provide more. We were teaching our classrooms more lessons than we even knew. We felt vulnerable, but our students saw us as learners too. We always had our goals in mind, but our role in the classroom had changed. Being a guide and support to our students increased their responsibilities for learning. Allowing students to choose their path within the Big Idea increased their motivation to participate, read non-fiction texts, and engage in thoughtful conversations with their peers. No two definitions to SWH planning are the same, but it's that malleability that opens doors we once kept closed.

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12. TEACHING TO THE BIG IDEAS OF SCIENCE

Shifting My Practice

INTRODUCTION

In the past ten years, teaching has developed into a new life for me. New instructional approaches are influencing new standards and expectations for all teachers and students across the United States. Every teacher wishes to help their students develop problem solving skills and persevere through challenges, skills that are recognized as necessary as a twenty-first century learner. That is why being a classroom teacher demands flexibility and willingness to being open to change. It is through all of this that student understanding has and will continue to flourish.

The Shift

What stands out when I reflect as a teacher about how my instruction has changed is the difference it has made in student learning. The change is that my focus now from a teaching standpoint is on the *learner* and how students *learn*. Making this shift has completely refocused the way I approach instruction and planning in my classroom. When I consider how I used to teach and compare that with WHAT students learned, I recall that the learning was temporary. I recognized the frustrating pattern of my ambitious attempts at content coverage which resulted in most student learning for a short time (to pass a test, complete a project), only to hear teachers in the next grade reflect about students not having learned the exact material I had ‘covered.’ I knew I needed to carefully examine my views on teaching and learning; I knew something had to be different. Doing the same thing from year to year was not cutting it. I was reminded by a very powerful quote often attributed to Albert Einstein, “The definition of insane is doing the same thing over and over again expecting different results.” That was exactly what I was doing.

When I was provided the opportunity to learn about an inquiry-based instructional approach around conceptual big ideas, I knew I had nothing to lose and my students had everything to gain. The idea that student learning should be centered not just around isolated facts was something new to me. In the past, learning has been so centered around a unit or the content knowledge. I used to teach topics like plants, main idea, and the Thirteen Colonies. In the past, these topics were the starting point for instruction, as I would sit down and begin thinking about all the fun activities students could

do, the vocabulary the students needed to know, and the study guide around factual knowledge that would need to be made. Even as I sit back and think about this process today, I don't believe I ever really did develop a unit. I was pretty much flying by the seat of my pants and often guiding my students where I thought they should go based on what I had covered and what still needed to be covered. My focus was on what and how much I had *taught*, rather than what and how students were *learning*. One thing is for sure—I never sat down and asked myself two critical questions:

1. Why is this information important for my students to know?
2. What is the big idea or transferrable concept(s) behind this content?

These are two questions that I live and breathe every day of teaching life today. My teaching and unit planning are guided by this foundation of beliefs.

Why Should I Change?

Why are these questions essential for teaching and learning in my classroom? Asking myself these two questions has completely changed the way I plan my unit and design instructional experiences. I can and should expect students in my classroom to ask about the relevance of their lives in the curriculum. I must also consider HOW they learn! There have been many times that students actually asked me why they needed to learn something. My best answer might have been, "Because it is in the curriculum," or "You will need to know it for next year." What pathetic responses! These answers don't have anything to do with rigor or relevance, two terms used so widely today. I needed to do better by my students. Students most certainly deserve to know why they need to know what they are learning, and so do I.

A great example of this that comes to mind is from an Iowa Core standard that states, "Draw and identify lines and angles, and classify shapes by properties of their lines and angles." This is one area in math where students frequently question the importance of learning. Why must they be able to identify properties of a shape? There was a time where I couldn't have given a response because I hadn't even considered this myself. Once I began asking myself this question and talking with others about every learning standard, it became very clear to me what I knew and understood (or didn't) about the content I was responsible for teaching. I challenged myself to consider about the importance of that particular standard and how I could communicate the intended learning conceptually to students and show relevance of that learning. With my 4th grade colleagues, this is exactly what we did with this standard. We started off by talking about what properties meant, which ones we could name and describe, and which ones were specifically identified in the learning standards. We looked back over the 3rd grade standards surrounding this content as well to determine what the learning progression from the year before and after fourth grade. This allowed us to develop opportunities that would build from prior knowledge experiences as well as set students up to extend learning to 5th grade. Knowing where my students had been also allowed me to anticipate as we developed

problems for students to explore. As a group we talked about having students first wrestle with the idea that *shapes have properties*. We decided to ask our students: “What properties do 2-dimensional shapes have that describe them?” This proved to be a little difficult for students. The idea of properties was just a term they weren’t completely comfortable with in math, despite our study of it in science earlier in the year. The transfer of their understanding was still not there for some of the students. When students were sharing their ideas it was easy to see and hear the students’ current understanding of shapes and properties. It was very clear in my class that my students just needed some time to explore and discuss with each other.

The next activity (a shape sort) used the information revealed through the students’ discussion. I purposefully picked specific shapes that students could do sorting with; shapes that had different numbers of sides, shapes that were symmetrical and asymmetrical, shapes with different types of angles and lines, and polygon and non-polygon shapes. While the students were sorting them with their classmates, I went around and took digital pictures, downloaded them onto my computer, and later projected them and asked the students to identify each groups’ sorting rules. It was during these student discussions that we talked about how the sorting rule the students used were actually properties. Students used rules such as the number of sides, symmetrical vs. not symmetrical, shapes that had right angles, etc. It was from these discussions that we as a class began hearing other vocabulary. This enabled us to continue talking about different mathematical vocabulary the class was familiar and unfamiliar with. Each time a new vocabulary term was used and discussed by the students, we would post that word onto our math wall. This became a very valuable resource as we continued our study of shapes. Students began using this resource to continue working on their understanding of shapes and the properties that are used to describe them. There were many other opportunities embedded throughout our unit for students to compare different shapes and sort, testing out the rules and attributes in describing the shapes. This provided assessment opportunities for me to look for evidence of student understanding surrounding the standard we had been investigating. Through the student-to-student conversations and artifacts I was able to identify which students were solidifying their understanding of properties. Our 4th grade team had developed ‘look-fors’ or things we would see and/or hear that would provide evidence of this understanding. This included what vocabulary we wanted our students to be able to utilize in their explanations and the properties we were expecting our students to be successful understanding and using. Careful observation and listening in on conversations allowed us to assess for these easily.

Another activity that we used was much like the board game ‘Guess Who.’ Students worked in pairs. One student would choose a shape from the set they were given. The other student would then begin asking their partner if the shape they chose had different properties (“Is your shape a quadrilateral?”) Through process of elimination, the guesser would then choose the shape their partner had picked. It was through this activity that as a class we began discussing why properties of shapes are important. The students shared ideas of describing for identification and sorting

for efficiency. This was the perfect opportunity for students to understand why these concepts were important to their understanding.

How Were My Students and I Benefiting?

Through activities like the ones described above, students had multiple opportunities for negotiating their understanding, and comparing their individual understanding to those of the class. This approach has been far more rewarding for both me and my students. It was during these learning opportunities that the facts and skills suddenly became important in their appropriate context. They knew why they needed that information and they could connect the facts to a bigger idea or concept, even beyond the classroom to real life situations. This created greater and more enduring understanding.

Another advantage is that it provides opportunities for cross-content connections. For example, something that I found to be even more powerful was when this idea of attributes/properties could be carried over into other subject areas. As I mentioned above, geometry was not the first place where my fourth graders encountered this concept of properties. Their understanding of this concept actually revealed itself in science class when we were studying earth materials and how the properties of those materials dictate how they are used. By the time we reached our geometry application of this concept, students were familiar with some knowledge of attributes/properties they had gained earlier in the year when learning about shapes and apply that to learning about rocks. Students learned some facts about earth materials and shapes (kinds, attributes, uses, etc.) and more importantly, they gained a flexible and adaptable understanding of the concepts of properties and attributes. To me, this is a great example of how conceptual understanding can really pay off. It was times like this that both the students and I realized the deeper understanding that resulted from teaching conceptually rather than simply acquiring factual knowledge

What Have I Changed?

One thing I have noticed in my own teaching is that to embrace conceptual teaching I had to change the way I approach planning. To truly understand exactly what the big idea/concept is around a learning standard, I had to utilize a backward design. I benefited from collaboration with others talking about what the standards are and what understanding is needed in order for true understanding. Again, essential questions I ask myself are: Why does a fourth grader need to know this? What impact will their learning in my class have on future learning in other teachers' classrooms? These are two questions that I am constantly asking myself and wrestling with. This has forced me to face some of my inadequate content knowledge and jump face first into my own learning. I have had to go back {and begin my planning by building my content knowledge} because I've needed to know content in order for me to understand embedded concepts. The short cuts and memorized isolated facts just

weren't helping me create adequate learning experiences for my students. I found myself being more aware of what I say and do today in my classroom and the affect it will have on my students in their future educational experiences.

In the past, teaching was telling. For example, *telling* kids that you can't subtract a larger number from a smaller number is something that I now understand is not likely to realize great gains in the understanding of subtraction. Telling the way to approach facts and concepts was limiting; I was taking away students' opportunity to be problem solvers and show flexible thinking and learn from the ideas in the room. I was simplifying the concept of subtraction, which in turn made it a more difficult road for my students when they entered their middle school years and learned that negative numbers are real and alive. They may have learned the rote mechanics of subtraction, but they lacked conceptual understanding to apply to more sophisticated uses for subtraction.

As I moved from telling to questioning, my approach changed. For example, in science, as I got ready to teach a unit on energy, I realized I didn't have much background knowledge. I had to go back and research and learn about the concepts that surround this huge abstract concept. It wasn't enough to rely on just the textbook to help me teach to my students' needs. When I started thinking and approaching planning conceptually, I realized that the coverage in the textbook was overwhelming. I had to sort out what concepts were essential and transferrable and then determine what factual knowledge students might learn and attach to those concepts. It is still a resource for both content knowledge and resources and activities. However, I have expanded the resources I include when I plan to include the Internet, etc. I have found myself being a detriment to my students larger understanding later without truly thinking about these types of concepts ahead of time. I found myself making statements that were actually false later down the road when they would encounter the content in an even deeper manner. For example, telling students to look for key words when solving math word problems when they are in the primary grades. The term 'altogether' does not always mean to add. The operation of multiplication might be a more efficient strategy. It is examples like this that have reinforced the idea for me knowing the path my students will be heading down other grades conceptually is so important. Approaching planning with the first step of building my own content knowledge allows me to anticipate student understanding that may need more development, potential gaps in understanding, and the most essential learning around the concepts. This change resulted in my shift from focusing on teaching facts to the teaching of big ideas and concepts, resulting in more enduring understanding.

This type of planning really made me feel more empowered and resourceful as a teacher. One illustrative example of collaborative planning with a backward design that I have done is when we began investigating the big idea, "There are many causes for changes on Earth that tell stories of the past and present." A group of 4th grade teachers decided to tackle this big idea by addressing the recent flooding that had just occurred in our hometown – the devastating flooding of the Missouri

River during the summer of 2011. The previous trimester our classes had focused on earth materials and the properties that they possess that dictate how they are used. We wanted to take this big idea and use it to carry into our new big idea. The way that we did this was through the farming culture in our area. Iowa is well known for its farming as a way of income and life style. The floods have really had a devastating effect on this culture and we wanted kids to see how this change that we had just lived through has really affected our local communities and state. We did this by having the classes investigate one large question; "What properties must soil have in order to grow plants?" Each class was then given a smaller question that would enable us to gather multiple points of information to then help us answer this question. Each class was given a variety of tools and information to discuss and experiment. At the end, each class had the opportunity to share their findings through a presentation and a final discussion was then made about how this change has impacted this farming culture. Not only did this help make a connection from our past big idea, but it also helped launch us into our upcoming unit as well. It also allowed us to go back and ask ourselves, "How does this help us understand our big idea?" It is collaboration like this and connections of the students' lives to the big ideas that help make student learning more exciting and relevant. My students felt a sense of accomplishment and understanding that they hadn't always experienced before because this was something so close to home.

The Shift in My Thinking

These examples illustrate a complete shift I have made that puts the emphasis in my classroom on student learning.

How Have I Made These Changes?

Collaboration time with colleagues has been essential. Providing opportunities for dialogue around teaching and learning has transformed my classroom practice. When collaborating, we share our resources, search for new ideas, discuss connections to other content areas, and build our understanding of content we are unsure of. I can't say how many times we would practice thinking out loud or finding resources, and then discuss the concepts we ourselves were missing. There are many times we would go to our own experts; our science consultants, high school science teachers, and experts in the field of study we were exploring to gain more knowledge for ourselves. This time also enabled us to find other cross-curricular connections that would help us surround these ideas with authentic opportunities that crossed the boundaries of multiple subject areas.

Probably one of the most substantial ways I have made these changes is that I have given myself permission to say, "I don't know." Accepting that I don't know all of the answers and giving myself permission to tell my students that I don't know and will need to do some investigating with them has taken pressure off of myself

Table 12.1. *The shift in my thinking*

<i>I Used to...</i>	<i>But now I...</i>
Start my unit by gathering my resources and filling out my lesson plan book. I would begin thinking about how long I had to teach it based on the calendar. It became a list of activities that I would follow from one to the next.	Meet with colleagues to develop or revise a 'concept map' with colleagues negotiating our understanding of the content/concepts and determining the most essential learning
Build my unit lessons by lesson from the textbook in the order it was presented.	Use the textbook as <i>one</i> resource for my background knowledge and adapt activities for inquiry
Think of all the activities students could complete during the unit.	Think about what my students need to learn and why and then carefully select activities that will help them wrestle with those ideas.
Assess learning after the unit was taught	Provide standards-driven instruction, starting planning with the standard and designing instructional experiences around the learning standards, formatively assessing growing understanding in various ways during the unit
Jump right into my lessons before working with my students to establish a sense of curiosity in the students.	Write essential questions for inquiry and select one or more that may 'launch' the unit and propel multiple inquiry opportunities for investigation, discussion, and research
Start with my unit plan and completing one activity and then the next until all were completed	Begin with assessing what my students' current understanding is through an activity or discussion in the classroom to determine where I will start
Move forth with my lessons and deal with student incorrect ideas as we went	Try to anticipate students' incorrect ideas before heading into the lessons.
Provide a writing experience before or after the unit, usually as part of a grade	Intentionally plan for write-to-learn and reflection opportunities before, during, and after a unit
Find ways to tell the students the content and answered questions students would have.	Provide daily private and public 'negotiation' opportunities for students to wrestle with, share, defend, challenge theirs and others' thinking

and empowered my students. This change was easy to make because I have seen how much it has improved my teaching. I have also been very fortunate to have a very supportive administration who is always supporting the changes I have made in my instruction. I now spend a lot of time with colleagues and others before teaching any new content, talking about what the learning standards say and mean for student

learning, how to organize the classroom environment and design instructional experiences that will provide opportunities for students to learn the standards and doing further research to better support my understanding.

I've Made Changes, So What?

Probably one of the most humbling things I have noticed as I have been involved with the SWH approach is there were days that I just wanted to go back to my 'old ways.' Things would get difficult and I wouldn't know what to do next and it felt hard and too much work to not just turn pages, teach facts and hope kids learn. This change was difficult for my students as well at times. After all, they were nine or ten years old and were very much set in their ways. I was asking them questions they had never been asked before like: Why do you think that? What is another way to solve it? What evidence do you have to back your claim? Not all students were comfortable being asked to publicly share their thinking and participating in discussions; many were much more comfortable with the predictable pattern of reading and answering questions privately. Letting go of myself as the one in charge and allowing students to use inquiry to be in charge of their learning was new and challenging for both myself and the students. Probably one of the most astonishing things I remember is that it was my higher functioning students that were struggling the most. They knew what they knew and didn't know how they knew; it was difficult for them to explain their thinking and they were unaccustomed to being challenged by others. There were times they would flat out get mad at me. It was imperative to build an accepting safe environment from day one. The students had to understand that I would recognize and value all student thinking whether right or wrong. We had to talk about how to disagree respectfully, how to question others, how to be flexible with our thinking, and how to explain our own thinking. This is why I believe this idea of teaching to big ideas is not something that can only happen in a couple isolated subjects. If we are asking students to think in new ways, why not do it all day every day? The SWH approach is not discipline specific nor a set of strategies for certain content areas; it is an approach to the way a teacher and her student operate in the classroom.

So how did I prevent myself from running back to my comfortable methods of teaching? I started to see progress! I started to see students' growth from day to day through their evidence such as their writing samples, self-reflections, and conversations we were having in one on one. I also saw it through school-wide and state assessments. I will always remember the first year I gave my students what is now known as the Iowa Assessments (formally known as the Iowa Test of Basic Skills). I had been utilizing a problem-based instructional approach in class, specifically in math (at that point in time). I remember walking around watching my students and trying to take a peek of the questions my students were facing. I remember the excitement I began feeling as the types of questions were asking for the type of thinking my students were doing each and every day. It wasn't always the

exact skills or facts that I noticed; it was that the questions were more concept-based. After seeing this I asked my students how they felt about the testing experience. I remember reading my students responses and how excited they felt and how they believed that this particular year was so much easier than the past. From that year on, I continued to receive incredible results. In fact, my class proficiency on the Iowa Assessments this year for reading and math was at an 82% while in science and social studies it was at 93% for both subjects. When I analyzed the cognitive levels that my students excelled in the most it included those of conceptual understanding as well as extended reasoning. Other things like acquiring information and evaluating the information proved to be valuable on this test.

My students are asked to take the Northwest Evaluation Association (NWEA), a computer-adapted assessment. The different strands of math are utilized and reported. At the end of the assessment, each student is given a score that is tabulated by their different scores of the strands. The program also provides proficiency scores that students at each grade level should obtain. As my instruction changed, my student growth has been incredible! The one thing I like about this assessment is the test varies according to student understanding. As students move from question to question, the test gives questions based on correct and incorrect answers. The bottom line is that every student at some point encounters a question that has content they have not encountered. It is at this point that students must use their problem solving abilities and concepts and big ideas they have to help them attack the problem. It is students that have this deep understanding that are able to navigate through such difficult content. Year to year I am finding my students more and more prepared to handle unknown content, as they persevere and think critically about what knowledge they can build on and concepts that can transfer to new and unknown situations. On average, each student is expected to grow at least nine points from their fall performance to their spring performance. My students on average experienced 9 points of growth in reading and 12 points of growth in math! This included my identified talented and gifted students. Not only have I seen growth in my students' understanding from day to day, but I have also seen the growth in standardized assessments. The quality of their thinking has just continued to awe me each and every year.

As mentioned above, test scores are just one snapshot of growth I have seen in my students. It is the day to day grind that keeps me plugging away as well. Some of the strongest benefits I have seen from teaching to big ideas and concepts are greater student connections of concepts across content areas, increased student interest, and greater retention of factual knowledge. I mentioned earlier in this chapter about how my students have used the concept of properties/attributes when studying earth materials to better understand the importance of properties when studying geometry. Students also used this understanding in literacy with analyzing literary characters and how their attributes dictate what characters say, do, and think. It is connections like these that become more rooted in their understanding and later help with greater retention.

I have also seen students' interest in what we are learning grow as well. I believe this is true because of the value that is placed on their current understanding from the beginning of any new learning. Students see that they often do already have understanding and problem solving strategies that they are able to connect to and build off of as we are examining the new content. I have seen valuable results in terms of students' motivation and engagement throughout my units by starting from where students are in their understanding rather than where an arbitrary teaching resource suggests I should start. This discovery has been very powerful in math and science, and I also use this approach when teaching my literacy block. A recent example was when students approached the big idea, "Authors help give us clues in our reading to help increase our understanding." Students generated beginning ideas about this big idea and what it means for them as readers. As we explored various fiction and informational text, students considered this big idea and added to their growing understanding of text features, vocabulary cues, and text structure. Based on the beginning ideas, I could tailor my literacy instruction to specific comprehension strategies and features of text. It is when students feel successful that they become more and more interested in what they are learning. It is success stories like these and the excitement that my students demonstrate that help me get through those days when things didn't go exactly the way I was hoping or the days that I spend trying to better understand the concepts so I can help set up a meaningful problem that will help students wrestle with their understanding.

Below is a chart that identifies Iowa Core learning standards, and 'big ideas' that help guide the planning of my units in literacy, science, social studies and math.

Table 12.2. Iowa core learning standards

<i>Iowa Core Standards (4th Grade)</i>	<i>Big Ideas</i>
<i>Reading:</i> Interpret information presented visually, orally, or quantitatively (e.g. charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	Author's use text features to help us, as readers, better understand what we read.
<i>Math:</i> Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	Two dimensional geometric shapes can be described in many ways.
<i>Social Studies:</i> Understand the role of individuals and groups within a society as promoters of change or status quo.	Events of the past have changed the people and our world today.
<i>Science:</i> Understand and apply knowledge of processes and changes on or in the earth's land, oceans, and atmosphere.	Changes of earth can tell us about the past and present.

The Challenges

As with all types of change there have definitely been some challenges which include the ‘pull’ of traditional teaching, lack of resources, and helping parents and students understand the approach. There were times I wanted to go back to my old way of teaching, which was easier and required very little thinking and planning. I just wanted to pull out an old lesson and do the talking and telling. It was after a few deep breaths that I would quickly remind myself that the old way hadn’t resulted in the learning I desire for my students and going back was not what was best for them.

One of the more frustrating challenges I have faced (and at times continue to) is the lack of resources already available to me, whether it was looking for informational text that supported my science or social studies content for our literacy block, or a problem based activity to kick off a new big idea. Gathering good resources is more work at times, but I also quickly learned how to take a spelled-out, directive activity and turn it into an inquiry opportunity. A great example of this is with a multimedia resource I have used before called Science Court. It is like court TV for kids except it is centered around a science topic. They have always been very entertaining for the kids and motivating. However, I didn’t feel like they really gave the kids a chance to wrestle with the concepts at hand. I did find that with some small tweaking that I was able to give my students a small piece of the daily court session and get them investigating. It was after my students had come up with their own ideas and claims that we then watched the clip for the day. This enabled my students to compare their information with the experts and negotiate their thinking before watching the clips. It is small adjustments like these that a mediocre, teacher directed type of activity could become more inquiry and student based. I also found that contacting my Area Education Agency and our science consultant also helped me obtain the resources I needed to implement my unit.

Another potential challenge with the conceptual approach to teaching is with parent involvement and communication. Many parents (and some students) are uncomfortable without worksheets and quizzes/tests that appear to assure parents students are learning. This discomfort comes from a history of teaching and telling and paperwork as an accepted method of teaching. My classroom doesn’t look this way, and as I understand changes I’ve made teaching this way, I am better prepared to communicate with parents about what they can expect in my classroom. Taking a proactive approach to involving parents in expectations for what and how students will learn in my classroom has helped bridge the gap between how my students’ parents learned and how their children are learning today in my classroom.

While these challenges are at times very daunting, knowing that this is what is best for kids in my classroom make it worth the extra effort. Through the SWH approach, I strive to provide daily opportunities of challenge for my students so they are better learners and equipped with the thinking and problem solving skills necessary for their school career and in life.

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13. QUESTIONS AND THE ROLE OF LANGUAGE IN OUR TEACHING

BEGINNING THE JOURNEY...

It has been said that a journey of a thousand miles begins with a single step. Some take that first step eagerly and jump right on the path to begin the journey. Others start the journey slowly and with great trepidation, dragging their feet down the path. Whether one begins eagerly or apprehensively, using the SWH approach to teaching and learning is definitely a journey. Here is the story of our journey.

Six years ago, it was suggested that we might be interested in joining a grant focusing on the Science Writing Heuristic Approach, because we participated in Every Child Reads and Six + 1 Traits of Writing during professional development for several years. At this point, two of us, one a fourth-grade teacher (Veronica) and one a fifth-grade teacher (Peggy), both educators with very different Science backgrounds, decided to join and become part of the grant. This grant started us on our journey with SWH.

Our experiences in science as students and as teachers before beginning our SWH journey truly could be categorized as falling on a wide spectrum. On one end of the spectrum you would find me, Peggy. Science has always been a favorite subject of mine, thanks to great high school science teachers of my own. When I became a 5th grade teacher, I was expecting to be able to make science exciting.

Until I became a part of the SWH grant group six years ago, I felt I wasn't able to make science as exciting as it should be because we just used a textbook and teacher directed experiments. When I first started using the SWH approach, it was mainly about science, but as I continued to be part of a second grant, the writing became a much bigger part of science and other subjects daily. The idea that "There is no science without language" truly became a reality for me. The combination of writing and science has shown me so much more of what my students are learning. I use an acrostic poem at the end of the unit called "The Human Body." Each student is to write any information from our unit that can fit into the letters. This gives the students opportunity to write about a variety of things they learned. It gives me a chance to see what pieces of information they found most interesting by how often they appeared in the student's writing. It also gives me a chance to see what information they pick up in our everyday conversations. It might be from discussions

while adding to the concept map or during negotiations when information that was found while consulting experts is shared. For example, one student wrote about how the liver can regenerate. This information came one day in a class discussion on the digestive system as a “Fun Fact.” He was able to share this because I used an acrostic poem for assessment. If I didn’t give them the opportunity to share their learning with writing, he wouldn’t have been able to share that piece of learning. If I had given a traditional assessment, that piece of information wasn’t a “need to know” question that would have been asked on a test. I also found out how well they retain information throughout the whole unit. This unit usually takes the second semester to complete. They showed their understanding in the differences in the veins, arteries, and capillaries elaborating that a bruise is made by a broken capillary. Other details coming from the circulatory system that were included were how red blood cells give blood its color and are made in the bones in the bone marrow. They also could tell about the components of blood and what each part does for the body. This is so much more than I would have found out in a multiple-choice test. I couldn’t get this much information without giving a test several pages long, which is something that would intimidate many students and not show their true learning.

Names of bones and muscles were also learned during P.E. class as they stretched and warmed up each day, which were also shared on their test. An acrostic poem is a great way for students to show that they are in charge of their learning (see [Figure 13.1](#)).

Moving toward the other end of the spectrum, you would find me...Veronica. Science was never my forte, so I was, admittedly, a little hesitant to begin. However, I knew I needed to do something in order to get over my dislike for science. Maybe I shouldn’t say that I disliked science, it was more that I felt it was very boring, especially to teach. In my classroom before beginning SWH, we would read out of the book and do a worksheet. Any experiments done in class would be demonstrated by me in front of the entire class. The students had very little control over what happened in class. Why should they? I was the teacher, so I should be in charge of their learning, right? Then, after a few lessons in the book, we would take a test and move on to the next topic. By fourth grade, students knew which topic was coming next because they had studied each one during the prior years, so we would just add a little bit to their previous knowledge. Science became the subject that I was willing to skip if we needed extra time in another area. While I definitely felt overwhelmed when I first started with SWH, that overwhelming feeling quickly turned to excitement. Now, I can’t imagine teaching science any other way. In addition, my students don’t want to learn science in any other way. They especially love the experiment days, which, by the way, *they* are in control of, not me.

This is where my story starts. My name is Denise and as a special education teacher, I already knew SWH was an avenue for the students on my roster to achieve success in science. Three years ago, at the end of the first grant that Peggy and Veronica participated in, we were asked about our interest in applying to be part of an IES SWH grant. This grant provided a unique opportunity in that teachers of students with IEPs were asked to join in the professional learning experiences and

QUESTIONS AND THE ROLE OF LANGUAGE IN OUR TEACHING

Throat - The throat is a muscular tube that squeezes food to the stomach.
 Heart - The heart has four different chambers, little doors let blood in and out of them.
 Digestive - This system consists of the stomach, the esophagus, small intestine, and the large intestine.
 The veins - These are like small tubes. They carry blood which is full of carbon dioxide and other bad stuff.
 Blue veins - These veins may appear blue, but are not. The carbon dioxide gave it the appearance.
 Muscle - Without muscle, we couldn't move. The muscle gives us the strength to lift a pencil.
 Arteries - These are the opposite of veins, they are thick and carry oxygen rich blood.
 Nerves - If you are cut, these tell you that it hurts. Nerves give you feeling.
 Bruise - When you get a bruise, it means you broke a capillary. Capillaries are bridges between veins and arteries.
 Red blood cells - These give your blood its color. They are also made in the bones because of bone marrow.
 Systems in the body - There are 7 systems in the body, the circulatory, respiratory, urinary, nervous, muscular, skeletal, and digestive.

Figure 13.1. Student acrostic poem

plan collaboratively to support the SWH process for students with special learning needs. A few years before my journey into this approach, I had a special education fifth grade student who showed her science teacher how to make a complete circuit. It was amazing for this student to be able to show this information and explain it with just a few words. There was no way for her to adequately write the information explaining the concept. It would be difficult for her to talk about it without being able to show it. I was on board for others to teach using this approach, just not me, oh no, not me.

So, you could truly say that in terms of science, I was completely at the opposite end of the science spectrum. As a special education teacher, I did not think I would EVER have to do anything with science. Science has never been an area of strength or confidence for me. When I was approached by the teachers in our building, who were a part of the SWH group, to join them, I thought they were crazy. I was a special education teacher helping students with language and math, not science.... how could I be involved? However, after much consideration, encouragement and ultimately knowing that if I joined them, as a school, we could apply to be one of the

treatment/control schools. In so doing, our school would be awarded money from the grant to be used for Science materials. Finally, with a really big sigh, thinking this could be a waste of my time, but trying to be a team player, I consented, beginning my adventure into the world of SWH.

When the treatment schools were brought together, the special education teachers were all wondering how we could use this information and still complete our IEP goals. We asked for meeting time with each other, with the people doing the teaching, and time to discuss. Allowances in time were given for the special education teachers to meet. It was extremely valuable as we were able to ask questions of those who had more knowledge than most of us did. As a group of special education teachers, we brainstormed with each other. Some of the teachers had some great tried and true ideas that they had used and we revised some of the approaches they discussed. From there, other ideas came out. I think most of us felt a lot more confident about using this approach to help our students achieve their IEP goals.

One thing that was very helpful for me was to observe in the classrooms using the SWH approach, and then participate in the large group discussions, asking clarification questions or restating the points the students and classroom teacher were making.

Negotiation

Negotiation is at the heart of the SWH approach. The SWH is an argument based inquiry approach to teaching and learning. We are constantly negotiating. Let's look now at our journey with negotiation. As teachers, we are constantly refining how we ask students to participate in public negotiation, especially during the sharing of claims and evidence.

Last year in 5th grade, I had a class that liked to argue during sharing of claims and evidence. They would point out grammatical things to question or argue, not to determine if the claim had enough support in terms of the evidence provided. They just seemed to enjoy telling someone they were wrong, even if their information was similar to their own. They just wanted to argue for the sake of arguing, not to truly negotiate with their classmates. So, I knew I had to find a different way to share out that would be productive and help them understand the question we were working on.

As a result this year, I decided to use information we learned in our summer SWH professional learning classes. We spent time sharing claims and evidence of our own which looked different with a group of adults than students. As adults, we were able to discuss in a large group without having to raise our hands or go around in a circle sharing one group at a time. Someone would start by telling what they discovered in the investigation, and then someone would add to that group's findings. It continued where groups would add things that were similar or add how they found out something different. If more than one person started to talk, one would back out and wait until the first person was done talking.

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Our group looked and sounded more like a literature circle. This is something we do regularly in reading class, so I thought I would remind them how we talk and listen to each other in reading and use it in science to interact with each other. I talked about how our adult group looked when we shared out. Literature circles are used throughout our building starting at an early age, so this was something they could relate to previous learning.

Additionally, in years past I would have one group stand up front and share their claim and evidence to the rest of the class. Students spent more time asking if others could repeat their claim or evidence, rather than focusing on the actual content of the claim and evidence. When that wasn't successful, I tried writing their claims on the board while they said them, so we could see the claims of each group. That worked better, but then we would have to repeat our evidence so they could remember what the group said. This year I took the idea from our summer class about a gallery walk. In a gallery walk, you post your claims and evidence around the room and the groups go around to each one. As students are walking, they stop and read each poster and then write questions or comments in their journal that they want to ask that group. In this way, we don't have to repeat claims and evidence statements over and over.

This activity was more successful than having one group stand up and talk one at a time. This kept everyone active and more focused since there is one group at each poster. Even though students were more actively involved, one problem we had was the number of students in the class and the physical space we had available to use as a result. We found there wasn't enough space to post the claims and evidence around the room and have up to 8 groups of students moving around. I had the students sit in a large circle with the people they worked with, and we passed the papers around the circle. Each group was able to read the posters and write comments in their journals, but we didn't have the congestion of 26 students walking around the room. When the posters were back to the owner, we started the oral discussion about the claims and evidence they read. They had information in their journals they could refer to and we didn't have to repeat everything that was said several times. A critical piece to this process, I believe was that I gave them phrases they could use to help them with their claims and evidence sharing, such as: "Something we found that is similar to yours" or "In our experiment we found _____ which is different than yours." Having them find likenesses and differences took away putting people on the spot about saying a wrong word or a different word than another group used. When we came to the end of the class period we could summarize by listing all the things we heard that were similar. That also gave us a place to start the next day trying to find out why we had different results. This brought the focus to answering the question we were working on versus looking to make someone wrong. It sounded more like a "Dinner Table Conversation."

In my fourth grade room, I found that the idea of gallery walks worked very well, due to the fact that it was a fairly small class. During most experiments, students were divided into four small groups of four. Students were able to read other groups' posters in a relatively short amount of time and find similarities/differences to their

own group's findings. Like Peggy, I would try to help students by asking them to find outcomes that were the same with another group. If students disagreed with another group, they had to explain why they disagreed. They couldn't just say, "I don't agree with you," and leave it at that. Previously, we didn't focus on those similarities and differences to as much extent.

Dinner table style "conversations" as explained above by Peggy, were helpful to the fourth graders as well. Students tended to be more willing to share their ideas when they knew other kids weren't going to pounce on them if they said something wrong. They felt comfortable contributing to the conversation, instead of just sitting back and letting the "smart" kids talk about it. While it took a little while for kids to fully grasp this idea, once they did, it helped our conversations run smoothly. Students were able to discuss and negotiate science concepts, not each other. This becomes a time when more timid students may gain the confidence they need to come out of their shells, as it may be, and really feel like they are contributing to the class. For example, I had one student this past year who was always nervous about being wrong. She got embarrassed and cried very easily. She tended to be a peace maker among the students, because she did not like confrontations. She was very smart in science, however. At the beginning of the year, she focused more on "keeping the peace" rather than sharing her own ideas. As the year progressed, she became more assertive and willing to share her thoughts and feelings. By the end of the year, she became a leader among those small groups. She no longer sat back and let the others in the group speak for her. She would start the sharing out process herself. It was a huge confidence booster for this student, which carried over into other content areas.

Supporting Students on their SWH Journey

As teachers and as learners, we know the importance of activating our background knowledge, our current understanding, of any big idea. In some cases, especially for our students with special needs, it is important to provide additional opportunities to build that background knowledge in both language and science.

Providing support for that background knowledge and supporting students with their language skills (reading and writing especially) was important for me, Denise, as the special education teacher. As I talked about earlier, the collaboration with other teachers through our professional learning opportunities was very helpful both to me and for my students.

One idea I gleaned from another special education teacher, Roxy, made use of the Picture Word Inductive Model or PWIM (Calhoun, 1999). I collaborated with the classroom teacher concerning the upcoming unit on forces and motion. This particular unit was always a challenge for me personally, so this was going to be major learning on my part as well. We discussed words that were common for this unit. The students and I wrote our ideas of what each meant on paper, then collaborated to write a sentence on a poster. We took turns looking the words up, collaborating again. We needed to come to consensus about what the word meant,

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which took some discussion. We used read alouds and think alouds to add to our knowledge base before we could do our second writing on the poster. We wrote that definition on the same poster with a different color. We then used the vocabulary to find examples on a PWIM poster. This process gave the students a better background when the unit started in class. They said they liked this and felt like they knew some of the information being discussed in science class. They were eager to share the books we had used as their experts.

Another struggle for students with special needs (and really all students) was summarizing their learning after they “asked the experts.” The special education students were having difficulty summarizing their reading. They would copy out of the book and state insignificant details and think they had summarized the chapter. I asked the literacy consultant from the AEA, Lynn Hockenberry, to come into my classroom and help me with some ideas on how to teach summarizing. She showed the students and myself how to use the GIST (Generating Ideas between Schema and Text) (Cunningham, 1982) approach. A GIST uses 15 or less words to retell something. Lynn used the current science unit being taught in the fifth grade for her read alouds and think alouds. Over the course of the week, Lynn modeled for students how to create several GIST statements (see [Figure 13.2](#)). Next, they did some together, and finally the students worked some out alone using their readings. The discussion between the students of which were the most important concepts was interesting and eventually they came to consensus. The students and I practiced this and they became quite good at finding the main points of passages whether it was in reading, social studies, or science. This support had a carry-over effect in the classroom as well. The fifth-grade teacher and I discussed how well this was going for the students we shared and how the boys’ confidence was soaring in several areas, not just summarizing in reading. This was helping them become more effective in the classroom when working on summarizing in other subject areas.

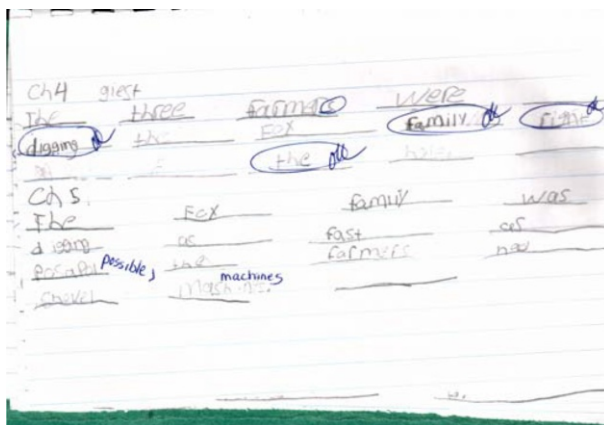


Figure 13.2. Students' GIST

Ask the Experts

Of course, as mentioned earlier, it's not just students with IEPs who need support, all students do at one point or another. In the SWH approach when students "ask the experts" and use the reading framework, there are often many students who struggle. This is a perfect opportunity for "just in time" instruction integrating language and science.

Many of our fifth-grade students were struggling with summarizing what they had learned from the text, which made it especially difficult to compare and contrast the differences between what the experts said and their own claims. Denise told me, Peggy, about GIST and how it was helping several of my students already and we decided to "give it a go" in the general education classroom as well.

Peggy and Denise started by reading the same short article and highlighting the information we found most important. We then made 15 blank lines. We wrote one word on each blank to create a sentence. It was interesting to see that our GISTs were different, but showed the important message of the article. We had the students work with a partner to come up with a GIST also. We then compared ours to the students by writing them all on the board and found what they had in common. Even though they weren't the exact words, the meanings of the sentences were similar. The fifth-grade special education students felt like experts because they understood the process while the fifth-grade teacher and I co-taught the GIST approach. The other students asked questions of the special education students because they could see they knew the approach.

The GIST approach helped all of the students when writing summaries across the curriculum. It particularly helped the special education students when writing their reading summaries and the note cards for their research papers.

Because of the success in science and social studies, we started using GIST in reading with the whole 5th grade classroom. I wanted to get the students to write summary sentences to help them to use the most important information without writing two pages of material. Typically, student summaries might be just two sentences written directly from the story they were reading or might be two pages telling every little detail of the story.

Although we originally thought that using the GIST would just be helpful for summarizing, we found that there was an added bonus. We have found that when writing claims in science, students have a hard time just writing a claim without including the evidence. After working on GIST, a couple students wrote their claim in a GIST. This was eye opening to me, I never thought about GIST being helpful in writing claims. When the students wrote their claims it reduced the number of words they used and I helped keep them from writing the evidence as part of the claim, which is something I have found as a regular problem with students writing their claims.

Because of the success of this collaboration and use of this strategy to help with summarizing, plans have been made for the special education teacher and the fourth grade teacher to co-teach the GIST approach at the beginning of the coming school year.

Assessing Students and Summary Writing

Through our SWH professional learning we began to think about the ways we assess students and think about the ways in which we ask students to show us evidence of their learning. In my fifth grade classroom, assessments in the past were a multiple choice, fill in the blank test, where I was the one who determined what was to be learned by every student. Since I have been focusing on including more writing in science I use multiple assessments throughout the unit, not just a big test at the end of the unit. Creative writing has a place in science too. While studying about the digestive system I had the students write as if they were a piece of pizza going through the digestive path (see [Figure 13.3](#)). This gave me a chance to see which students only picked up the very basic part of the digestive system-naming the major organs and a little about what happened in them, compared to the students that picked up considerably more information including what takes place in the liver, gallbladder and the pancreas. Had I asked multiple choice or even fill in the blank questions, I would have only found out the same information from every student in the class.

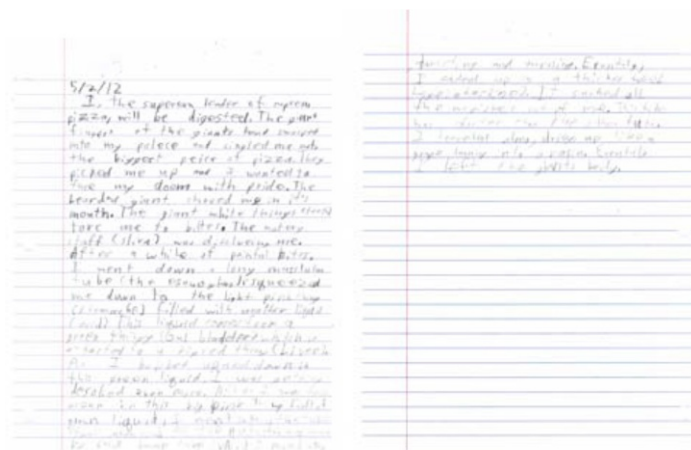


Figure 13.3. Student digestive tract explanations

Another example of an assessment in this unit was the end of the unit assessment. This assessment was an acrostic “The Human Body.” Once again, the information I found that students picked up on was different, but yet I know they learned the “need to know,” but what I found out was from “the want to know,” which was amazing (return to [Figure 13.1](#) for example). Since the students are in charge of their learning, shouldn’t they be able to show what they learned?

In my fourth-grade classroom, students used a different way to demonstrate their learning. This year’s class was very artistic, so they preferred to use drawings to show their findings in their journals and when sharing out their claims/evidence.

They found it easier to explain what they had drawn to each other, rather than to find the exact terminology they knew they needed. Once they were finished negotiating their pictures, the small groups could help each other find the terminology they were seeking. This use of pictures for claims/evidence then transitioned into their assessments. They could use the idea of “show, rather than tell” to demonstrate their knowledge. One example of this was in the beginning of the year when we were studying earth materials. Students were more comfortable with showing the difference in three types of rock when they could draw what they had seen (see Figure 13.4).

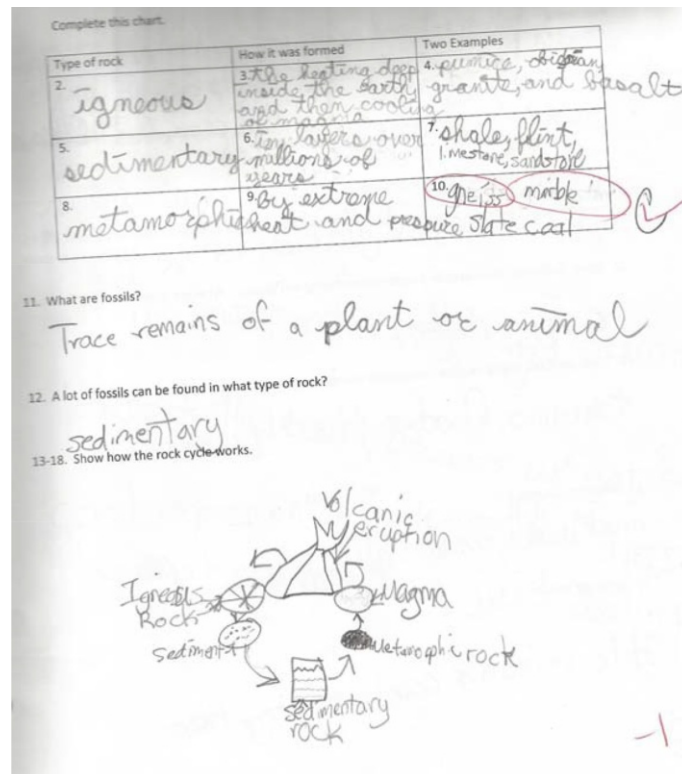
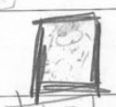


Figure 13.4. Rock cycle

When learning about erosion during this unit, students were also able to draw their observations of what happened to sand in a tray when water was poured on the tray (see Figure 13.5). The tray was moved to different heights before the water was poured.

At the end of the unit, they were also able to share their learning with the second graders, who had also been studying earth materials at the same time and with the fifth graders, who hadn't had the opportunity to study this unit at all. The fourth graders set up mini museum exhibits in our multi-purpose room, where they could

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Observations/Results:			
Height of Tray	How quickly did the water flow?	What happened to the sand?	Draw what you saw.
2 inches	slow	It Rloped and it was	
3 inches	faster	It showed more track	
4 inches	fastest	it washed down	

Conclusions:	
Erosion cracks the earth. the higher the land is the more damage the erosion makes.	

Figure 13.5. Erosion drawings.

each focus on a different aspect of earth materials. Some groups had interactive activities they had created, while others made slideshows to share.

Still others created mini models for their exhibits or brought in examples of fossils to share. It was a great opportunity for the kids to show others what they had learned throughout the course of the unit, using mediums where they felt most comfortable. All of the students were quite proud of their work.

Next Steps in Our Journey

At the beginning of the next school year, the GIST strategy will be taught in both fourth and fifth grade. We hope that this summarizing strategy will help students when writing claims and evidence, as well as when they summarize in other content areas. We have realized during the last few years how strategies from literacy naturally blend and fit with our science content. We plan to use more read alouds and talk alouds to help with background knowledge, to compare and contrast with our claims and evidence and to further student negotiation with the big idea.

Ideally, we would love to collaborate at least once a week as well. This would enable us to share new ideas, brainstorm possible activities and concepts, discuss what has been working or not working in the classrooms, and share information to use

for pre-teaching with IEP students. Realistically, we know that scheduling may not allow for us to collaborate every week, but we all know we have to make the effort to meet at least twice a month. Knowing how language has helped students demonstrate their learning in science, we want to move this forward into other curricular areas, especially math. We already use some of the SWH vocabulary in other curricular areas, such as claim and evidence. When looking at difference problems in math, students will need to make a claim about how to solve the problem and then provide evidence. In 5th grade when working with placing decimals in multiplication and division problems students will look at several problems with decimals placed in the answers correctly. Then they will make a claim about where the decimal was placed instead of the teacher telling them where it is placed. Fourth grade students also use claims and evidence in math. When given different multiplication and division problems, students work on their own to find the product or quotient before negotiating in their small groups to come up with their group claim. All groups then have the opportunity to share their claims and evidence with the rest of the class. If any of the small groups don't agree with the rest of the groups, the class then negotiates until they reach a consensus. However, we want it to become more constant in our daily routines. Our hope is that by having students explain their thinking and negotiation their understanding through writing and discussion that we will see a correlation in the understanding of number sense in mathematics, just as we have seen an increase in their understanding of science content.

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14. STUDENT NEGOTIATIONS

TRACY

For years in my 5th grade classroom, I have known that teaching from a textbook was not for me or for my students. My students were not excited about learning, engaged in the content, or eager to embrace new ideas. They simply sat and waited for me to tell them what we were doing and how to do it. I would give them a worksheet and they would start searching for the answers they thought were right, not paying much attention to what they were learning, but only hoping they got the answer right and received a good grade. I tried to deviate from the book whenever possible, but found myself returning to make sure we were getting to what the book said. Needless to say, myself and my students needed a science facelift, but without the right tools and training, I did not know what that facelift would look like.

It was about five years ago when a colleague of mine asked me to join her and become a part of the Iowa science initiative Every Learner Inquires (ELI). It was through ELI that I found validation in not using the textbook, but I still needed more. The facelift for science was complete when our elementary school in grades 3–5 began learning and implementing the SWH (Science Writing Heuristic) approach for science learning. What I did not know is that it would change the way I teach across the curriculum and not just the way I approach learning in science.

For me, it was sink or swim with starting SWH. I chose to swim, so I jumped head first and was amazed at what a difference there was in student engagement when I turned the learning over to them. It was quite a rush watching students learn. Yes, for the first time I was actually watching my students learn and not just look for the answer they thought I wanted; I knew this was what I had been missing all along, students choosing the path of their learning instead of me telling them what to remember or memorize for the test. When you actually give students the opportunity and power to take charge of their own learning, it is truly amazing how far they will take it without even being told. I was amazed at how it only took me asking an essential question to engage them in conversation about their current understanding of the content which led to natural discussions in their small groups.

Natural discussion was good, but it did not go to the depth that I wanted it to. I really wanted students to start challenging one another's thinking. It was my deeper understanding of "negotiations" as part of the SWH process and how to implement that component that really allowed my students to go to that next level of learning and understanding. This did not come without trial and error to the students, but over

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time their communication skills and critical thinking improved. I would say that we still have a long way to go, but with each year as the students come into my fifth-grade classroom having background in the SWH approach, it gets better and better.

ANNE

This is where Tracy brought me into the picture – she asked me if I would be interested in training in a “new” way of teaching science in 4th grade. Since I’m up for about anything that will improve student learning, and I, like Tracy, was frustrated with textbook teaching I figured I had little to lose! Plus, in all honesty, it helps when the person that is asking you is someone that you enjoy working with and that you have deep, professional respect for. Also, like Tracy, I pretty much jumped in head-first. Much of the terminology was new to me – Big Idea, Essential Questions, Negotiations ... I knew what the individual words meant, but hadn’t given much thought to how they related to teaching and more importantly, to *learning*.

When I think of what it means to *negotiate* I think it means to discuss – an opening of a dialogue, to share ideas – to barter information in a way... We all use our prior understanding of things to help us learn about new things – either to relate to something familiar, to compare and contrast, etc. We can have this dialogue within our own thinking on a strictly personal level as well as in a discussion involving others. Getting students to think about their own thinking is a pretty BIG idea in itself, it takes time, patience, modeling, opportunity, modeling, modeling, and yes, more modeling!

TRACY

When I ask myself, ‘What does negotiation mean to me?’ I really have to stop, think, and have a personal negotiation with myself about that idea. The best way I can explain negotiation and how I get the concept across to my students is explaining it as thinking, discussing, and arguing about the meaning of a concept. The students really come alive when I use the word “argue.”

All students have some level of prior knowledge when a new concept is introduced. The prior knowledge that the students have is theirs, right or wrong, and that leads to great negotiations. I believe students personally negotiate every time they answer a question or make a decision. Labeling this process for the students and letting them process the concept that they have naturally negotiated their whole life is what allowed that process to happen and develop in the classroom. Negotiations could be verbal or written. The main idea behind negotiations is simply getting your ideas out there, having dialogue, and questioning.

ANNE

Negotiations in the classroom really are quite similar. Students come into my 4th grade classroom with varied levels of understanding on everything. For many kids,

it's a natural process for them to gather information, they've been using this since they began speaking and making sense of their world; for others, it's a process that needs to be modeled and practiced extensively. Many kids have strong prior knowledge on concepts while others have never given scientific thinking any real thought – but they all have ideas. I can pose a question and on any given day get 20 different answers from 20 different students. But are there really that many answers? Most times – no, but their ideas are valid and very real, but may lack clear evidence or data of any kind to support it. But how do you get students to come to that understanding on their own? Certainly, we don't want to just tell them what the answer is; nor do we really want them to simply read the answer out of the textbook. Learning is a process and *NEGOTIATING* is a fun, active way to get students thinking about their understanding of concepts and discussing their ideas with each other.

If I posted the question “How does a planet's orbits affect the length its year?” I will, without a doubt have some students that have an understanding of what the word orbit means, but little else. Some will have memorized the names and order of the planets, and a few might even know that plants have years that are longer/shorter than others. So how do we begin to answer that question? I would first open the discussion up to “What does orbit mean?” The discussion that ensues is a negotiation. They may use textbooks or reference books/technology to find supportive evidence – but it is a discussion of ideas shared between the learners. All the while the discussion is going on, my students that may not even have much to say are gathering information – rationalizing, questioning, interpreting, yes, learning!

TRACY

Getting students to talk is not hard, they love to talk! The problem is keeping their conversations focused on the topic at hand. Kids want to talk all the time and then when you give them something to talk about, they clam up. I believe their natural instinct to question and negotiate everything is squelched when they enter school. As an education community, we train them to sit and listen and to only speak when raising a hand and hand out consequences when our rules are not followed. Trying to retrain them when they get to fifth grade is sometimes a challenge, but as they get the SWH process more in the lower grades it has become easier. I have noticed that they still look for me for validation when they comment or question a peer about a claim or evidence that has been made. Modeling the negotiation process is something I find myself doing often. Some kids are natural communicators, but others need a lot of encouragement. I find encouraging them has helped when we are negotiating and the conversations are more directed to me by using the following prompts:

- “So what I heard you say to (name) is (and repeat students' words)”
- “I think you are talking to (name), maybe you should ask them”
- “Are you asking me, because I think (name) is the one you really need to ask. It was his evidence.”

ANNE

Trying to get kids to realize that being right is not as important as what happens throughout the learning process is sometimes difficult. When students come into the classroom in August and are asked to record their initial thoughts for negotiation down on paper without having been taught about the concept at hand, they look at me like I am crazy. We want them to feel comfortable sharing their ideas, but their concerns are that if they are not right it will affect their grade. For most students, they are fine with sharing their ideas if they know they are right, but taking that risk and setting themselves up to the vulnerability of other students is not something that comes naturally. We have found that starting this process in a small group setting is more comfortable for all and allows them the opportunity to practice taking risks in an unthreatening situation. By May, we have seen an enormous amount of growth and students are becoming more comfortable sharing during negotiations. However, this is still such an unfamiliar style of learning by the time we get them in 4th and 5th grade.

TRACY

This was and is not only hard for the students but also for myself as the teacher. Naturally when something is stated incorrectly I want to jump in and correct. Learning to step back and wait for the students to pick up on the incorrect data has been a learning experience for myself as well. I have found that the majority of the time they will catch it and that is fun to see.

One other struggle with getting kids to talk with each other and not at each other has been learning how to respect others' opinions. Kids see their way of thinking as being the only possible correct answer. Teaching/modeling that there could possibly be more than one correct answer or that their answer is wrong is a constant battle with their egocentric way of thinking. Modeling by giving them appropriate ways to disagree has been positive. The following phrases are common language that we try to use across grade levels.

- "I understand what you're saying, but I really think it's ..."
- "I disagree with what you said, because I know ..."
- "So you're saying ..."
- "Can you tell me more about that?"

ANNE

Getting kids to talk *with each other* and not *at each other* is tricky and I feel the most challenging part of the negotiation process. In many ways, they come into 4th grade "trained" to prove their knowledge to me directly. It's been an ongoing struggle to remove myself from their negotiations. Their age and immaturity often makes them egocentric and so without even responding to what someone has just said,

they simply state what they think. For 4th graders, negotiations tend to be focused more on *competitiveness than on cooperation*. With that said, it must be reiterated that negotiating is not compromising, but a sharing of information and knowledge to gain a deeper understanding. I think it takes a tremendous amount of modeling – true conversation is an open, back and forth dialogue and a give and take of information, but so often their discussions are one-sided and focused on stating their opinions only; they say what they think and then they're done!

We practice using phrases such as:

- “I understand what you’re saying, but I really think it’s ...”
- “I disagree with what you said, because I know ...”
- “So you’re saying ...”
- “Can you tell me more about that?”

I’ve had several lessons where I asked students to write down their ideas and to explain their thinking— then in small groups or partners they share what they wrote – they then have to think of one or two GOOD, THICK questions to ask the other person about what they read. This helps in encouraging them to really give what other people think serious consideration. I’ve also had students share their ideas and then the partner has to explain what the other person’s ideas/thoughts are.

I was partners with Jane. Jane said that she thinks the longer it takes for a planet to orbit the sun the longer its year is. If it orbits the sun faster, it has a shorter year.

Having kids listen and paraphrase is one way to get them to think and listen to what someone else says. Asking them to question their ideas leads them to internalizing the thoughts and in turn either agree with or discredit the idea.

It takes extensive modeling of talking with and not at – I know adults that don’t have this skill! If it’s modeled and encouraged/praised, it will become an integral part of their learning process. Initially, I find that the students that normally have much to say are the ones that do most of the talking. There are just some kids that have more confidence and background knowledge in science so they are far more comfortable sharing and they tend to dominate the negotiation process when it’s first introduced. I think that’s why it’s important to integrate writing and even drawing into the negotiations, it opens a door to the more quiet and unsure students to share their ideas. Placing kids in smaller groups or partners also helps with anxiety that some kids have talking in front of the whole class. Through small group discussions they may realize that there are others like them that maybe have limited understanding but still have valid ideas. They get more comfortable at the same time gaining useful knowledge. As their teacher, I really feel that it’s my job to take the time to have small, but important discussions with these small groups – once they have some validation confidence levels soar and over time, the quiet ones begin to speak up. I have had to force my hand a few times, in one small group discussion, a student

shared an idea with me about density and sinking/floating. When we all reconvened into the large group, I asked if anyone had something to share – new ideas? Of course, there were the talkers, the sharers ... but this one still said nothing. Finally, I said, “Jerry, I heard you say something about density and its relationship to sinking/floating. Would you please share it with the rest of the class?” I figure, as the teacher, it’s my prerogative and job to push them out of their comfortzones a bit!

TRACY

Beginning the SWH process was not easy; it was a lot of work. Using this process is not like anything I had ever done before. I came upon many roadblocks that made me continually ask myself, “Why am I doing this?” The hardest part of the process was just getting started. Taking that first initial leap away from what you have always known is quite scary, especially when you are doubting yourself and wondering if you really know everything you need to fully begin implementing something so different. Getting rid of the textbook was the easiest part for me. I have found a better use for them and the students do not even mind getting them off the shelf for answering questions during our “Force and Motion” unit. The major difficulty has been with time, student questioning, grading, and assessing student learning.

Time has always been a struggle for me when it comes to fitting in the whole curriculum into the 180-day school year calendar. Even though I now only have four “Big Ideas” in science to cover, time still is a factor. At first I thought to myself, “How will only teaching four concepts fill up my year?” I can honestly say that now that I am teaching for deep conceptual learning, I no longer have the concerns about filling my time for science. My new concern is not filling the time, but fitting their learning into those 180 days. There are times when our negotiations can last for three days or more. Sometimes I have to wrap it up just because of time.

I would have to say the next of the biggest struggles has been with students’ questions. At this age their questions are thin rather than thick, and they are more of a fun to know/nice to know rather than need to know in order to understand our “Big Idea” and take their learning to the next level. This has been a professional growth goal of my own for the past three years. I have modeled and provided mini lessons on deep question writing, but I still feel that this area is the weakest for my students and myself. I even find myself struggling with helping kids take their “thin” questions and turn them into “thick,” deep questions that will help the kids make those deep conceptual connections back to the big idea. I continue to work on this and find that it is usually my “thick” questions that become the essential questions and their questions become their researchable questions in the computer lab. We then have small group table talk about their personal questions and answers.

The final area that I find to be my largest struggle is grading. The district I teach in is very grade driven, and I find it difficult to attach a letter grade to many of the learning opportunities that are provided in my classroom. I see proficiencies

and non-proficiencies, but during the learning process, a letter grade is not always the assessment I have in mind. We have discussed this at many of our planning meetings and have thrown out the ideas of rubrics, checklists, and other types of assessment, but I do not feel those justify a letter grade either. I know that grades are important to a large number of schools, communities, and students. However, I think grades sometimes give kids the wrong idea about learning. Kids put a lot of emphasis on grades and at our level I want kids to be encouraged to strive for learning, not an “A.”

I will say that after several years of implementation it has been worth all the struggles, frustrations, and effort in the form of countless hours of planning. I am not in any way saying that my struggles are over, but they have become less frequent and not so intimidating to conquer. I have wonderful support system in staff that is also implementing the SWH process. When I come upon one of the roadblocks I know help is just down the hall in a valued and trusted colleague that has been with me on every step of this journey. Even though we do not teach the same grade level, we are always bouncing ideas off one another and usually find answers to our struggles in the office, hallway, or after school.

ANNE

I have to be honest, it has been a struggle at times. Questioning and deep-conceptual thinking are not traits I would identify as my strengths as a teacher, sad to say, but very true. In many ways, I’m in the same boat as my 4th graders – I have to question myself “Why do I think this?” “What evidence do I have that supports my idea?” I also know that I am a learner that learns through conversations – that probably explains why on-line classes are so hard for me. I need to hear ideas and questions from other learners – questions that I would have never thought to ask, ideas I hadn’t thought of ... certainly if I learn better this way (negotiating), some (most) of my students do, too. I also needed to learn to stop talking and lecturing ... Gone are the days of me standing in front of the room with my teacher’s manual giving a lesson, explaining why, or how. There’s an old saying about giving someone a fish and they eat for a day – teach them to fish and they eat for the rest of their life. Really, teaching is similar. If I tell you, and you read it out of a book and then fill in the pre-made worksheet that corresponds to the book, you might remember it. But if you have the opportunity to discuss, debate, research, share, get passionate about what you know, you are far more likely to create a deep relationship with that knowledge and take that far beyond the classroom door. What has helped me the most, without a doubt, was having someone nearby that was implementing this process too. It was a comfort to know that I could walk right down the hall and find a colleague that I respect and that I could have my own negotiations with.

TRACY

I would say 99 percent of my students find learning science using the SWH process to be so much better than traditional book learning. My students enter the classroom each day and immediately have questions about what they will be learning today and how they will be learning. We often run out of time and their comments are always, “Wow, science class goes by so fast!” My response is always the same, “Time flies when you’re having fun, and we are always having fun and learning.” They simply agree and head out the door for their next class, but are always asking if they can just stay in science all morning. That is confirmation for me that what I am doing is working and they are loving science.

One of my former students (my daughter) once said to me, “The way you teach science is so much better than learning from a book. It is hands on, makes us think more, and lets the kids teach you. Other teachers who teach from the book have students look for the one right answer and if they don’t find that one answer, even though there could be more than one, in the book it is counted wrong. The teacher then tells you the answer you should have had, sometimes, and we didn’t learn a thing. We then just memorize facts they tell us for a test.” This was another validation from my daughter that encouraged me to continue to become the best I can at using this process.

Now for that one percent that prefer traditional type learning. I do believe they change their mind in the long run, but for a while it is a battle and I get comments like, “Can’t we do a worksheet?”, or “Do you have a video for us to watch?” I think that way of learning is more comfortable for them and sometimes even easier. Looking answers up in a book does not require a whole lot of brainpower and believe me when I say that there are days I ask myself what was I thinking when I started this whole new process to learning. I also feel it would be much easier to grab a textbook, copy a worksheet, give the assignment and head to my desk and catch up on paperwork, but then I tell myself that easy is not always the best way to do things and in the end all of this crazy hard work will have the most positive impact on student learning.

ANNE

In my own classroom, negotiations are ongoing, loud, sometimes quiet, spill over to the next day, and the day after that, over in 5 minutes, heated, and dull. It just depends, and it changes all the time. I do think one of the most rewarding parts of teaching is witnessing kids developing their use of language to convey their own ideas – I honestly feel that the use of negotiations has helped in that area. When you ask a 4th grader in August to explain their thinking on any given topic, more times than not, I’ll get the standard response ... “because that’s what I think.” I can take that same child in May, and ask the same question and I might just receive an eloquent response that is supported with specific data and evidence.

STUDENT NEGOTIATIONS

When I say this needs to be modeled – I do mean modeled, and the more the better! We use negotiations in all subject areas. We’ve had pretty intense ones while discussing character traits in reading; once they learn the process of it, it becomes a very natural way for them to express and communicate their ideas. When I reflect back on how my students have responded to this, I think it’s similar to what I did before, but now with so much more purpose. I am more aware of their internalizing, their language, their word choices – telling and memorizing aren’t true, deep, conceptual learning. What I strive for is to provide opportunities for my students to make strong connections, to discover relationships between concepts, and to question and share authentic dialogue meaningful to them.

TRACY AND ANNE

The process of negotiation is still well under construction in our classrooms. We have not yet mastered the process, but continue to use it across the curriculum daily. We believe once the process was introduced as “negotiation” the kids began to feel more comfortable with open negotiations and realized that was just dialogue that allowed them to question, make connections at a deeper level, and begin applying their learning to real life. Watching the students and seeing those light bulbs turn on frequently is why we went into the field of education.

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15. REFLECTING ON WHAT WE HAVE LEARNED FROM TEACHERS IN THREE INTERNATIONAL CONTEXTS ABOUT IMPLEMENTING ARGUMENT-BASED INQUIRY

The SWH approach, being a language-based approach, has enable me as a classroom teacher to FINALLY make that multi-disciplinary plan a reality. Ever since I have been teaching I have always heard experts talk about the power of connecting all that we teach together, but I have never been able to figure out the how. SWH has made that possible. I have learned how to use our science and social studies topics to serve as a game field for my students to see the literacy skills in action. I finally feel like I can actually take content based information and use it to practice literacy skills and concepts that we are learning. This is so incredibly powerful because our students are then receiving opportunities to interact with all of the concepts that we are learning in multiple doses.

(USA Elementary Teacher, 5th grade)

Hand and Keys first published their thinking about the Science Writing Heuristic approach with an article in *The Science Teacher* that appeared in 1999. Now almost 20 years later, we continue to hear from teachers about how this approach is transforming their practice. In this book, you heard the words and thinking of teachers in three international contexts who have in essence, three critical elements in common: (1) Writing to learn not only applies to our students but also to teachers making sense of practice, (2) Immersive argument environments are critical to teaching and learning not only in science but across subjects, and (3) When teachers are supported to be researchers in their own classrooms, they continually have the opportunity to align their teaching with learning.

THREE CRITICAL ELEMENTS

Language encompasses both the oral and written aspects. SWH encourages students to utilize both. Through listening to teachers and their peers and sharing ideas they develop the very important skill of respectful communication. Also included are negotiating and arguing – two skills that have had negative

connotations in the past. All of these encourage higher level thinking skills, requiring students to think through their ideas and defend them with evidence they have gained through investigation. Organizing their thoughts in journals, developing vocabulary through concept maps, and working in groups or alone writing/recording their findings also helps students to deepen their thinking and make connections to what they know. This program not only helps students LOVE science, but it also helps them to become better people through improving communication skills that ‘the old way’ missed, where students memorized facts and took a test! I’m excited to use this in my classroom! (USA Elementary Teacher, 2nd grade)

In the reflection written above by a second-grade teacher from the USA (children are typically 7–8 years old at this stage), she illuminates her transformation in considering how to teach so children can learn. In the following paragraphs, we explore how the teachers who wrote chapters for this volume illuminate three critical elements of the journey to put the SWH approach to work in their teaching repertoire.

First, writing to learn. As you read each teacher’s (or group of teachers) chapter, you witnessed an important writing to learn experience where we ask teachers regularly throughout our professional development workshops to engage in reflective writing about their practice. We see it as critical to the way they make sense of new thinking, question old thinking, and re-align their practices with a theory of how students learn. This writing to learn practice for teachers is critical for them to understand what they know, where are the gaps in thinking, and what are potential pitfalls, fears, concerns about adapting their pedagogical practice.

Second, each teacher discusses the creation of immersive argument environments – for their students and for their own development. Each teacher discusses how they are a part of a community of teachers, support personnel, and university faculty who create supports as well as an ongoing immersive argument environment where, during professional development workshops, we challenge each other, question each other, and negotiate ideas about science, about language, and about the act of teaching and learning.

Third, in each chapter you see the authors take up a stance of “teachers as researchers.” From our very first SWH project, we approached teachers to be our partners in this research. We do not presume to know more than a teacher but that we each have a knowledge base that can inform, challenge, and shape the research questions, analysis, and dissemination.

A NEW MODEL FOR CONSIDERATION

In 2008, Norton-Meier theorized how children experience language in SWH classrooms building off of Halliday’s (1975) theory that children learn *about* language, while they learn *through* language, all while *living* language. In analyzing the chapters written by teachers in this volume and revealing the three critical

elements, we offer up a new model for teacher learning where we recognize that teachers learn about the SWH, while they learn through the SWH, all while living the SWH approach (see [Figure 15.1](#)).

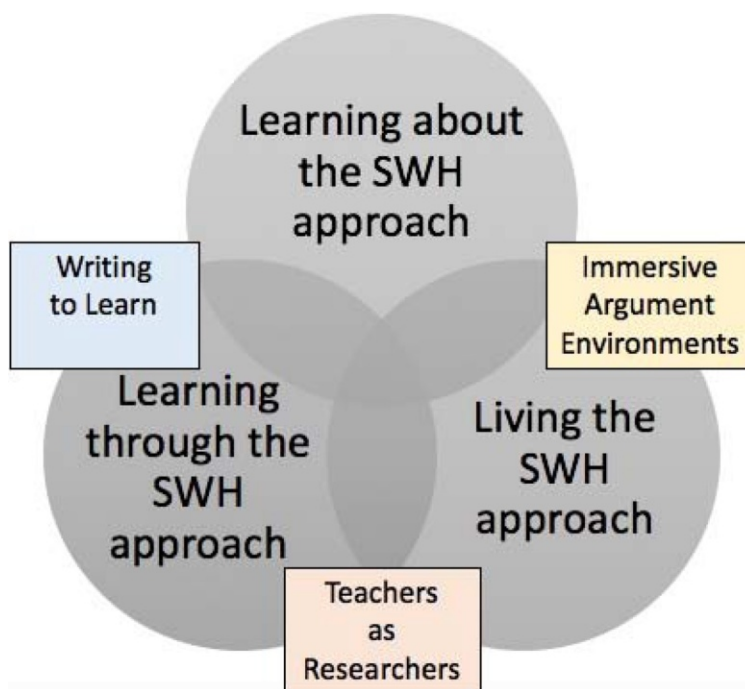


Figure 15.1. Model of teacher learning in SWH classrooms

Learning *about* the SWH approach – In reading the words written by teachers in the previous chapters, we see where teachers describe what they learned about the approach. How it is different from traditional science lab reports? Why does this structure help children learn?

Learning *through* the SWH approach – Several of the teachers described that it was through the SWH approach that they now understand aspects of science content that made no sense to them previously. In addition, teachers describe that through this focus on argument-based inquiry approaches that what they thought they knew about science content became weak when they attempted to make arguments to support their thinking. As our professional development workshops create immersive argument environments where teachers are learning the SWH approach engaging as learners themselves, they are able to wrestle with complex science content knowledge while also examining the role of language and argument in thinking.

Living the SWH approach – In every chapter, you read about how teachers were transformed by the process of embedding the SWH into their classroom teaching repertoire. At times, teachers talk about how the changes in their science teaching impacted how they teach other subject areas (such as mathematics, reading, writing, social studies). Others will describe how they use the questions, claims, evidence argument structure in all aspects of their life in and out of school settings. To live the SWH approach is to know that it is a lens through which to view the world and in particular, acts of teaching and learning. It is to recognize what it means to learn and to align your teaching with an understanding that the learner controls learning ... the teacher does not.

IN CONCLUSION

We will end this text the way it began ... with the words in writing from a teacher. This 4th grade (ages 9–10 years) teacher from the United States illuminates the bigger purpose of learning and how she continues to live the SWH approach which leads to meaningful and purposeful learning for her students. We hope that the stories the teachers shared in this volume from across international contexts help you to consider not only student learning but also how we support teacher learning. Traditional forms of professional development do not create the spaces where teachers can question their practice, write-to-learn about their negotiated thinking, and exist in an immersive argument environment where they inform our larger body of knowledge as teacher researchers.

Claims and evidence in Math?
Claims and evidence in Social Studies?
ABSOLUTELY!

By providing students opportunities to construct their own meaning through inquiry and through the questions we ask we are attacking our standards and making the idea of claims and evidence a daily occurrence. At the end of the math period when we, as a class, come back together students are sharing their solutions and solution strategies (claims) and then explaining their thinking and connections they were making (evidence) that is when the real power occurs.

The conversations are always so incredibly powerful and the students are able to hold discussions that allow students to be pushed and want to learn more from their peers. I have NEVER seen kids more excited about learning our Social Studies content due to our instructional approach of entering from the lens of a big idea. It is no longer just about memorizing dates, events, and definitions. It is about a bigger purpose and concept that students are then able to learn about this type of content and then see a bigger purpose for the information. (USA teacher, 4th grade)

REFLECTING ON WHAT WE HAVE LEARNED FROM TEACHERS

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EDITORS

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Jeong-yoon Jang is a post-doctoral scholar at Seoul National University where she is researching the role of writing in the Science Writing Heuristic approach. She has been responsible for developing a student framework to promote both the argumentative and summary writing components of the approach. Her research has been conducted both in the US and in Korea.

Lori Norton-Meier is a Professor of Literacy Education at the University of Louisville where she studies the language and literacy practices of children, families and teachers as they engage in the act of inquiry. This research occurs in and out of school settings both in urban and rural contexts. Most recently, her work centers on young children's language and literacy practices while engaging in science inquiry.

CONTRIBUTORS

Yesrip Akbay is a science teacher at Molla Halil İmam Hatip Secondary School in the southeast region of Turkey. He is in his 20th year of teaching. He was introduced to Argument Based Science Inquiry (ABI) implementations 6 years ago. With the ABI approach, he has gained positive and enjoyable experiences. His ideas about traditional teaching approaches and his procedures for planning and implementing units has drastically changed with the ABI approach. His students have also changed with this process. Both himself and the other teachers in his school noticed that the students' in the practice class were moving in a dynamic way in terms of cognitive development, learning abilities, generating and organizing ideas.

Recai Akkus is a math educator at Abant İzzet Baysal University, Bolu, Turkey. His main areas of research are teacher change and professional development related to problem solving. While working in the SWH projects during his PhD, he developed Mathematics Reasoning Approach (MRA) that is based on problem solving, argumentation and writing to help math teachers change their pedagogies towards

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student-oriented approaches in their classroom practices. He has been involved in several projects related to SWH and MRA in Turkey. Recai is married to Pinar and has a five-year daughter, Mira, and a two-year son, Kuzey Akın.

Anne Campbell is a 4th grade teacher at Treynor Elementary School. She was a participant in the 2011 SWH Summer Workshop and worked with her school team to implement argument-based inquiry practices into the school's existing curriculum. Together with Tracy Jarrett and Lori McGoldrick, they worked as teacher researchers to think together about how students learn and how to transform their classrooms into spaces where inquiry and literacy practices came together to help their students engage with intellectually challenging science content.

Mustafa Demir graduated from the Science Education Department at Karadeniz Technical University in 2002. In the same year, he started to work at a village school in Rize, Findikli. After working at this school for four years, he was assigned to a primary school in the city center of Findikli. As of now, he has been teaching for 14 years. His teaching interests primarily include what kind of applications students prefer during learning, which learning approaches are most influential in student learning and the communication skills of students, and the ability to understand the nature of science, teamwork, the development of democratic attitudes through argumentation.

Lydia Gatton is in her 7th year of teaching. She spent three years at Lone Tree Community School District in Lone Tree, Iowa, where she was first exposed to the SWH approach. While there she implemented the instructional style with her fourth graders. Since then she has moved to Bettendorf, IA and is currently teaching fifth grade at Hopewell Elementary in the Pleasant Valley Community School District. Although science is no longer a subject area that she teaches, her philosophy toward great teaching and learning has remained the same; student-driven inquiry around big questions and big ideas. She incorporates that thinking into other areas of her instruction, and hopes that SWH will find its way into more classrooms. Lydia lives in Bettendorf with her husband, Zach, and their French Bulldog.

Fatma Gundogan has been a science teacher since 2006. She teaches at Yahyali Atatürk Middle School, Kayseri, Turkey. She is also pursuing her Master's Degree in Science Education at Aksaray University. Since her involvement in Argument Based Inquiry project (SWH in Turkey), many changes happened in her life, most of which are her personal relationships with people and especially with her students. She changed her language in communication towards a more humanistic way. After the ABI PD programs, she became interested in EU projects that have affected her students' learning of science. Her special areas of research are argument-based learning and STEM education.

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Murat Gunel has a BS degree in physics education, and a Masters and Ph.D. in science education. He was part of the first SWH team at Iowa State University in between 2000–2006. After working with teachers in Iowa, he initiated several projects and PD programs for Turkish teachers. Teaming up with researchers and teachers Murat has been working with different grade levels and school systems across Turkey, Europe, Middle East and Africa. He is passionate to adopt the argument-based inquiry approach into different disciplines such as language, vocational-technical and engineering education.

Megan Hach taught for 5 years at Lone Tree Community School District in Lone Tree, IA (preschool, first, and fourth). That is where she first learned and taught using the SWH approach. Along with her fellow author/colleague, Lydia Gatton, they started initially just using the SWH approach during science but then started applying the concepts of SWH to other subjects as well. After 5 years at Lone Tree, she started teaching at Center Point Community School District where she taught three years in fourth grade and currently is in her second year as the Intermediate (grades 3–5) instructional coach. As the instructional coach, she works full time with the teachers in her building on improving collaborative structures and instructional practices. Megan lives in Marion with her husband, Kyle, and two boys, Carter and Easton.

Peggy Hansen has been using the SWH approach for many years, getting the opportunity to further her love of science while learning ways to teach students using the Argument-Based Inquiry Approach. She has taught in the Griswold Community School district for 30 years. During those years, she has taught first, second, and fifth grades. Peggy lives in Griswold with her husband Scott. She has two daughters, Britney, a teacher in Council Bluffs, and Brooke, a Junior at Buena Vista University.

Lynn Hockenberry is a former elementary school teacher who implemented the Science Writing Heuristic approach in her classroom and understands the power that linking science with literacy has to engage students. Lynn has been a literacy consultant with Green Hills AEA in Southwest Iowa for the past 12 years and provides professional development and coaching to K-12 teachers in the area of literacy and specially designed instruction.

KyungHwa Jang started teaching in 2005 when she just finished university. She has been using the ABI approach for 9 years in her science teaching. During her teaching career, she moved to 3 different middle schools and used the ABI approach at all schools. She received her Ph.D degree in science education and her thesis focused on negotiation in the ABI approach. She lives in Busan with her husband and their son and daughter.

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Tracy Jarrett has been teaching since 1997 and using the SWH approach for eight years. Much to her surprise the SWH approach fostered a love for science teaching/learning that she had never had before. She began using the SWH approach while teaching 5th grade in the Treynor School District. After moving her family across the state in 2013, she began teaching at Mt. Pleasant School District in 2014. She is very proud of her three children Gage (U.S. Marine), Emma (11th), and Cole (8th). Since using the SWH approach it has encouraged her to start her master's degree in STEM.

Carrie Johnson has enjoyed working with students and teachers as a teacher, instructional coach, consultant and administrator. Carrie enjoys working in classrooms to promote student engagement and learning and continues to advocate for use of the SWH approach to support students using questioning, language and literacy to learn.

Laurie Kammrad has been using the SWH approach for five years. This Argument-Based Inquiry Approach has allowed Laurie to partner with her students in growing their passion and curiosity for learning. She has been an educator for fifteen years. The past ten years she has been with Lewis Central Community School District in Council Bluffs, Iowa. She has taught first/ second multiage, second/third multiage fourth grade and served as an instructional coach. Laurie lives in Council Bluffs with her husband Justin, and their four boys, Braylon, Landon, Quentin, and Kroy.

Nilay Keskin Samanci is an associate professor and has been teaching biology in Biology Education Department and Primary Education Department since 2003. She holds a Master's and Ph.D. degree in biology education from Gazi University. Her research interests include bioethics education, socio-scientific issues and argument-based inquiry.

Sevgi Kingir is an associate professor of Chemistry Education in the Department of Elementary Education at Hacettepe University, Turkey. She completed Five Year Integrated Master of Science Program without Thesis in Chemistry Education from Selcuk University and received a PhD in Chemistry Education from the Middle East Technical University, Turkey. She spent a year as a visiting PhD student at the University of Iowa, USA. She has taught chemistry and science methods courses for pre-service primary teachers. Her research mainly focuses on science teaching and learning at elementary and secondary levels.

Kyounghwa Kwak has 20 years of teaching experience. She was fascinated by incorporating argumentation into teaching science when she was working on her master's degree. She started using the ABI approach in the second year of her Ph.D program. Since then, she has been using the ABI approach for 10 years. From the beginning of implementing the ABI approach at the middle school level in Korea,

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she worked as an instructor for the professional development program organized by Busan Education Board and she is still working with teachers 10 years later. She is working as a consultant for teaching the ABI approach in Busan. She has also been teaching pre-service science teachers at university.

Sunduk Lee has 28 years of teaching experience. She encountered the ABI approach when she was in her 20th year of teaching middle school science. Since then, she has been using the ABI approach for 7 years. She recalls the moment that she encountered the ABI approach as a turning point in her teaching career. She received the Ministry of Education Award for Science Teacher of the Year in 2010. Recently, she is in early retirement. She started her new career as a lecturer at Pusan National University, teaching pre-service science teachers.

Denise Lembke used the SWH approach for three years to help her special education students have a better background and more confidence in the general education classroom in the area of science with very good success. Denise has retired after teaching for 38 years for the Atlantic and Griswold School Districts. Denise lives near Griswold with her husband, Doug. They have four grown children, a daughter, Megan and triplet sons, Seth, Garrett, and Micah.

Veronica McKee has been using the SWH approach for close to 10 years. It has given her the opportunity to teach students the argument based inquiry approach, which has carried over from science to other subject areas. She has been teaching for 21 years, with the last 16 being in the Griswold School District. During those 21 years, she has taught second, third, fourth, fifth, and sixth grades. Veronica lives near Massena with her husband Troy and their three sons. Trevor and Jarod are in college, and Connor is in middle school.

Nurten Mutlu-Pehlivan is an immigrant from Bulgaria. She has been teaching science for over 22 years and is currently working at Bayrampasa Middle School in Istanbul. In her school, the majority of her students are Turkish immigrants from Bosnia and Herzegovina. Her first encounter with the SWH approach was in 2010 through the PD programs. She is still using the approach as a predominant teaching method in her 6th, 7th, and 8th classes. Nurten strongly believes that the approach can be implemented across the science curriculum and other subject matters' teaching. She lives in İstanbul with her husband, Necmi, and her son Göksel.

Jeonghee Nam is a Professor of Chemistry Education at Pusan National University. She has lead a group of teachers in exploring the use of the Science Writing Heuristic within Korean classrooms. Her research is focused on understanding how the approach promotes student writing in science, how we can improve students' use of modal representations and the role of critical thinking.

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Melike Ozer-Keskin was born in Mus, Turkey, in 1973. She received the B.S. and M.S. degrees in agriculture engineering from the University of Ankara, Turkey, in 1993 and 1997, respectively, and M.Ed and Ph.D degrees in Science Education from the University of Pittsburgh, Pittsburgh, USA, in 2000 and 2004, respectively. She is an Associate Professor in the Department of Biology Education at the University of Gazi where she has been a faculty member since 2004. Her professional interests focus on ethics, bioethics, bioethics education and Argument Based Science Inquiry.

Selçuk Ozgur is currently teaching science at Cumhuriyet Middle School in Dikili, which is a coastal city and a district of Izmir Province in the Aegean Region of Turkey. He graduated from Balikesir University with a bachelor's degree in biology education in 1997. He started his career as a combined elementary classroom teacher where the first 5 grades were educated in the same classroom and then shifted to work as a middle school science teacher. He has been working as a middle school science teacher for eighteen years. He participated in ABI professional development program for the past three years and began implementing argument based science inquiry in a middle school classroom. This approach has changed his view of teaching and learning and enabled him to create a learning environment where negotiation takes place.

Hwamok Sung has been using the ABI approach for 10 years in her science classroom. She is in her 11th year of middle school teaching. She was introduced to the ABI approach when she was in the first year of a Master's degree. She continued her study and received her Ph.D degree in science education. Her Ph.D project studied the ABI approach in the middle school science classroom. She lives in Busan with her husband and their seven-year old son.

Mary Grace (MG) Villanueva is a former Institute for Education Sciences postdoctoral research scholar from the University of Iowa. Her research focused on the use of ABI to engage students with special education needs in science. In addition, she researched how ABI could impact scientific epistemic dispositions. After leaving UI, MG returned to South Africa where she continued to engage pre-service and practicing science teachers on ABI and scientific literacy at the Nelson Mandela Metropolitan University and the University of Witwatersrand. MG is passionate about science education and quality public education.

Kim Wise is an Instructional Services Consultant for Green Hills Area Education Agency (AEA). She has been providing professional development on the Science Writing Heuristic approach for over fifteen years. Prior to working at the AEA, Kim was an upper elementary and middle school teacher. Kim currently serves on Iowa Department of Education committees responsible for the rolling out of new science standards. Her work is focused on using the SWH approach to fully implement the new science standards.

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Funda Yesildag-Hasancebi is an assistant professor at the Department of Science Education at Giresun University in Turkey. She received her MS degree and doctoral dissertation in science education from Ataturk University. Dr. Hasancebi's research interest areas include argument-based science inquiry, non-traditional writing in science, improving students' understanding of science with multi-modal representations. Funda has used the argument-based science inquiry approach within her classroom for pre-service teacher education and in helping teachers to use this approach. She has taken roles as a researcher in several projects about the ABI approach and she has enjoyed working with teachers for the past 9 years.