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## Abstract

Grounded in the theoretical framework of interpretivism, the purpose of this qualitative case study was to explore the experiences of a teacher from an inner city high school in South Texas when using interactive notebooks to inform students' understanding of physics concepts. The participant for the study was purposefully selected with an intention to gain an in-depth understanding of the experiences. Data collection incorporated multiple methods such as interviews, participant observations, and document analysis. Descriptive, In-vivo, process, and Labovian six-part model of narrative coding were used to reduce and manage data. The codes were grouped into eight categories. Two major themes were identified from the data analysis: Interactive Notebook - A Testimony of Constructive Learning and Interactive Notebook- A Pioneering Approach to Instruction. The findings of this study intersect science education and qualitative inquiry and create space for openended, autonomous, constructivist learning of scientific principles. Additionally, the findings raise implications for transferable aspects of individualized learning processes for any areas of education where concepts are challenging for students to grasp.

## Keywords

Interactive Notebooks, CaseStudy, Qualitative Inquiry, Science Education

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# Exercising Autonomous Learning Approaches through Interactive Notebooks: A Qualitative Case Study

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*Grounded in the theoretical framework of interpretivism, the purpose of this qualitative case study was to explore the experiences of a teacher from an inner city high school in South Texas when using interactive notebooks to inform students' understanding of physics concepts. The participant for the study was purposefully selected with an intention to gain an in-depth understanding of the experiences. Data collection incorporated multiple methods such as interviews, participant observations, and document analysis. Descriptive, In-vivo, process, and Labovian six-part model of narrative coding were used to reduce and manage data. The codes were grouped into eight categories. Two major themes were identified from the data analysis: Interactive Notebook - A Testimony of Constructive Learning and Interactive Notebook- A Pioneering Approach to Instruction. The findings of this study intersect science education and qualitative inquiry and create space for open-ended, autonomous, constructivist learning of scientific principles. Additionally, the findings raise implications for transferable aspects of individualized learning processes for any areas of education where concepts are challenging for students to grasp.* *Keywords: Interactive Notebooks, Case Study, Qualitative Inquiry, Science Education*

The mandates for high stakes testing in the U.S. and the demand on students to master concepts in science under these pressured conditions have created some decline in the students' interest in science, especially in learning physics. For example, Bramby and Defty (2006) noticed a decline in the number of students who were choosing to take physics during their college studies because of their low expectations for success in physics and their perceptions of it as less interesting and more difficult when compared to other sciences. Jones, Howe, and Rua (2000) reported a similar trend where female students expressed greater difficulty learning physics compared to males. It is evident that while some students do not respond well to physics because of their self-perceptions regarding their learning and self-esteem (Yerushalmi, Eylon, & Seggev, 2004), others struggle due to their misconceptions about science (Dunbar, 2004). Therefore the question that seeks immediate attention is "How can educators make physics instruction more effective for their students?" In this paper, we explore this question further through a qualitative inquiry of physics education. This paper is a collaborative effort between a physics educator, the first author, and a qualitative methodologist, the second author, serving as a mentor for the physics educator in executing this study. This qualitative inquiry of physics education was inspired by the discourses that address the shortcomings of the physics education where only a fraction of students are successful and interested in physics after being exposed to the subject.

Specifically, addressing the failure in physics instruction, Redish (1994) suggests that if physics teachers are to make serious progress in reaching a larger fraction of students then they must focus less on physics content and more on students' learning. He further recommends that teachers must ask not only what do they want the students to do but pay attention to what the students know when they come in the classroom, how they interact with the learning environment, and how they respond to the content provided. This kind of constructivist understanding of learning can be achieved through incorporating interactive notebooks in physics classes. An interactive notebook is a spiral notebook that has a right hand and a left hand side allocated for specific purposes (Endacott, 2007). The right hand side is used for the teacher-directed activities, which include notes, lectures, videos or any other primary or secondary source. The left hand side is for students to capture the teacher-directed information on the right hand side, process it, and express it through student-directed output in many different forms such as Venn diagrams, concept maps, graphic organizers, diagrams, poems, or songs. The left-side page of the notebook is where the students travel beyond the regular classroom instruction delivered to them and allow the lesson to penetrate for better understanding (Wist, 2006). Since it has been suggested that all individuals relate to information differently based on their learning style (Gardner, 1993), the use of interactive notebooks might enable the teachers to design a rich learning experience for all students in their physics classes (Moran, Kornhaber, & Gardner, 2006).

The first author of the paper is a high school teacher with fifteen years of experience in teaching physics. Four years ago, the idea of interactive notebook was introduced to the teachers in the science department at her school. What was missing was how to incorporate them. Although, most of the teachers in the department were resistant to the idea of interactive notebooks, she found no harm in experimenting with them. She learned that the notebooks were based on the theory of multiple intelligences. As a mother of a four-year old child who has a unique ability to learn through music, she had an invested interest in this strategy. Since most of her students were struggling to learn physics, she decided to use interactive notebooks in her class. Despite few initial setbacks, she had great success in using the notebooks with her students. She realized that the notebooks not only helped improve students' performance, but offered her, as a teacher, a chance to stop and reflect on her teaching practices. The notebooks enabled her to understand her students better and grow as an educator. Having had some positive experiences using the notebooks in her class, the first author became interested in learning about the experiences of other physics teachers using the same strategy, to gain a deeper understanding as to how the notebooks can be used more effectively to improve physics instruction. This interest informed the purpose of the qualitative inquiry, the focus of this paper.

Specifically, the purpose of the study was to explore the experiences of a teacher from an inner city high school in South Texas when using the interactive notebook to inform students' understanding of physics concepts. The research questions for this study were:

1. What are the experiences of the participant when using the interactive notebook in a high school physics class?
2. How does the participant describe the role of the interactive notebook in informing the students' understanding of physics concepts?

## Theoretical Frameworks

This qualitative study is informed by interpretivism as the methodological framework and Universal Design for Learning along with Gardner's theory of multiple intelligences as the substantive frameworks. We identified interpretivism as the appropriate methodological framework because we believed in the idea that one's reality and understanding of truth could be constructed through one's interaction with the world, thereby creating room for multiple ways of understanding realities and truths (Crotty, 2004) was legitimate for this study.

Interpretivism rests on the ontological belief that reality is socially constructed, complex and ever changing (Glesne, 2011). This means that a possibility for different interpretations of the same phenomenon exists. Interpretivists assume that the person cannot be separated from the reality because reality is constructed based on individual interpretation and is subjective (Weber as cited in Crotty, 2004). According to Schwandt (1998), particular people, in particular places, at particular times, interpret and make meaning of various events. These events are distinct and cannot be generalized (Mack, 2010). Given that the goal of qualitative research is not to generalize, and given that we understand the multiple ways of interacting with reality and making meaning of it, we invite the reader to construct their own truths about the credibility, transferability, dependability, and confirmability (Weber as cited in Crotty, 2004), criteria that can be used to determine the value of this study.

Substantively, exploring teaching with the interactive notebook is designed around the theory of multiple intelligences. Gardner (1993) defined intelligence as a set of abilities, talents or mental skills, which all individuals possess to some extent, but differ in the degree of skill and in nature of their combination. He identified eight different intelligences that include linguistic, musical, bodily-kinesthetic, logical-mathematical, spatial, interpersonal, intrapersonal and naturalistic intelligence. This theory provides a clear understanding of the brain's complexity explaining why different students learn differently based on their learning styles (Stickel, 2005).

Universal design for learning (UDL) is a framework that emphasizes on developing flexible curricula that provide multiple pathways to engage students' interests and so allowing them to access content in different ways and express their understanding in various forms (Howard, 2004). UDL allows teachers a multidimensional view of their students as learners thus providing them unique insights into assessing their knowledge, interest, and understanding.

Students come into a learning environment with varying experiences and abilities and therefore construct different meanings of the information delivered by the teacher in the classroom (Redish, 1994). These meanings undergo constant transformation due to the interactions between students, teacher, and the curriculum. Therefore, for the purpose of this study, interpretivism becomes the apt lens to look at how knowledge is co-constructed by the students and the teacher. The theory of multiple intelligences and the framework of UDL help to understand the different ways in which teachers design instruction and deliver information that is adaptable for students with differing abilities and learning styles.

## Literature Review

Young children are naturally curious and passionate about learning. From birth, they are constantly experimenting in their pursuit of knowledge (Lind, 1999). These attitudes of young children reveal that they are engaged in scientific thinking through natural curiosity even before they enter a class room. That's why the traditional presentation of science education as memorization and regurgitation of facts has been antiquated. When learning science must involve a design cycle of asking questions, probing for answers, conducting investigations, and collecting data, it is confined to mere memorization of factual information. This traditional style of learning explains why leading the world in science, as revealed by recent results of the TIMSS project, still remains a challenge for American students (Loveless, 2013). In order for science educators to design strategies for effective science instruction, it is important to briefly examine the history of science education and scientific literacy.

With the growing competition in the global market, US is in desperate need for more scientifically literate citizens who can maintain competencies and make informed decisions on science related public policies (Duit & Treagust, 2003). Although scientific literacy has always been the expected outcome of science education, it has defied clear-cut meaning since the time it was introduced in 1950's (DeBoer, 2000). From a broad description of it as knowledge of science and scientific enterprise, scientific literacy is now seen as the ability to identify questions and to draw evidence-based conclusions that aid in making informed decisions about the changes made to the natural world through human activity. It encapsulates a set of science processes and cross-curricular competencies. The science processes include: recognizing scientifically investigable question; identifying evidence needed in a scientific investigation; drawing and evaluating conclusions; communicating valid conclusions; and demonstrating an understanding of science concepts. Cross-curricular competencies include self-regulated learning; problem-solving; communication and collaboration (Duit & Treagust, 2003).

As the description of scientific literacy changed over time, so did the approach to science teaching. In 1960s, the new sciences courses were mostly developed by scientists themselves with the belief that within the science discipline laid the knowledge that can enhance the economy and the military needs of the country. Science was taught using abstract models of the natural world. Inquiry approach was used not with a goal of developing independent thinking but to imitate and appreciate the way scientist themselves did their work (DeBoer, 2000). It was not until 1970s, with the increase in global competition, science educators realized that it was pedagogically unwise to concentrate on the structures of the discipline ignoring the interests and the developmental needs of the learners. Science literacy was then used in a broader perspective, especially in relation to everyday applications. Then, the relationship between science and society along with the technology was brought back into science curriculum (DeBoer, 2000).

During the times when the science education community was busy debating whether science education was primarily about science content or science-based social problem, the National Commission on Excellence in Education (1983) issued a report called A Nation at Risk: The Imperative for educational Reform. The report raised a concern that the falling standards of US education system as indicated by the declining economic position of America in the global market and therefore recommended a more rigorous curriculum built around the areas of English, mathematics, science, social studies, computer science, and foreign languages (Gardner, Larsen, & Baker,1983).

In 1992, National Science Standards became a part of the U.S. government's approach to educational reform with an objective for all students to achieve scientific literacy by mastering a set of content standards. Everyone must be able to use of scientific information to make choices that arise every day. They must be able to engage intelligently in public discourse and debate about important issues that involve science and technology. They must be able to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world. People must learn to reason, think creatively, make decisions, and solve problems in their work places. The most important goal was for the United States to have equally capable citizenry to maintain peace in the global market (National Research Council, 1996). The historical review shows that scientific literacy is about people's understanding of science which is very open-minded and ever-changing. Therefore, there is no one correct way of teaching science. The most important thing is that students must learn meaningfully in ways that spark an interest in them to pursue science both formally and informally in the future (DeBoer, 2000).

With a common goal of improving students' learning, the education world has seen several ideas on ways to individualize and enhance instruction for all students. Learning styles, alternative and authentic assessments, multiple intelligence theory, and differentiated instruction are some of them (Waters, Smeaton & Burns, 2004). One of the ideas that evolved from this research is the "interactive notebook."

The idea of interactive notebook originated at Teachers' curriculum Institute (TCI). TCI was established in 1989 by a small group of motivated social studies teachers with an idea to bring a positive change in social studies instruction (Endacott, 2007; Wist, 2006). TCI strongly emphasizes the idea that every learner is different and that all students benefit from multiple ways of learning (Teachers' Curriculum Institute, 2010). They designed innovative instructional strategies to help educators across the nation bring meaning and life to their social studies lessons (Wist, 2006). These instructional strategies are based on five important theories – Understanding by Design (Wiggins & McTighe, 2005) , Nonlinguistic Representation (Marzano, 2010), Multiple Intelligences (Gardner, 1993), Cooperative Instruction (Marzano, Pickering, & Pollock, 2001), and Spiral Curriculum (Bruner, 1960). According to TCI (2010), interactive student notebooks make note-taking an active and engaging process where students use their multiple intelligences to make their learning experience fun and exciting.

Intelligence is a set of abilities, talents or mental skills which all individuals possess to some extent, but they differ in the degree of skill and in nature of their combination. There are eight different intelligences (Gardner, 1993). These multiple intelligences include linguistic, musical, bodily-kinesthetic, logical-mathematical, spatial, interpersonal, intrapersonal and naturalist intelligence (Gardner, 1993). Musical intelligence is the capacity to recognize and compose musical pitches, tones and rhythms (Brualdi, 1996). Bodily-kinesthetic intelligence is the talent in controlling one's body movements and also handling objects skillfully (Armstrong, 2000). Interpersonal intelligence is an ability to understand and work with other people while intrapersonal intelligence is the ability to work with oneself and operate effectively through self-reflection (Gardner, 2006). Brualdi (1996) identifies logical-mathematical intelligence as one's ability to detect patterns, reason deductively and think logically while linguistic intelligence deals with the ability of a person to argue or persuade, instruct effectively through the spoken word. Armstrong (2000) defines spatial intelligence as the talent to manipulate and create mental images in order to solve problems. Naturalist intelligence is defined as the ability of a person to appreciate nature, observe patterns and understand nature and man-made systems as well as compare them during the process of learning (Wist, 2006). The theory of multiple intelligence helps us understand the brain's complexity and why different students learn differently based on their learning style (Stickel, 2005).

Interactive notebooks are a good way to incorporate visual intelligence by including visual elements such as concept maps, illustrations, pictowords, and visual metaphors. Musical intelligence by incorporated into the notebooks by asking students to compose a song or a music piece in writing. Students can use intrapersonal intelligence when reflecting on how the concept taught in the class would relate to the past experiences or how it would make a difference in their lives. Recording group discussions and reflecting on each other's opinions enhances the use of interpersonal strengths. Logical-mathematical intelligence can be integrated into the notebooks through problem solving and the use of charts, and graphs (Endacott, 2007). Interactive notebooks can help teachers meet the needs of their students as an organizational tool to help them plan lessons that involve the use of different intelligences, thus making the lessons more fun and meaningful to the students (Wist, 2006). Escalada and Moeller (2006) found that students learn better in classrooms where the teacher uses interactive and engaging instructional methods as compared to traditional courses that rely primarily on passive strategies such as lecturing.

The interactive notebook provides opportunities for students to engage in self reflective and collaborative experiences that foster meaningful discussions in the class

(Waldman & Crippen, 2009). Waldman and Crippen also present interactive notebook as a viable tool that helps students to showcase their effort and creativity, demonstrating a sense of pride and ownership of their work. This increases the students' ability to control their learning which can contribute to their confidence and empowerment. Interactive notebooks allow students to express themselves personally giving them a freedom of choice with many assignments (Endacott, 2007). Interactive notebooks can empower students for learning science as they are intended to actively engage students with the content, assess their understanding through self reflection, and help students visualize and demonstrate understanding as evidence of self-regulation (Waldman & Crippen, 2009). Interactive notebook is a very effective method that promotes scientific inquiry while it also enhances general learning involving writing across the curriculum, personalization and metacognition strategies (Chesbro, 2006). During scientific inquiry, students focus, experiment, reflect and apply based on their own learning styles.

The left-side page of the notebook is where the students travel beyond the regular classroom instruction delivered to them and allow the lesson to penetrate for better understanding (Wist, 2006). It allows them to process the information that has been presented, review it in a number of ways and reflect the understanding of the subject matter in a creative and personalized way. Interactive notebooks can empower students for learning science as they are intended to actively engage students with the content, assess their understanding through self reflection, and help students visualize and demonstrate understanding as evidence of self-regulation. During scientific inquiry, students focus, experiment, reflect and apply based on their own learning styles. Waldman and Crippen (2009) found that the use of color and highlighting in the interactive notebook helped students' learning in their science class as it emphasized and reinforced the main concepts, vocabulary. The color also helped to distinguish details of diagrams and concept maps. Condon (2006) also noticed that the ideas of drawing and writing in their notebooks were beneficial to create meaningful learning situations in her science class.

Interactive notebooks can be used as tools for formative assessment. that the assessment of the notebook does not have to pertain just to the notebook. Endacott (2007) noticed that allowing the students in his social studies class to use their notebooks on their tests and quizzes have allowed them to think beyond just recalling the names and dates. In addition, his students were required to apply the information they have recorded in their notebooks to reach the higher levels of Bloom's taxonomy (i.e., analyze, synthesize and evaluate). He also noticed that by doing this, his students viewed the notebook as an important tool that can help them beyond their daily work. Students began to understand how the daily work in the notebook can lay a foundation for test responses. Waldman and Crippen (2009) suggest that teachers can assess interactive notebooks informally awarding quick grades to the input and output activities for different lessons or can do a summative evaluation formally for completeness of the notebooks. Wist (2006) suggests that if teachers plan on grading the notebooks then the students are to be provided with rubrics clearly explaining the expectations.

## Methodology

Since the study explores in depth the experiences of an individual teacher when using interactive notebooks in his physics class, it can be referred to as a case study (Glesne, 2011). In a case study, the emphasis is on understanding the complexity within the case, the uniqueness of it, and its connections to the social context of which it is a part (Yin, 2006). Creswell (2007) defines case study research as a "study of an issue explored through one or more cases with in a bounded system" (p. 73). Case study methods can be applied when the research is addressing a descriptive question such as what happened or an explanatory question such as why it happened (Yin, 2006). In case studies, the researcher explores cases or a case over time, through in depth data collection procedures involving multiple sources of information such as observations, interviews, audiovisual material, documents, and reports (Creswell, 2007). Yin (2006) also addresses three important steps in designing a case study: defining the case that is being studied; justifying one's choice of single-case study or multiple-case studies; and adopting or minimizing theoretical perspectives to develop data collection and analysis strategies.

## Design of the Study

This case study focused on the experiences of Bill Jacobs, a physics teacher from an inner city high school in South Texas. In the following sections we will outline the methods for recruiting the participant, data collection, management, and analysis.

### Participant Selection

In order to gain a better understanding of the interactive notebook, we purposefully selected Bill for the study because Patton (2002) explains that, "The logic and power of purposeful sampling derive from the emphasis on in-depth understanding" (p. 46). There were three criteria for selecting Bill Jacobs: he was willing to participate in the study; he was a high school physics teacher; and he was using interactive notebooks for atleast a year. Bill started working at this school in 2009. He has been using interactive notebooks to teach physics for past three years and had multitude of experiences to share.

The first author knew Bill as a trusted friend and a colleague. They shared a mutual respect for each other and therefore gaining access was relatively easy to explore Bill's teaching approaches. We attempted to align with Glesne's (2011) take on gaining access to the best of our ability where the optimum situation would be "to go wherever you want, whenever you want, observe whatever you want, obtain and read whatever documents you require, and do all of this for whatever period of time" (Glesne, 2011, p. 57).

### Data Collection Methods

This study was conducted over a period of five months. The data collection methods for this case study included formal interviews, participant elicitations, document analysis, and participant observations. Knowing that one source of information would not only be limiting our in-depth understanding, we wanted to inform our data collection strategies with the reminder that multiple sources of evidence can strengthen good case studies by contributing to the authenticity and trustworthiness of the research work. (Glesne, 2011; Yin, 2006).

#### Interviews

Since the purpose was to explore the experiences of a physics teacher when using interactive notebooks, four open-ended interviews played a vital role in data collection for this study. In-depth open-ended interviews provide the participant with enough room to express meaning in their own words and to give direction to the interview process (Brenner, 2006).

Permission to conduct the study was obtained from the school district and the IRB committee. Upon explaining the purpose of the study, Bill readily accepted to participate. After seeking Bill's permission, conversations with Bill were recorded using a Sony audio recorder. The first interview was fifty minutes long and was conversational. Even before any questions were asked, Bill started to narrate his experiences in using interactive notebooks. He pulled out his sample interactive notebooks for the past three years and began talking about them. The first author elicited rich stories by asking some leading questions to direct the conversation. According to Glesne (2011), "qualitative researchers begin with some interview questions and remain open to reforming and adding to them throughout the research process" (p. 102).

Two weeks later, Bill participated in another interview where more details about interactive notebooks were explored in-depth. The semi-structured interview contained specific lines of inquiry driven by the research purpose and questions. The questions for the interview were as follows:

1. Take me through the steps of how you set up your notebook.
2. Describe to me some of right hand side and the left hand side activities that you use in your notebook.
3. Tell me how you use the notebooks in your class.
4. Describe to me how you use color in your notebook.
5. Give me ten words that describe your experiences when you used for the notebooks for the first time.
6. Give me ten words that would describe your experiences now.
7. Describe to me how you check your students' understanding of the material using interactive notebook.
8. How do you know that the students are actually synthesizing information in their notebooks?

Once the interview was completed it was transcribed and the information in the interview served as confirmation of hunches, patterns that were surfacing, and added to the working draft of the research paper. According to Glesne (as cited in Patton, 2002), obtaining the reactions of the participants to one's working drafts may verify ideas that the researcher is reflecting and help develop these ideas further or identify new ideas and interpretations.

**Document Analysis**

Knowing that another important source of information is analysis of documents (Hoepfl, 1997), Bill volunteered some sample interactive notebooks which allowed for understanding of how the notebooks were set and how the students used them. Bill was generous enough to offer other documents such as his grading rubric and worksheets he designed for the notebook. While the documents supported the information provided by Bill during the interviews, they also provided a deeper insight into how he designed the notebooks for his instruction in order to engage his students.

**Participant Observation**

To develop a better understanding of the students' use of the interactive notebook in the classroom, the first author conducted some participant observations in Bill's class. Observation can aid in understanding the contexts in which events occur, and may enable the researcher to see aspects that the participants themselves were not aware or were unwilling to discuss during the interview (Patton, 2002). Upon Bill's permission, the author visited his class and sat at a desk away from the students and observed carefully. The observer role was a passive participant role (Spradley, 1980), rather than being an active member of the class. Observation notes were kept as condensed notes in a journal and expanded immediately after the observations were concluded where more details were added and the value of the information documented was further assessed (Spradley, 1980). For example, the condensed notes read, “Bell rang, students walked in, took out Ins, answered sq, left. T waited.” It was then expanded to “The bell rang and the students walked in. They took out their interactive notebooks and began answering the starter question that was already written on the board. They answered the question on the left hand side of their notebook. While the students were answering the question, the teacher waited patiently”.

In addition to the above-mentioned data collection methods, journal entries, peer-debriefing, and member checks added to about 380 pages of data that was reduced and analyzed. In the next section we discuss data management and analysis of these sources.

## Data Management and Analysis

The interviews were recorded through a Sony audio recorded with a USB. The audio files were downloaded on to the desktop as mp3 files. The transcripts of the interviews were typed and saved as word file on the first author’s computer. The printouts of the transcripts that were hand coded were filed and labeled separately. The documents received from Bill such as portfolio documents, rubrics, pictures, etc. were filed and dated for future references. All the names on the documents were masked and pseudonyms were used to maintain confidentiality of the participant. The digital files were saved on multiple storage devices for safety reasons.

Please note that in the discussions below we offer various types of data management and analysis techniques. We do not see coding as inherently limiting or reductive, unless that process is informed by some limiting or reductive epistemology. Instead, what we did was approach data management from multiple data reduction perspectives to understand the ways in which the participant and the researchers co-constructed meaning and in-depth understanding of the experiences of using interactive notebooks in a physics class. The findings we claim are not stable, nor are we claiming that they will not change through another lens of understanding and analysis. Our presentation is what we have, in this moment, through our sensibilities now, as a snapshot, with ways to create entry points for readers who resonate and differ for engagement and dialoguing purposes.

The documents gathered for the study such as the interactive notebooks of the teacher and the student, worksheets, rubrics, and starter questions generated by the teacher were analyzed using Descriptive and InVivo Coding. Description is extremely important in qualitative inquiry to assist the reader to see what we saw and hear what we heard (Saldana, 2009). Therefore, data reduction was approached first with a Descriptive Coding to provide a rich description of the interactive notebooks. Here is an excerpt of the field notes to demonstrate Descriptive Coding.

[1]It is a hard bound composition notebook. [2]The front cover of the notebook has the student’s name, subject, and the teacher’s name written on it. [3]The cover is decorated with the [4]pictures of a pig holding a ball on one side and a picture of a baseball player throwing a ball on the other. [5]The book cover is numbered 0 and the first page on the right is 1.

[1]Notebook
[2]Front cover
[3]Front cover
[4]Pictures
[5]Numbering
[6]Numbering

| | |
|---|---|
| [6]Both sides of the pages are numbered.[7] There are 8 pages allotted for Table of Contents. | [7]Table of Contents |

The text in the documents was analyzed using InVivo Coding. In Vivo Coding is a method of extracting the indigenous terms that can help the researcher condense and crystallize meanings of what is significant to the participant (Saldana, 2009). A list of codes generated from the rubric developed by Bill for assessing the interactive notebook were as follows: WOW product, scoring, evident, neatly done, well-organized, shows creativity, colorfully illustrated, completed on time.

The field notes developed from the classroom observations was analyzed using Process Coding to understand how the interactive notebook was being used in the classroom. According to Saldana (2009), Process Coding uses "gerunds" (words ending with –ing) to connote action in the data. The example of an excerpt from the field notes coded using Process Coding is given below.

| | |
|---|---|
| [1]The objective and starter question were displayed on the Smart Board. | [1]Displaying the objective and starter question |
| The objective for the day was for the students to [2]calculate the speed, velocity and acceleration in a given situation. The starter question was as follows: | [2]Calculating speed, velocity, and acceleration |
| [3]Explain how you measure changes as you move around in a circle. | [3]Explaining how you measure change |
| Be sure to [4]discuss positive and negative directions. | [4]Discussing positive and negative directions |
| [5]Draw the sketch. | [5]Drawing sketch |
| [6]The teacher waited for few minutes at his desk for students to answer. | [6]Teacher waiting for students' answers |
| [7]Students copied the objective and the starter question on the right hand side of the notebooks. | [7]Students copying on the right hand side |
| They started [8]answering on the left hand side. | [8]Answering on the left hand side |

The recorded conversations during the interview were downloaded to the computer and transcribed. Narrative Coding was used to analyze the experiences of Bill's use of interactive notebooks because, "stories express a kind of knowledge that uniquely describes human experience in which actions and happenings contribute positively and negatively to attaining goals and fulfilling purposes" (Polkinghorne, 1995, p. 8). After observing a sequence in the experiences narrated by Bill, a Labovian approach was used to analyze the data because, "One method of recapitulating past experience is by matching a verbal sequence of clauses to the sequence of events which actually occurred" (Patterson, 2008, p. 23). Labovian six-part model has six elements:

1) abstract (A),
2) orientation (O),
3) complicating action (CA),
4) result (R),
5) evaluation (E),
6) and coda (C) (Patterson, 2008).

Abstract is the summary of the story that can be optional depending on the context in which the story is told. Orientation provides the setting, complicating action relates the events of the story, result tells how the story ends, evaluation mediates the crucial point of the story, and coda links the present world of storytelling to past world of the story (Patterson, 2008). Here is an excerpt from the interview that was coded using the Labovian approach.

| | |
|---|---|
| [1]This spiral note book is what um.m…my head of the department then gave me just as an explanation of what the science note books were when I came here in December 2009. | [1]O |
| [2]That is when I started here at [this highschool]. | [2]O |
| [3]Ummm…m.I walked in and she said oh… we do science interactive notebooks, and my question was, what is that? | [3]CA |
| [4]And she said "ooh…in a nutshell… here it is" and she gave me this example. | [4]CA |
| [5]Umm…This is all it was and consider I started mid-year, I didn't take it much farther than that. | [5]CA |
| [6]Now the kids, the class I took over was from a teacher who had not been doing it had not been using them, had not made the kids do them and that the kids didn't do much with them and to say that I....... | [6]O |
| [7] I didn't really use them. | [7]R |
| [8]That first semester I was here, I didn't understand it. | [8]E |

**Crystallization of Themes**

The codes obtained from different data sources were grouped based on commonalities and differences. The codes were further clustered into eight categories based on related meanings and functions. Two broad themes were crystalized after deep reflection and free writing. The outline below represents the themes, categories informing the themes, and a sample of codes.

1. Owning Interactive Notebooks: An Exploratory Journey
    a. Organization of Learning
        i. Structure
        ii. Central location
        iii. Resource
        iv. Student's textbook
        v. Use of color
    b. Autonomy in Learning
        i. Cover page
        ii. Choice
        iii. However they want
        iv. Drawings
        v. Illustrations
    c. Ownership of Learning
        i. Responsibility
        ii. Decorate
        iii. Proud
        iv. Look nice

            v. Highlighting
        d. Reflection of Learning
            i. Left hand side activities
            ii. Right hand side activities
            iii. Problems
            iv. Sketches
            v. Memory triggers
2. Interactive Notebook – A Pioneering Approach to Instruction
    a. Access to Learners
        i. Who don't speak
        ii. Girls
        iii. Get attention
        iv. Prove wrong
        v. Communicating through notebooks
    b. Critical Thinking and Problem-Solving
        i. Draw
        ii. Practice problems
        iii. Process
        iv. Mechanism
        v. Look back
    c. Active Learning
        i. Thinking
        ii. Drawing
        iii. Brainstorming
        iv. Questioning
    d. Highlighting Authentic Assessment
        i. Does not test well
        ii. Carrot and Stick
        iii. Creative
        iv. Problem-solving
        v. Improve

The different codes obtained from analyzing the narratives, documents, and participant observations were organized to formulate a story informing the two broad themes that evolved from the study. During the course of the study, nonlinguistic forms of art was also used to analyze and represent data because while the words mean what they mean, drawings, paintings, sculptures, and poems can seldom allow unambiguous interpretation (Barry, 1996). Therefore, Bill's journey is also depicted by drawings to enhance the narrative with the intent to capture the readers' attention and leave room for multiple interpretations.

In the section below, we offer narratives. These narratives are not to be taken as final assertions and outcomes of the study. Instead, they represent the shared understanding between the researchers and Bill. The narratives stand as a picture, in a photo frame, in its illusion, appearing to be stable, captured, but it is only captured momentarily with the potential to transform into something else in the next moment.

## Owning Interactive Notebooks: An Exploratory Journey

December 3rd, 2009 marked the beginning of a new chapter in Bill's life. After being self- employed for six years, Bill decided to go back into teaching. He had accepted a job to teach physics at one of the inner city high schools in South Texas. At the end of the exciting first day, Bill went to Mrs. Roberts's room on the second floor to share his first day experiences. During a casual conversation, Mrs. Roberts, the head of the science department, mentioned, "We do science interactive notebooks here."

"What are they?" Bill asked making his ignorance very obvious.

She smiled and pulled out a purple color spiral notebook from the draw in her desk. "In a nutshell…here it is."

Bill opened the notebook and on the very first page, it said 'Interactive Notebook.' Underneath was written 'Title Page.' Anxiously, Bill turned the pages with a hope to see more. The next three pages said table of contents, but were incomplete. Bill noticed 'Teacher Info Notes' written on the right hand side of the fourth page and the words drawings, reflections, and journaling on the left. After five minutes of quick training, Bill walked out with the sample spiral notebook in his hand and numerous questions on his mind.

To his dismay, Bill learned that the teacher from whom he took over the classes had not been using interactive notebooks. In the midst of heavy student resistance and with very little to almost no training, Bill reluctantly started using interactive notebooks in his physics class. The notebooks were not sophisticated. Students wrote their notes in their notebooks, however, wherever they wanted. They were all not on the same page since they kept their own numbering system without any organization or apparent logic. No structure in the notebook existed which made it difficult for Bill to grade them. By the end of the year, he was frustrated. Bill did not want to deal with the notebooks anymore. He found that the students were not invested in them because they were tedious and menial. Bill thought of notebooks as a pain and something extra in his way adjusting into the new atmosphere. For him, the notebooks were a waste of time and did not work at all. He gave up and was determined to not use them in near future (Figure 1).

*Figure 1.* Bill's frustration with interactive notebooks

That summer, the situation changed. Bill was invited to AVID (Advancement via Individualized Determination) training, where he was formally introduced to the idea of interactive notebooks for the first time. He learned about the brain-based theory associated with the notebooks, the importance of using color, and the left-hand and right-hand side activities designed for notebooks. Bill returned for a new academic year rejuvenated to try out new ideas that he did not have an opportunity to do the first year. He wanted to consider using interactive notebook for one more year but now with lot more confidence in them. It has been a successful venture since then. The notebook itself constantly evolved over time and so did Bill as a teacher (Figure 2). Now, Bill views interactive notebooks as a testimony of constructive learning and as an innovative approach to instruction.


*Figure 2.* Bill's success with interactive notebooks

**Interactive Notebooks- A Testimony of Constructive Learning**

For Bill, the interactive notebook was a student's text book. Here is an excerpt of the interview where he expressed the idea.

> "It is everything that we do distilled down. So if it is anything from worksheets, textbooks, power points, all these resources, stuff that they had to search for on the web. So everything gets distilled into a little notebook. I try to convince them that when they take physics class in college, they have to have this notebook with them that is good for their review. So I see it as their textbook, as a portfolio, as a record of what they did and how they did. It is a journal. It is a diary."

Bill mandated his students to buy a composition notebook at the beginning of the school year. During the first week of school, he allocated a day for setting up the notebook. He gave clear guidelines as to what he expected students to do with their notebooks. He is currently customizing and adjusting the design of the notebook to meet his students' needs informed by his experiences in using them. "I know some people do title pages on inside of the notebook. I do title page right on the cover. So, I have them fill out in a particular way" Bill said, when talking about design of the interactive notebook for his class. During the conversation he also mentioned,

> "They had to put the formula chart in the back, variable list. So…again another huge jump. They are supposed to do a summary at the end of each page in the cornel notes but I changed my summary to…at the end of two page section because they may be working on both sides of the page and I want them to summarize it all at the very bottom."

Students added new formulas and variables (Figure 3) to the lists as they were introduced during the lesson.

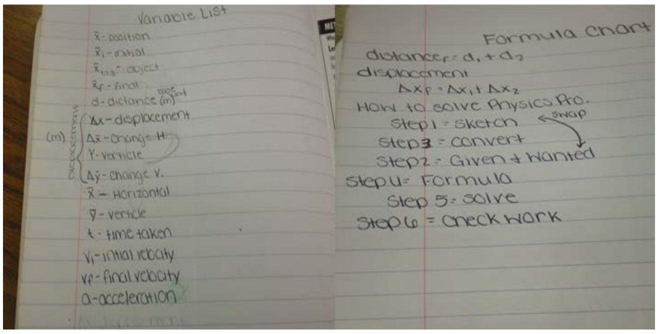

*Figure 3.* Formula and variable charts in the interactive notebook

The first five to seven pages of the notebook was for Table of Contents where the students had to keep a log of the assignments in the notebook for them to access the information easily when required. All students in a class maintained the same page numbers. Here is an excerpt from the conversation where he described the reasons for students to maintain the same page numbers.

> "I want them all to stick to the same pages is so that I can say everybody turn back to page 30 and they can all just as they would in their text book turn to page 30 and have whatever it is I wanted to review before we go on. Turn to page 30 and let's look at sine, cosine, and tangent, basic trigonometry. Turn back to page 42 and let's talk about…let's review what we did for vector analysis when we did displacement. How does this apply to velocity? How does this apply to forces when we started doing force diagrams? So with everybody being on the same page I have the power to say, everybody go to this page number and it being the absolute kind of location instead of having them to go to table of contents and find them."

Students were allowed to use only two pages every day. Those who needed more writing space had to extend the page by attaching more notebook paper but were not allowed to move to the next set of pages. He assured uniformity in the notebooks throughout the class which made it easy for the students to refer back to the material and grading for him. Upon learning the importance of using color, Bill emphasized color in the notebooks. He commented,

> At all the trainings they talked about how the brain learns in color and highlighting is one of those switches the color signifies what it is. It makes it easy for them to look through their notebooks in search of resources. I don't remember that vocabulary and well it is related to this topic I can flip back to the topic and I can see what is it.

He expected the students to highlight the questions in pink, vocabulary in yellow, facts and rules in blue, and formulas in green (Figure 4).

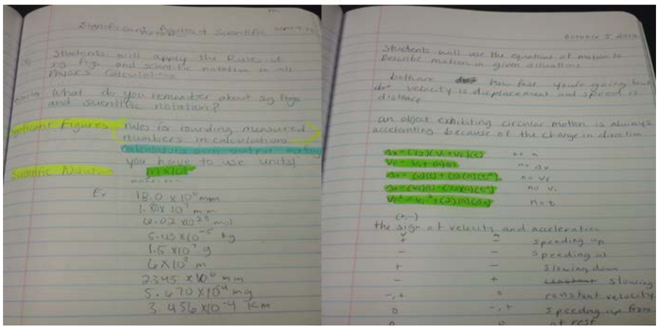

*Figure 4.* Use of color in interactive notebooks

Bill explained the reasons of his choice of colors as follows:

> Pink is my clue and I can see pink across the room. Yellow, blue, and green start to blend in, so I picked pink for a specific reason. Yellow I chose it because it was the most common color. We are going to have the most vocabulary and what I found is yellow is the one that most commonly and easily found. Green is the next easiest to find and so we used it for formulas and so many colors are picked based on logistics more than any other reason.

Bill found that the act of writing, analyzing, and using different colors forced the students to spend more time on the topic.

During a visit to Bill's class, the first author observed that the right-hand side page of the notebook was divided into one-third and two-thirds. Students used the two-thirds of the page for teacher-directed information such as notes from lectures and presentations while the remaining one-third was for writing questions for the teacher, cues, key words, concepts to remember, and other memory triggers. The left-hand side of the notebook was for the students to take the information on the right hand side and formulate something new in a way that appealed to them. Although Bill has difficulty coming up with activities such as poetry, and riddles, his strong points are doing sketches, brain maps, brain storming, reflections, and summaries (Figure 5).

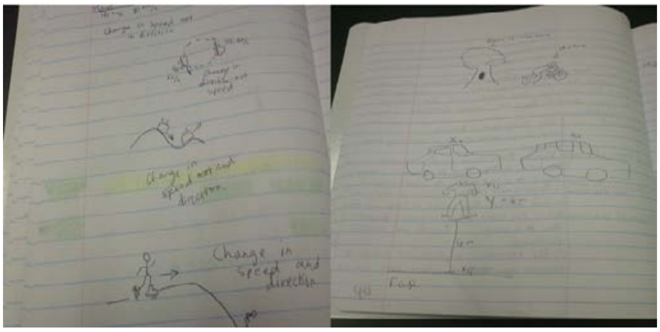

*Figure 5.* Left-hand side page in the interactive notebook

During an interview Bill mentioned that students were required to write a summary at the end of class every day that reflected their thinking. Bill started class every day either with a warm-up question about what they were doing that day or a summative question from what they did the day or week before. "Explain how you measure changes as you move around in a circle. Be sure to discuss positive and negative directions. Draw the sketch". This was one of the approaches Bill used that the first author also noticed during a classroom observation.

Here is an excerpt from the interview where Bill described how his students synthesized information in his class.

> So, part of the synthesis is they take the given problem on the right hand side, draw the visual representations of it, process the information, apply what they learned to the new situation and solve the problem. And how taking a concept that is truly concrete on the right hand side and explaining as an illustration on the left hand side is synthesis. They take the vocabulary and filter it through the language centers of the brain and to put it back into art. They are taking the information, chopping up, mixing it, and reestablishing it and then putting it back in a different format. Every day I have a starter question that they put down on the right hand side and they answer on the left. It can be a question to review the stuff from day before. It can be a question to prepare for the lesson coming.

It is evident that the students in Bill's class were no more working at knowledge level but were now demonstrating higher levels of thinking in their notebooks, mainly analysis and synthesis of information.

Bill negotiated autonomy in his classroom by allowing his students to decorate the notebooks with pictures they like but related to physics in some way (Figure 6).

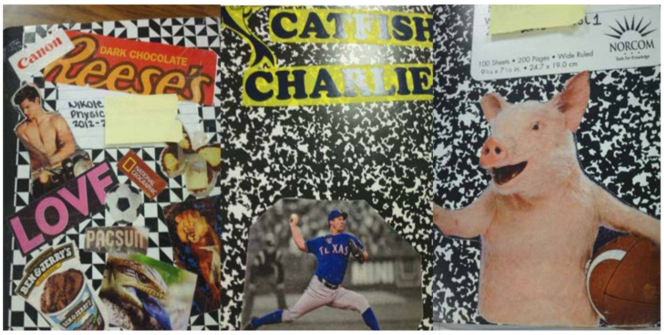


*Figure 6.* Front cover of the interactive notebook

Not only did the activity allow students to take ownership of their notebooks but also gave him a chance to see what his students conceived as physics. Illustrating the importance of the activity, Bill said,

> I ask them to take it home and decorate it because generally we don't have time in class. Decorate it however you want. What makes it you. The one thing I would like is that somehow it should be related to physics. Some of those who decorated were completely off. There was no physics there but you know what, that is what they thought physics was. I had a kid last year who had put their glass jewels all over it. Made the note book weigh five pounds but we knew whose it was. It was her's and she was happy for it. And I have this students' sister in my class this year and she has mentioned that the notebook is still at the house so if she had that much value not to throw it away then I did something right with it.

Bill realized that the students valued the notebooks and the amount of effort they put into them. He noticed that the girls took the notebooks more seriously than the boys. During the interview, Bill commented,

> Most of the girls did them seriously**.** Wrote notes and did the right hand side, left hand side, used colors and highlighting. They wanted to really keep this something they could be proud of and I think that especially with science being the field where women necessarily do not take interest. Whereas boys, especially in my lower level physics classes…didn't think they needed it. It was anti macho.

Unlike other teachers in his department, Bill did not keep notebooks in the classroom. He required the students to assume responsibility for their learning. Since Bill used a class set of textbooks, the only resource available for them to do homework or prepare for tests is their notebook. With physics being a subject that builds topic upon topic, Bill understood the importance of having all the material they learned in one place, which offered a chance for students to flip back and make meaningful connections between different concepts. Unlike doing their work on separate sheets of paper, the notebook allowed students to see each concept as a part of the collective and not as a separate entity. They were required to take their notebooks home and bring them to class every day. Bill was proud that only one or two students out of the thirty in a class might lose their books mostly because of catastrophic reasons. If they ever did then they were expected to replace the notebook with a new one. Recalling one of the instances from his school year, Bill mentioned,

> I had a kid that dropped his notebook in a puddle and he brought it back and we put paper towels in between the pages and we set it in front of the fan that I had and after a week it was dried out. Instead of it being a nice flat you know… less than one inch book, it was three inches but he recovered his notebook and actually it was pretty cool looking because the ink bled and everything else…you can still read it but it was his and he was proud of it and which those who do it, it becomes something that they really are glad to have.

It became apparent that both Bill and his students treasured the notebooks dearly. More importantly, it seems that while Bill experienced his own tensions and skepticism towards interactive notebooks, his ownership of interactive notebooks being a useful tool in his classroom engaged the students further. Additionally, Bill became more engaged in how he wanted to instruct students, flexibility he wanted to offer to students, and create a constructivist learning environment. Consequently, the students started taking ownership of their own learning, creating meaning, dialoguing with Bill about the meanings they were making through their work in the interactive notebooks. Eventually, the notebooks became an extended part of who the students were, so much so that losing information in the notebook due to damage in the puddle was unacceptable and collaborative efforts were made to salvage what one owned proudly, the learning environment, and the product that was created through the support from the learning environment.

**Interactive Notebooks- A Pioneering Approach to Instruction**

Bill viewed the notebook as an authentic tool to assess his students' understanding of concepts. He allowed them to use the notebooks on the tests and quizzes. Several students liked the idea of having a safety net even though some of them eventually stopped using notebooks on the tests. Bill observed that the students who did the best job in their notebooks made the best grades in his class. When he had students that performed poorly on a standardized test, Bill could look at the notebook and evaluate their understanding of the concepts. It also helped students assess their own learning and reflect on it. Describing how he used notebook as a diagnostic tool, Bill reported,

> If I have a student that does not test well, I can still look at their notebook and know where they are with the concept. It is also a way for the students to know why they didn't do well on the test. OK… let us look back at the problems you did in the notebook. Oh… I didn't do the problems. OK… what do you need to do to improve. And once they start doing that… it is a carrot and a stick. It can be fun to do the creative stuff but I can use it for, oh you didn't do this. You left it blank.

The interactive notebooks helped Bill as tools for formative assessment. They aided Bill in better understanding his learners. Students that caused problems as well as those who asked questions demanded his attention, but those that didn't speak up were lost. Bill noticed that the notebooks quickly became the medium for communication between him and the students. Reflecting on his practices, Bill remarked,

> It was that the students who don't speak up and get caught in the middle, who I was not sure what they were doing, are they getting it? Are they participating in the lesson? The ones causing problems get my attention, the ones that are asking questions get my attention the ones in the middle don't and what worked extremely well with the notebooks is that those kids that I thought were doing nothing, I asked to see their notebooks and they proved me wrong. They proved that they were doing more than what I thought they were doing. For me that is the greatest benefit of doing the notebooks.

Bill recognized an increase in the critical thinking and problem-solving abilities of his students when using interactive notebooks in his class. When we asked Bill about how the interactive notebooks affected his students' understanding of the information, he paused for few seconds and said,

> With problem solving, it is easy to see if they are understanding the problem. I could see the mechanics of the calculations. Did they get it right, do they have all steps and did they do it correctly? I look at their drawings. I am a comic book reader so it is very easy for me to understand and interpret their drawings. I ask and if they can explain what they have done and why they did it, I know they are understanding the material. It is not quantifiable. It is a subjective type for assessment.

Bill agreed that the interactive notebooks have transformed his learners from being passive listeners to active learners. He acknowledged that the notebooks have transformed his teaching dramatically over the past few years. During the conversation he said that the notebooks constantly come into his thinking when planning lessons, formulating questions, and designing assignments that lived on both sides of the notebook. Although Bill struggled to design activities for the left-hand side, he was proud of the improvements he made in using more cognitive tools to make the notebooks work better for his students. Reflecting on his experiences, Bill mused,

> Over the past few years, I am becoming more and more comfortable with the notebooks, I am using them more and more, I am putting more effort into the notebook hoping that they (students) would also invest their time and effort. I try to incorporate other people's ideas into my work. A notebook is a very strong attempt to bring all students into a place where they can learn even if they have very different learning styles. We do not have little machines sitting in our classrooms. They are each individuals. They come from different places and they learn differently.

The interview excerpt clearly describes the idea that Bill embraced the idea of multiple intelligences and incorporated the aspects of UDL into his instruction to fulfill the needs of his learners. The notebooks allowed Bill to see the differences in his learners and acknowledge their individual strengths and weaknesses. Bill discovered innovative ways to not only incorporate students' experiences and varied interests into his lessons but also found authentic ways to assess his students understanding of the material. He was able to connect with his students more effectively and invite them into his world of learning physics, by using notebooks to provide multiple venues for success. By incorporating interactive notebooks in physics instruction, Bill provided space for students become actively engaged in the process of thinking about their thinking, which is the true essence of learning.

Since education has been undergoing constant transformation, teaching calls for a significant change in science education to make it effective and relevant for a much larger fraction of the student population (Wieman & Perkins, 2005). Therefore the goal of the science community is not just to train a small population to be future scientists but to build a large group of people who can understand science (Redish, 1994). Physics is a key domain of science without which students face reduced access to jobs in today's technological and scientific world (Sadler & Tai, 2001). However, there is a decline in the number of students who are choosing to take physics during their college studies. This is because of their low expectations for success in physics and their perceptions of it as less interesting and more difficult in comparison to other sciences (Bramby & Defty, 2006).

With defined capacities like spatial intelligence, bodily-kinesthetic intelligence, interpersonal intelligence, and musical intelligence, the theory of multiple intelligence establishes a direct correlation of intelligence to visual art, theater, dance, and music, affirming the of need to educate young people in these domains in order to fully reach all students (Groff, 2013). A survey of more than 3,800 individuals conducted by the Group Brain Project at Harvard revealed that more than 80 % of participants were nonverbalizers (Chabris et al., 2006) which suggests that there is a significant portion of the population whose dominant cognitive processing system is not language based. Therefore there is a need for alternate instructional and assessment opportunities. This argument explains the need for interactive notebooks for physics instruction and an understanding of students' and teachers' experiences in an in-depth manner to explore the context of concept development. The notebooks can enable teachers to design rich, engaging, and creative learning experiences for the nonverbalizing population in their physics classes (Moran, Kornhaber, & Gardner, 2006).

## Discussion and Implications

This study was designed to explore the experiences of a teacher from an inner city high school in South Texas when using the interactive notebook to inform students' understanding of physics concepts. Two major themes were identified after analyzing the data from the study: Interactive Notebooks - A Testimony of Constructive Learning**,** and

Interactive Notebooks - A Pioneering Approach to Instruction. Although Bill's initial introduction to the notebooks was described as painful and confusing due to lack of understanding, the insight that he gained from the training on the notebooks helped change his perceptions and motivated him to move forward with them. He went from not believing in the idea of interactive notebook to now customizing and personalizing them for students to fit their needs in his classroom. He describes the notebooks as 'constantly evolving'.
For Bill, the interactive notebook is a student's textbook, a diary, a portfolio of their accomplishments, and a record of what and how they learned the concepts. He views the notebook as a diagnostic tool for both students and teachers to assess and communicate their understanding of the concepts without the fear of failure. The interactive notebook provides the student with autonomy and ownership of their learning. It is a safe space for students to construct meaning of the material taught in the class using their experiences and express it in a way they like. This is especially critical to understand since many students fear learning science and many teachers and students perceive science in the classroom to adhere to strict guidelines, devoid of creativity. According to Bandura (1993), the aspirations, level of motivation and the academic success of students depend on their beliefs of self-efficacy to control their own learning and master the academic activities. The notebooks not only transformed the learning of Bill's students but helped inform his own teaching practices making him a better teacher.

Since the 21$^{st}$ century students are not passive learners, it is hard for them to learn something that they already did not encounter in their life in some form or the other. They come into science instruction with deeply rooted conceptions and ideas that are not in harmony with the science views or are even in stark contrast to them (Redish, 1994). These pre-instructional conceptual structures of the learners have to be fundamentally restructured in order to allow understanding of the intended knowledge, that is, the acquisition of science concepts (Duit & Treagust, 2003). The different learning pathways students take to integrate the new knowledge to the previously existing knowledge is often addressed as conceptual change (Novak, 2002). There is not one set way of teaching physics as different students learn differently depending on their learning style. People learn better by doing than by watching something being done (Redish, 1994). Khol and Finkelstein (2005) noticed that students learn better when they are given a choice to represent a particular concept or problem in multiple ways. Therefore, teachers must provide students with learning experiences that promote the construction of their own knowledge in order to attain higher cognitive level outcomes.

Research in high school science classrooms has indicated that these things seldom occur as the teachers are concerned about covering the content in the syllabus and ensuring that students perform well on tests and examinations (Geelan, Louden, & Wallace, 2004). Research also suggests that the ability to use knowledge in new contexts without the need for explicit prompting can increase with the use of metacognitive strategies (Mestre, 2001). Metacognitive strategies help learners become conscious of their learning by monitoring their own understanding through self-regulation; ability to plan, monitor success and correct errors when appropriate; and assess their own readiness for high level performance in the field they are studying. Reflecting about one's own learning is a major component of metacognition. But students seldom reflect in their physics classes because instructors do not emphasize the importance of reflection in the learning process. Students come into their first year course of physics with a system of beliefs derived from a wealth of personal experiences (Fencl & Scheel, 2003). These beliefs are major determinant of students' learning and are often ignored by physics teachers. As a result teachers fail to impact students' thinking about the physical world. Several teachers are fooling themselves that they are teaching successfully when in reality they lower the standards by removing the word understanding from the definition of successful learning (Redish, 1994).

Geelan, Louden and Wallace (2004) suggest that instruction should move from the teacher's role of being a source of knowledge and control to that of a facilitator of a student-directed search for understanding. An effective instructor has a wealth of pedagogical content knowledge along with the expertise in a discipline. They must be aware of the types of difficulties that students experience, different paths students take to achieve understanding and probable strategies for helping students overcome learning obstacles, all of which are discipline-dependent (Mestre, 2001). Another important aspect missing from today's science classrooms is formative assessment, mainly intended to provide feedback to both students and instructors. This feedback can give the students an opportunity to revise and improve the quality of their thinking, and instructors can tailor instruction appropriately. The age-old fashion of presenting a question to the class to which only a few students reply by raising their hands does not seem to work well for assessing students' conceptual understanding. It is very important for the teachers to attend to students' gestures when learning physics as it helps in diagnosing students' thinking and forming effective pedagogical responses (Scherr, 2004). The new knowledge constructed by the students always depends up on how the information given by the teacher interacts with the prior knowledge that the students have. Many teachers are interested in promoting scientific literacy, in helping students think analytically, or in having them understand the impact of science on the real world through the use of effective non-traditional techniques such as no texts, fewer topics and project work. But sadly they must defend their decision to skeptical parents and administrators (Sadler & Tai, 2003). So, one of the biggest restraints to using formative assessments in science classes is that instructors lack techniques that seamlessly blend in with instruction (Mestre, 2001).

The findings of the study provide evidence that an interactive notebook used in this context of physics education was an effective and powerful strategy which promoted scientific inquiry, focused on students' individualized learning styles, and reinforced research in the field where interactive notebooks are seen to enhance general learning, personalization, and metacognition strategies (Chesbro, 2006). Bill's story can change the story of many teachers who fear to step out of their comfort zones and use this tool to influence teaching and learning positively. The rich stories described by Bill in this study might help educators gain a better understanding of the multiple, non-linear approaches that children take to interact with the concepts of physics. Most of the attributes of good physics education using interactive notebooks described above does not confine specifically to learning physics; these are general foundations for good teaching/learning across all content areas.

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