

**DESIGNING VIRTUAL SCIENCE LABS FOR THE
ISLAMIC ACADEMY OF DELAWARE**

by

Nada Saeed AlZahrani

An executive position paper submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership

Summer 2015

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by

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DEDICATION

This study is dedicated to my beloved father who passed away two months before the completion of this effort and whom I miss dearly

Saeed Al-Zahrani (1955-2015)

for his support, wisdom, endless love, and being the light of my life. I hope that I have achieved his wish and made him proud. Without fail, in every phone call he and my mother would ask if I had finished my studies yet. I doubt I could ever explain sufficiently to him, but I deeply regret I will never be able to say to him “Yes, I have finished!” No words are sufficient to express my deep gratitude and appreciation to my wonderful mother *Sameerh* for her continuous encouragement and for dealing with me being worlds away. Gratitude and love go to my sisters, brothers, and all of my extended family for their help, love, support, and prayers each in their own way.

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ABSTRACT

Science education is a basic part of the curriculum in modern day classrooms. Instructional approaches to science education can take many forms but hands-on application of theory via science laboratory activities for the learner is common. Not all schools have the resources to provide the laboratory environment necessary for hands-on application of science theory. Some settings rely on technology to provide a virtual laboratory experience instead. The Islamic Academy of Delaware (IAD), a typical community-based organization, was formed to support and meet the essential needs of the Muslim community of Delaware. IAD provides science education as part of the overall curriculum, but cannot provide laboratory activities as part of the science program. Virtual science labs may be a successful model for students at IAD. This study was conducted to investigate the potential of implementing virtual science labs at IAD and to develop an implementation plan for integrating the virtual labs.

The literature has shown us that the lab experience is a valuable part of the science curriculum (NBPTS, 2013, Wolf, 2010, National Research Council, 1997 & 2012). The National Research Council (2012) stressed the inclusion of laboratory investigations in the science curriculum. The literature also supports the use of virtual labs as an effective substitute for classroom labs (Babateen, 2011; National Science Teachers Association, 2008). Pyatt and Simms (2011) found evidence that virtual labs were as good, if not better than physical lab experiences in some respects. Although not identical in experience to a live lab, the virtual lab has been shown to provide the

student with an effective laboratory experience in situations where the live lab is not possible. The results of the IAD teacher interviews indicate that the teachers are well-prepared for, and supportive of, the implementation of virtual labs to improve the science education curriculum. The investigator believes that with the support of the literature and the readiness of the IAD administration and teachers, a recommendation to implement virtual labs into the curriculum can be made.

Chapter 1

INTRODUCTION

Science education is a basic part of the curriculum in modern day classrooms. Instructional approaches to science education can take many forms but hands-on application of theory via science laboratory activities for the learner is common. The National Board for Professional Teaching Standards (NBPTS) sponsors the National Board Certification program, focused on how able teachers were at providing high quality learning opportunities. One of the twelve standards for the teaching of science, Fostering Science Inquiry, NBPTS (2013) stresses the point that learning happens best by doing and that students must have ample hands-on opportunities. In Bohr's report on the teacher's perceptions of virtual labs (2014), she stated that "accomplished teachers are encouraged to take full advantage of the technology resources available. While not specifically addressing the use of virtual labs, the NBPTS implied that technology, including the use of online courseware, can enhance the learning experience."

Not all schools have the resources to provide the laboratory environment necessary for hands-on application of science theory. Some settings rely on technology to provide a *virtual laboratory* experience instead. Babateen (2011) found this to be true, stating that virtual labs are seen as alternative methods to original and real experiments when there are financial constraints and space considerations. This relationship of education and technology is a complementary one, the success of

which depends on the level of consistency and compatibility. When students learn using technology in a manner that encourages systematic thinking, based on the alternatives and possibilities, they not only interact with a new world of information and communication technology, but are able to use it creatively.

The Islamic Academy of Delaware Science Program

The Islamic Academy of Delaware (IAD), a typical community-based organization, was formed to support and meet the essential needs of the Muslim community of Delaware. IAD has taken steps to fulfill a long felt need to develop an Islamic school for the ever-increasing Muslim community in Newark, Delaware. It was, and still is, a difficult task to fulfill this dream due to a lack of financial resources. But, with patience, hope, and faith, the community has taken small but significant steps over the years to make this dream come true. Established in 2008, IAD is an official full-time school for the Islamic Society of Delaware. It is registered with the Delaware Department of Education to serve the needs of the Muslim community in the State of Delaware. The IAD began with just a few of the lower grades (pre-K through first), and expanded one grade each year thereafter.

IAD recognizes parents as the primary educators of their children and seeks to assist this effort by helping students develop to their full spiritual and intellectual potential. The IAD recognizes children as a precious gift from Allah (God). As such, the entire school community is dedicated to providing quality education in order to prepare Muslim children for success in a complex, technologically advanced, multicultural society. The IAD mission statement states that the IAD “envisions and works towards the day when Islamic schools will be the preferred centers for learning

and leadership that nurture and encourage children to develop their innate creativity and inquisitive nature in the pursuit of academic excellence, while anchoring their hearts and souls in a moral framework of a life centered on the Islamic faith.”

The IAD offers classes to children as young as 36 months of age through grade eight. IAD strives to provide a comprehensive, value-based, educational program in an Islamic environment, with a comprehensive curriculum offering a broad range of academic and religious subjects. In addition to standard curricula adopted from public schools (Language Arts, Mathematics, Science, Social Studies, and Health and Physical Education), IAD also offers Arabic, Quran, and Islamic Studies. IAD is experiencing a high enrollment rate at this time; however, they have very limited funds and resources. IAD relies on just the tuition payments to meet its expenses. The IAD struggles with resource issues such as limited space and inadequate financial support. Because almost every room in the building is a classroom, there is limited room for facilities such as a science laboratory.

Purpose of the Study

IAD provides science education as part of the overall curriculum, but cannot provide laboratory activities as part of the science program. The lack of funding for equipment and materials has prevented students from the laboratory experience that would prepare them for scientific careers. Virtual science labs may be a successful model for students at IAD. Virtual labs can be designed to fit into student schedules, are flexible, and provide real experience using online instruction. This study was conducted to investigate the potential of implementing virtual science labs at IAD and to develop an implementation plan for integrating the virtual labs.

The rural and private schools with limited funds seen in Bohr's study (2014) face many of the same challenges as the IAD; they may not be able to provide quality lab facilities, supplies, or prepared teachers. In their study, Hannum, Irvin, Banks, & Farmer (2009) found that "rural schools face unique challenges...can have difficulties offering a comprehensive curriculum that includes upper-level courses, advanced placement courses, and vocational courses because of financial and human capital constraints" (p. 1). Virtual labs represent the technological innovations that have emerged in recent years. This phenomenon is an extension of the early simulation of electronic systems; they mimic real laboratories and can obtain similar results.

This study addresses the following questions:

- What are the best practices of virtual science labs for K-12 schools?
- What are examples of effective virtual science labs?
- To what extent is the staff at the IAD ready to support virtual labs?

Science is about understanding the world around us. To understand it, we must explore it. As noted by Wolf (2010) however, "laboratories are important environments for student learning. High setup and maintenance costs make it challenging to provide laboratory facilities at institutions where budgets and technical expertise are limited" (p. 216). The National Research Council (2012) developed new national science standards aimed at improving student performance, in the fall of 2012. The council's framework for K-12 Science Education stresses the importance of laboratory inquiry at every grade level. Students should be able to investigate well-formed questions and then execute the steps of scientific method in a thorough manner to achieve results.

Scalise, et al. (2011) found that offering students the most effective teaching methods is vital for learning, but organizations are faced with many constraints to deliver them: (a) high cost of lab equipment; (b) the dedicated school space for hands-on labs; (c) the possible dangers of using chemicals, tools, and other lab materials; (d) the hours needed to set up traditional experiments and repeatedly gather data; and (e) the ethical questions when using real animals or material that may not be environmentally friendly. These constraints are more difficult in the smaller schools that do not have science labs. Virtual labs may be the answer students need to get lab experience in science courses in order to meet graduation requirements that can qualify a student for college acceptance. For schools struggling with the costs, practicalities, and philosophy of providing real labs, virtual labs have significant advantages that make a strong case for virtual science instruction.

Definition of Key Terms

The terms defined in this section provide a framework for this paper.

- *Blended labs* combine technology-mediated, classroom instruction, and/or virtual labs (National Science Teachers Association, 2004).
- *Best Practices* can be described as teaching practices that facilitate engaged student learning.
- *Best instructional/teaching practices* can be defined as “a superior method or an innovative process that contributes to improved performance” (Spencer & Johnston, 2003, p. 19), in instruction and teaching or manner in which “a science teacher uses materials, media, setting, and behaviors to create a learning environment that fosters desirable outcomes” (Fraser & Walberg, 1995, p. 70).

- *Traditional laboratory* (also referred to as a lab, face-to-face lab, or hands-on lab) refers to classroom laboratories, or the field work where students can interact directly with data collected by others or natural phenomena. Students can manipulate real equipment, chemicals, and specimens. (National Research Council, 2001).
- *Virtual labs* can be defined as virtual studying and learning environments that simulate real labs. They provide students with tools and materials; students access the lab via a computer in order to “perform experiments subjectively, or within a group, anywhere and anytime (Babateen, 2011).” They are “lab activities involving computerized models, simulations, and other manipulative programs used as a replacement for face-to-face lab activities (Scheckler, 2003).” Teachers can use virtual labs in addition to or instead of a laboratory exercise. Virtual labs can employ computerized models and simulations to replace face-to-face lab activities. Keller & Keller (2005) defined the virtual lab as a laboratory experiment without real laboratory walls and doors.
- *Laboratory experience* “is a key factor in technical and scientific education. Virtual laboratories have been proposed to reduce cost and simplify maintenance of lab facilities while still providing students with access to real systems (Wolf, 2010, p. 216).” Laboratories are important for student learning. “High setup and maintenance costs make it challenging to provide laboratory facilities at institutions where budgets and technical expertise are limited” (ibid, p. 216). In response, virtual laboratories have addressed these challenges. Virtual laboratories allow using real systems with remote access. As such, laboratory resources can be

shared among a large group of users in multiple locations and limiting the overall setup and operational costs (Wolf, 2010).

Review of the Literature

Several areas related to science learning, specifically virtual labs, were examined. The investigator reviewed relevant studies to identify the role of labs in science education and how virtual labs compare to classroom labs. The investigator originally focused on studies of mid to upper grade levels, while elementary and college level studies were not considered. However, more studies appear to have been conducted at the college level than the lower grade levels, so they were included in this investigation.

Scientific and technical literacy is relevant for all people today. This can be achieved only by implementing effective science education programs in schools. Hands-on laboratory experiments in sixth through twelfth grade science are mandatory in many school systems. In fact, they are required by most U.S. states (National Research Council, 1997). The laboratory has been a part of science instruction since the late 1800's. Labs provide learning opportunities in observation and the testing of hypotheses, while encouraging student interest in the sciences (Blosser, 1990). Labs are still seen as a relevant teaching method. In the 1880's, Professor Josiah Cooke developed a pamphlet outlining a good lab experience, beginning with observations that allowed the students to make their own inferences in order to arrive at general scientific principles (Tamir, 1976).

In the late 1900s, the National Science Teachers Association (NSTA) agreed that laboratory experience is integral to student learning in every science program

(2004). Keller and Keller (2005) agree with this assessment stating that the “laboratory is a vital environment in which science is experienced...problem-solving abilities are refined in the context of laboratory inquiry... provides an optimal setting for motivating students while they experience what science is” (para.1 and 2).

Science experiments let students test hypotheses, observe science concepts in practice, and interact more directly with the natural world (Wolf, 2010). The role of laboratory work in science education has been detailed by several researchers. Dikmenli (2009) reports the main purpose of laboratory work in science education is “to provide students with conceptual and theoretical knowledge to help them learn scientific concepts, and through scientific methods, to understand the nature of science.” Laboratory work also provides opportunities to use scientific research procedures. Laboratories can develop analytical and critical thinking skills as well as encourage an interest in science.

Dikmenli (2009) reviewed several research articles that support the use of laboratory work in science education. He found that “to date, many studies have been conducted on the importance of laboratory work while teaching science” (p. 2). He found agreement between science educators that laboratory work is integral to the understanding of science.

Student-led experimentation and scientific inquiry is a popular method in today’s schools as they strive to invoke higher order thinking and problem solving skills into everyday situations. Many initiatives of this nature are promoted by organizations such as *The Partnership for 21st Century Skills*. They promote the idea that students not only understand scientific concepts, but develop the skills of inquiry,

technology use, and an understanding of science in their own lives (Partnership for 21st Century Skills, 2008). The National Research Council (2012) provides guidance for standards in science education and how those standards support student learning.

The literature reflects the expectations and requirements for laboratory experiences in schools through documents and statements issued by professional educational organizations, state curricula, and national standards. The *National Science Education Standards* were published in 1996 by the National Committee on Science (National Research Council, 1996). According to the Committee on Conceptual Framework (National Research Council, 2012) for the New K-12 Science Education Standards:

The overarching goal of our framework for K-12 science education is to ensure that by the end of 12th grade, *all* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of science, engineering, and technology. (p. 9)

The framework discusses the computer for use in simulations and data collection as well as analysis and assessment. While the framework does not directly reference virtual labs on computers as a replacement for traditional labs, it does focus on the goals of science education, not the means and practices used to reach them.

The Integral Role of Laboratory Investigations in Science Instruction, NSTA (National Science Teachers Association, 2007) stated that “labs are an integral part of proper science education courses and that every student should have the opportunity to explore scientific phenomena, collect and analyze data, understand the scientific method, develop skills to handle equipment, learn to collaborate with others, and present resulting data” (para. 2) While NSTA does not reference virtual labs as a

replacement for traditional labs, they sponsor a website called the NSTA Learning Center (<http://learningcenter.nsta.org/default.aspx>) that features webinars for teacher professional development, including virtual laboratories.

Dikmenli (2009) lists the purposes for lab work in science education as follows:

- Supporting or strengthening theoretical knowledge
- Experiencing the pleasure of discovery and development of their psycho-motor skills
- Teaching how scientific knowledge may be used in daily life
- Increasing creative thinking skills
- Improving scientific working methods and higher order thinking skills
- Developing communication skills
- Developing manual dexterity by using tools and equipment
- Allowing students to apply skills instead of memorizing

A more recent policy document (Rocard et al., 2007), written by the *High Level Group* on Science Education, argued that the inquiry-based methods would increase the students' interest in science. The report claims that inquiry-based science education (IBSE) has been a proven method for both primary and secondary school levels by increasing interest and attainment levels while also improving teacher motivation. The study supported the use of IBSE by stating that:

IBSE is effective with all kinds of students from the weakest to the most able and is fully compatible with the ambition of excellence. Moreover IBSE is beneficial to promoting girls' interest and participation in science activities. Finally, IBSE and traditional deductive approaches are not mutually exclusive and they should be combined in any science classroom to accommodate different mindsets and age-group preferences. (p. 2)

Technology and Science

There is no doubt that education is a human investment. The intervention of technology in this investment has brought attention to the role of that technology in the educational process in recent years. There has been considerable debate about the

importance of technology in education to include the types of technology, the feasibility of its use, and the best methods for incorporating technology into the education process. In addition, there is the question of how technology in education can raise the performance of both teachers and students.

Multimedia and the web make it possible to simulate laboratories. Schools can now offer students virtual laboratories via the internet or multimedia. Students can now solve experiment-oriented problems without schools incurring the overhead required for a full laboratory.

Several reputable groups have issued guidelines or statements concerning the use of virtual laboratories. NSTA, for instance, supports virtual labs in the blended classroom activities for kindergarten through college (National Science Teachers Association, 2008). However, they stress that the virtual lab experiences must be integrated into the overall process using well-designed laboratory activities.

Professional organizations for science education, such as the National Science Teachers Association, emphasize that student interest and acquisition of science skills can be enhanced with hands-on activities. Classroom teachers determine that a student has met the objectives of a lab experience through observation of the student during the activities and by asking the students questions. Teachers can also measure a student's understanding by having the student complete a clearly written lab report that describes the purpose of the activity and explains their conclusions.

Virtual Labs

Kolloffel (2013) found virtual labs to be an easy and effective means to present the laboratory experience. The virtual lab provides the students' learning

environment as well as their laboratory environment, and is located on a website that usually contains a main page with links to the activities, achievements, and laboratory evaluation.

In an article from Digital Learning, Joseph (2012) agrees that virtual labs are effective, stating that they “have slowly and gradually become meaningful alternatives to physical labs” (para.2). The latest computer technologies allow for web-based laboratories to be used as a substitute to actual labs. The article continues by discussing how engineering and scientific disciplines use virtual labs in Indian educational institutes.

Organizations such as the armed forces and medical fields successfully create and use virtual labs for training. As reported by Long (2007) via the National Education Association, “Doctors use them to practice surgery” (para.1). If these organizations deploy virtual labs successfully, why not extend them into the school classroom?

Effectiveness of Virtual Labs

Rajendran, Veilumuthu, & Divya (2010) studied the effectiveness of virtual labs used in Chennai, India. The study analyzed whether there was an increase in learning skills and a better understanding of concepts by implementing virtual labs for school students. The study also focused on whether virtual labs help increase self-paced learning among the students. The study showed that the majority of the students were familiar with and liked virtual labs. The students seemed to prefer computer assisted tools rather than textbooks for learning. A member of the study team, Suresh Kumar, stated that “the animations (visuals) have a huge impact in the

minds of the students, even though they might not recognize the technology behind them.” (p. 2174) Kumar views the virtual labs as a very interactive component that helps the students understand the concepts. Kumar also believes that “future generations will use computer based tutorials with embedded virtual labs and the number of students reading books will be negligible.” He felt strongly that multimedia formats will surpass all other media.

Pyatt and Sims (2011) found that student performance showed very little difference when comparing the virtual lab and the physical lab. Their study took place in a public suburban high school in the southwestern United States over a two year period. They reviewed assessment data to determine the instructional value of physical and virtual lab experiences as they relate to student performance and attitudes. The researchers found that “students showed a preference towards the virtual medium experiences...students found virtual experiences to have higher equipment usability as well as a higher degree of open-endedness” (ibid, p. 133). This study reviewed the learning dimensions that occur in physical and virtual hands-on, inquiry-based lab investigations for first-year secondary school chemistry classes. The results demonstrated “virtual lab experiences resulted in greater learning gains...equal to, if not greater than physical lab experiences” (p. 143). Learning outcomes appear to show that virtual lab experiences can be equal to, or better than the traditional lab experiences. This study also indicated that students had a preference towards the virtual lab simulations.

Brian Woodfield disagrees with the position that the lab experience cannot be provided in a virtual lab (Woodfield, B., Caitlin, H., Waddoups, G., Moore, M., San,

R., Allen, R., and Bodily, G., 2004). In his study, *Virtual ChemLab Project*, he found that the virtual lab can meet most if not all of the learning objectives in a science lab. The purpose of the *Virtual ChemLab Project* is “not to teach laboratory technique...” but “...instead focus on the ‘what’, ‘when’, and ‘why’ of experiments” (p. 1672). The *Virtual ChemLab Project* used observation and interviews, both online and live, of 1400 students enrolled in freshman-level chemistry, in computer labs employing virtual assignments. The study found that two thirds of the students thought the simulation programs allowed them more freedom to explore and repeat experiments because they were easy to use.

Wolf (2010) performed a study on assessing student learning in a virtual laboratory environment at the graduate student level using Open Network Lab. The results of the study indicate firmly that learning indeed occurs during lab sessions as compared to live lectures, but the numbers are very close; 45.9% of students learning in labs as compared to 54.1% in lectures.

Schools in Turkey experience limitations to hands-on experiments due to lack of equipment, but could experience the labs virtually. A study of ninth grade students investigated their achievements with and attitudes toward virtual labs. For this study, the test group completed sixteen virtual experiments using a flash program. The results of the study showed that the virtual laboratory had a positive impact on students’ achievement and attitudes compared to traditional teaching methods (Tuysuz, 2010).

Another similar study was conducted in Taiwan by Koun-tem Sun. This study focused on learning styles and the use of web-based virtual labs for elementary

students (Sun, 2008). Sun considered the virtual lab to be an “experimental teaching method.” His study concluded that (a) virtual lab students achieved better grades than those in the traditional labs, (b) the web-based virtual learning environment accommodated well for various learning styles, and (c) that the majority of students (75%) preferred web-based virtual labs to reading textbooks.

Virtual labs reflect a movement among educational institutions to make the equipment and elements of a traditional science laboratory more accessible to learners from any location, via the web. Johnson (2012) found in his research that virtual labs allow students to practice in a “safe” environment rather than attempting to use actual lab equipment. He concluded that virtual labs are a viable substitute when lab equipment is inaccessible. He also found that the virtual lab could relieve the financial burden imposed by actual labs.

In Chen’s study (2010), virtual labs were found to be acceptable ways to model authentic laboratories. Babateen’s study (2011) found that virtual labs can provide advanced individualized learning to meet educational needs and provide flexibility. He also found that one of the most important features of the virtual world is how easily you can update the content to address changes in learning objectives, unlike physical labs where changes require financing and construction.

Carnevale’s (2003) article reviewing an online microbiology lab at the University of Texas, *The Virtual Lab Experiment*, reports on the effectiveness of virtual laboratories. In the article, he interviews Vicki Freeman, chairwoman of clinical laboratory science. She remarks on how students can perform bacterial studies virtually using more variables than would be allowed in a clinical lab.

Carnevale notes the high cost of materials and time necessary for clinical laboratories. He states that “with the virtual lab, students don’t have to worry about messing up,” and they do not have to fear wasting time and materials. Carnevale highlighted a program run by Professor J. Reeves at the University of North Carolina and Professor D. Kimbrough at the University of Colorado. In their program, students at a local community college performed remote chemistry experiments. Professor Reeves commented that “...they are also learning at least as much as they would learn in an on-campus chemistry lab” (p. 3). Carnevale also noted that “online students outperformed on-campus students on the final exams and on the in-lab practical exams that Reeves gave to some of the distance learners” (p. 3). This study supports the virtual labs as an equivalent to traditional labs.

The effectiveness of technology for lab experiments has been studied broadly to determine the benefits. Braund and Reiss (2006) remarked that the rapid developments in technology demand that schools offer greater opportunities for science education that includes the internet. Millar (2004) found that computer-based simulations helped students focus more on the process of experimental planning and data interpretation than the set up and safety needs of the experiment. Dillon (2008) reviewed and cited several studies where researchers found that employing technology allowed the students more time to observe and reflect in ways that provided greater understanding of the concepts. Citing Nelson and Ketelhut, Lunetta and others, Dillon presented findings that indicate technology can provide real-world, authentic experiences for learners, that it is effective regardless of gender, and that technology can enhance learning. Dillon’s review of selected studies also provided

cautionary evidence that technology (p. 411), used inappropriately, can interfere with learning. This can occur with the introduction of technology before the learner has acquired a solid understanding of the underlying science concepts. In discussing teacher readiness, Dillon found evidence that the teacher's attitude and ability to incorporate technology in successful studies was very positive (p. 792).

Advantages and Disadvantages of Virtual Labs

In Reese's study, the researcher found that several studies indicated that higher education institutions are replacing traditional laboratories with virtual laboratories to conserve resources (Reese, 2013). Although a virtual lab can never completely replace a traditional lab, the study supported the view that the benefits of a virtual lab are just as equivalent to the learner. In addition, the virtual lab can offer a more flexible environment for the experiments.

Unlike the low enrollment at rural schools or underfunded private schools mentioned previously, some universities find that increasing student enrollment is an issue many universities face. One study conducted by Walker, Altemus, Allen, Klinkhachorn, & Kraszpulska (2007) addressed this issue. When their institution was challenged by lack of lab space, students wishing to enroll were turned away. They used to virtual labs to address the issue. This meant that all students interested could enroll and be guaranteed a lab experience. Other institutions struggle with the same challenge. With the increasing popularity of distance learning, virtual laboratories offer solutions to these obstacles (Sommer & Sommer, 2003). Campbell, et al. (2004) cited various reasons for replacing what they described as "place-based education" with alternatives like virtual labs. The top reasons they mentioned were that (a)

authentic labs are time-consuming and difficult to work into schedules, (b) inconsistencies exist between lab sessions and teaching methods among teachers/assistants, and (c) up-to-date lab equipment and supplies are costly. In concurrence, Muhamad, Zaman, & Ahmad (2010) argued the benefits of virtual labs. Their study found the same advantages of space and funding as well as support for hands-on activities.

Scheckler (2003) cited several advantages and disadvantages to using virtual labs. The benefits mentioned included the ease with which a student could repeat experiments, a safe environment that presented no danger to the student, and the extra time allowed to conduct the experiments in general. Scheckler saw the disadvantages as not being able to gain true hands-on experience and the lack of feedback from onsite instructors. In addition to the lack of an onsite instructor, he cited the lack of interaction with an onsite lab partner. Some difficulties were experienced by students from other cultures because they struggled with the language or learning styles. Carnevale (2003) found that a lab partner can be achieved virtually, eliminating that issue for the learner. Virtual partners are one way some instructors have dealt with that disadvantage.

It is clear there are advantages and disadvantages to virtual labs in the science class. The cost of running a traditional lab is high while the human interaction within the virtual lab is low. Wolf (2010) noted how few studies are available to get a true measure of the virtual lab's value. Traditional and virtual experiences have their advantages and limitations (Scalise, 2011).

Best Practices for Virtual Science Labs

Because virtual science labs are relatively new in science education, a set of best practices has not been identified. Challenges arise when trying to define best practices for virtual science labs. In the review of literature for this study, several areas related to science learning and its specific impact on virtual labs were examined. Many studies on virtual science labs have been conducted at the college level rather than the lower grades. The literature search used primary sources from educational journals in online education. Organizations offering official guidelines for schools that wish to use virtual science labs (such as The National Science Teachers Association (NSTA) and The National Board for Professional Teaching Standards) were reviewed. The University of Delaware library resources provided access to many journals that contain articles reviewing the use of virtual science labs. Databases such as ERIC and EBSCO were searched. A search was conducted using the following terms: science labs, distance learning, virtual labs, and science lab software.

The NSTA has developed a set of comprehensive standards for science laboratories. These standards serve as a guide for best practices. The recommendations are related to safety, the lab environment, and learning expectations. These standards are benchmarks for virtual labs (SuccessLink, 2007). In 2010, the National Academy of Sciences, Achieve, the American Association for the Advancement of Science, and the NSTA began to develop the Next Generation Science Standards (NGSS). The framework lists the science concepts deemed

necessary for all K-12 students to know (National Science Teachers Association, 2014).

Multiple articles on the best practices using online education exist but mostly at the higher education level or corporate educational settings (Fish & Wickersham, 2009). Best practices for implementing online programs at the elementary level were not found in the literature. In Abel's search for best practices at the college level (2005, p. 35) he found several factors [success factors] that appear to lead to a successful implementation of online programs. The success factors put forth in the study were not looked at in depth, but provide a high level view of how the educational institutions viewed success of programs. Abel's success factors can be applied to the IAD case:

- Executive leadership
- Faculty and academic leadership
- Student services
- Technology infrastructure: reliable
- Course/instructional quality
- Financial resource and plan
- Training: staff support online
- Marketing

The success factor of executive leadership and support aligns very well with the IAD case. The need for the administration to be focused on the implementation effort and understand the overall importance of how virtual labs can support the curriculum is necessary to a successful implementation.

The success factor of faculty and academic leadership commitment does not completely align with the IAD case. The study focused on incentives for participation and protection of intellectual property. This success factor does not align completely with the IAD because the teachers are not being paid separately to teach online

courses and the use of virtual labs will not fall under intellectual property. However, the commitment aspect does align and is valid for any environment.

The success factor of student services refers to a dedicated staff to support the distance learner. The IAD program will not be fully online. As such, 24 x 7 support is not required. However, support of the teachers and the learners in accessing and navigating the new virtual labs will be needed so this success factor does align to the IAD case.

The success factor of technology infrastructure relates to reliability of the systems as well as the alignment of the technology to the pedagogy and would be very important to a successful implementation at the IAD. Internet access, classroom equipment, and user support services should be addressed in the recommendation.

The success factor of course/instructional quality aligns to any educational implementation, online or otherwise. Only high quality programs should be considered. There are many authors on the internet, but few are supported by accredited associations and governing bodies that can ensure quality and align with accepted standards. Measures of quality in this study focused on inquiry based and team activities, faculty/student interaction, and alignment to course standards. The recommendation should also focus on selection of virtual labs based on similar quality standards.

The success factor of financial support aligns with the IAD case. Without the appropriate financial plan and support, the technology initiatives are not easily supported and assimilated into any curriculum. Some attention to budget should be included in the recommendation.

The success factor of training aligns with the IAD case. Both students and teachers will require training in order to use the virtual labs effectively. So the recommendation for implementation of virtual labs should include a training element.

Lastly, the success factor of marketing at first seems to not align with the IAD case. In a lesser sense of the term, *marketing*, this success factor can be applied to the IAD case. In order to get support for future improvements and adoption overall of the virtual labs, it will be important to market the program, its successes and future state, to the faculty, administration, and parents. This can further support the financial plans, mentioned above, in order to grow the program over time.

Virtual Science Lab Examples

The investigator searched for virtual labs currently available via the web. Many sites were found. Only the most relevant sites that could be included in the final recommendation are listed below. Physics Education Technology (PhET) web site is included because it contains a large number of simulations with diverse simulations and was referenced in many research articles. The various labs reviewed are listed below. The first five listed are the primary labs reviewed.

- Virtual Physics Laboratory: <http://www.phy.ntnu.edu.tw/ntnujava>
- Science Courseware.org: <http://www.sciencecourseware.org> (see Figures 3 and 4)
- Y Science Laboratories: <http://yscience.byu.edu/> presented by Brigham Young University (see Figures 1 & 2)
- PhET Project: http://phet.colorado.edu/simulations/index.php?cat_Featured_Sims
- MyPhysicsLab: <http://www.mypysicslab.com/index.html>
- Interactive Physics and Math with Java:
http://www.physics.uoguelph.ca/applets/Intro_physics/kisalev/index.html

- Virtual Labs Electricity:
http://www.wsd1.org/LTCActivities/46%20Freeware/virtual_labs_electricity.htm
- Thermo lab: <http://www.chemcollective.org/applets/vlab.php>
- Concord Consortium: <http://www.concord.org>



Realistic outcomes are shown when the wrong metals are dropped into the calorimeter.

Figure 1 Virtual ChemLab. Safer than a wet lab (Y Science Laboratories).



The Organic Chemistry Laboratory where Students can Perform Synthesis and Qualitative Analysis Experiments

Figure 2 Virtual ChemLab. Laboratory setting (Y Science Laboratories).

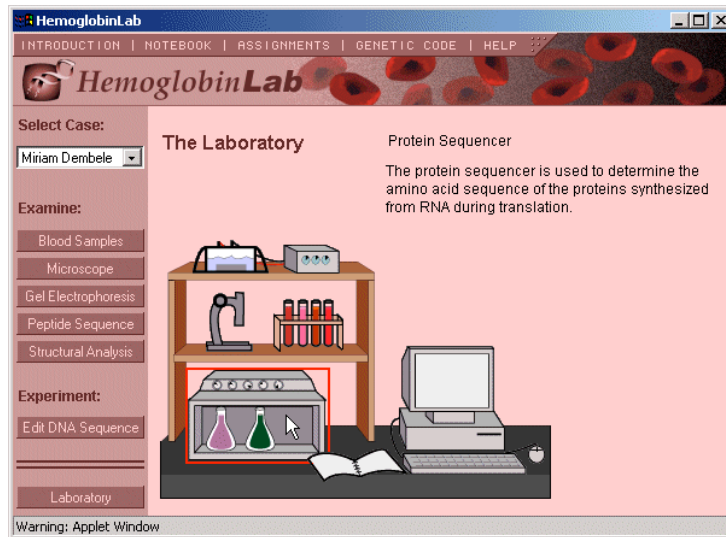


Figure 3 Hemoglobin Lab. Protein sequencer (Science Courseware Project).

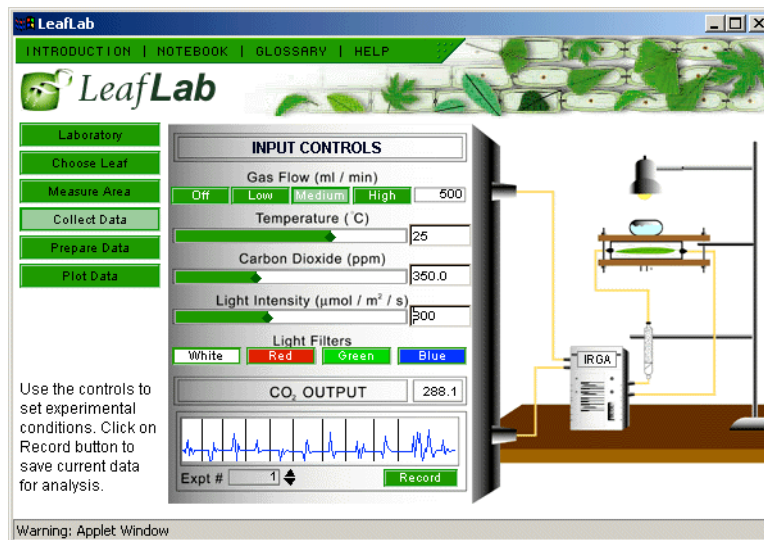


Figure 4 Leaf Lab. Collecting data (Science Courseware Project).

Chapter 2:

METHODOLOGY AND ANALYSIS

Understanding the teaching staff's support of science laboratories in the science curriculum is required in order to facilitate the use of virtual labs. It is also necessary to determine if the teachers understand how to use virtual labs effectively. Each teacher's level of comfort with technology and their willingness to incorporate technology into their classroom is pivotal in the overall implementation of virtual labs. In addition, understanding their current knowledge and background with technology in the classroom informs this study as to what additional training resources may be needed for a successful implementation. As such the investigator chose interviews as a qualitative measure to determine the IAD staff's readiness to implement virtual labs. Qualitative studies are useful for gaining a richer understanding of a subject's opinion and experience. This chapter provides a detailed description of this qualitative study, including the design, instrumentation, and procedures.

Design

Creswell (2009) defined qualitative research as a study that looks to establish the meaning of a phenomenon [use of virtual labs] from the viewpoint of the participants [teachers]. One can use case studies, described as a special kind of qualitative research, to look at a phenomenon in a natural context (Hancock & Algozzine, 2011). The case study might include one or many subjects. Merriam

(2009) sees case studies as "...an intensive, holistic description and analysis of a single entity, phenomenon or social unit" (p. 46). The case study method was a good fit for this study because it was limited to the IAD teachers who had experience teaching science with limited resources.

Human Subjects Review

The interview protocol was submitted to the University of Delaware's Human Subjects Review Board. This was approved in May, 2014 (Appendix A). All Institutional Review Board (IRB) guidelines were followed concerning the treatment of human subjects and the storage of data. Potential study participants were given the research study design and the Consent to Participate in Research form. Each potential study participant was asked to confirm their participation in the research project by signing the consent form (Appendix E and F). The consent form included the EPP's purposes and procedures, data collection process, participants' rights, and confidentiality notice. The reader was informed that no personal identifying information would be made available to anyone. The informed consent letter contained no identifying information so that identification of the participants was impossible. If the potential participants chose not to complete the study, the investigator would have thanked them for considering taking part in the study and collected no further information; however, all invited teachers chose to participate. In addition, a permission letter (letter of cooperation) to conduct this study was obtained from the IAD administration (see Appendix B).

Population Sample

The investigator used a purposeful sampling for this study. Purposeful sampling is used to seek individuals who are already informed about the research topic (McMillan, 2012). The sample included all IAD science teachers (n=4) and the school principal (n=1).

Interview Questions

Interviews are used in educational studies to provide an opportunity for detailed understanding of the meaning of what the interviewees say (Kvale & Brinkmann, 2009). According to Bailey (1982), the interview method has advantages over the quantitative method by providing flexibility, higher response rate, observation of nonverbal behaviors, control over the interview environment, order of the questions, observation of immediate reactions, confirmation of the true source of the data, completeness, and more in-depth information.

Two interview instruments were used; one was used to interview the teachers and another was used to interview the administrator of the school. The teacher interview instrument contained twenty questions. The administrator interview instrument contained eleven. Most questions were open-ended to give teachers and the administrator the opportunity to say as much as they felt was necessary to answer each question. Answers to open-ended questions can provide rich descriptions for analysis. The remaining questions were used to obtain demographic information about the school and the teachers. The questions were asked in order to inform this study on whether or not the staff at the IAD is ready to support virtual labs.

The original design was for face-to-face interviews with each participant. Due to time constraints in the IAD school calendar, the IAD administration requested that the questions be asked via email so that the participants could submit a written response. The request was honored and each participant was emailed the protocol and questions. The teacher and administrator questions were provided via email using a structured questionnaire (see Appendix C and Appendix D). The responses were collected via email. Email made the request and collection of data very efficient. The interview was completed by the participant without intervention.

The interview questions were designed specifically for this study. There were eleven Administrator interview questions in a single section. Those questions asked for some demographic information and included questions pertaining to implementation issues, teacher readiness, school support, and technology development. There were twenty teacher interview questions divided into five sections: Teacher Background and Philosophy, Curriculum and Instruction - Science in General, Technology, Virtual Labs, and Personal Technology Use. The questions asked for demographic information such as years of teaching experience, degree major, attitudes toward technology, and personal use of technology at home or in the classroom. Some questions focused on current teaching and learning resources in addition to science lab activities, while others focused on the teachers' opinions and beliefs toward virtual science labs. Other questions let the subjects discuss the professional development they received in regard to virtual labs, if any.

Procedure

The interview questions were distributed to the teachers and principal via email the first week of June 2014. Teachers were informed of the purpose of the interview in a cover letter that was attached to the interview questions, as well as through personal communication when the investigator visited the school. Teachers were asked to complete the interview within two weeks, prior to the closing of school. Most of the interviews were collected by the end of June, 2014.

Data Collection

All data collection activities were conducted in strict accordance with the guidelines and procedures outlined by the university and the IRB. Both interview instruments were collected, recorded, and analyzed via spreadsheets. The teachers and the administrator responded to the interview questions by typing directly into the interview document. Upon completion, the responses were submitted to the investigator via e-mail.

Data Analysis

As stated by Merriam (2009) “There is no standard format for reporting qualitative research...there is tension between having the right amount of supporting data versus analysis and interpretation” (pp 14-15). In an attempt to find a balance, the investigator chose to describe the findings and analysis using a mix of investigator narrative and tables of the raw interview responses.

The investigator analyzed the responses to determine if there were any general unifying themes and identified suggestions for the implementation recommendation. To analyze the data the investigator highlighted, coded, and sorted significant

statements, quotes, and pertinent sentences. The investigator summarized the similarities and differences between the teachers' responses and continually assessed how the data collected was answering the key questions that guided this work. Specific vocabulary that informed the study was noted during the review process.

In order to code the responses competently, the investigator looked to the literature for guidance. The investigator looked for common themes and patterns in the responses based on the National Science Foundation (1997) recommendations. In addition, the responses were reviewed to see if interesting stories emerged or if remarks were similar to the literature reviewed. The investigator devised a coding system to retrieve and organize chunks of data into categories specified in the interview questions: teacher background and philosophy, curriculum and instruction, technology, virtual labs, and personal use of technology. Subsequently, the investigator used tables to report the responses. For each table, the responses are coded using A-D to identify which of the four teachers responded.

Results

The results of the interview responses are detailed within each category of the interview protocol and discussed on the following pages.

Teacher Background and Philosophy

The teachers in this study have diverse backgrounds: varied degrees, varied majors, and various classroom experiences. Two teachers have a Master's degree, and one is pursuing a Masters. Teacher experience varies from three to twelve years. The type of teaching experience also varies: preschool teacher, all subjects, and specialization as a science teacher. Results reveal that one teacher had worked as a

computer science teacher which suggests that her technology skills may be higher than the others. Overall, there are not many commonalities between teachers within the demographic data.

As for the teaching philosophy, most mentioned the use of inquiry-based learning. Inquiry-based learning is the pedagogical choice in the IAD curriculum (Table 1). Responses included remarks that learning should be hands-on, used to actively construct ideas, and be fun. Teacher C responded that “children should be engaged in actively constructing ideas, demonstrating and learning the skills of questioning, forming hypothesis, testing and drawing conclusions, evaluating their own results and communicating the findings effectively.” The educational philosophy described by each teacher is supportive to the use of laboratory experiments as part of the learning environment.

Table 1 provides us with a description of each teacher’s philosophy or approach to teaching science. This provides insight as to how the virtual lab may align to the teaching philosophies.

Table 1. Teaching Philosophy

Teacher	How do you describe your teaching philosophy regarding teaching Science? What is the role, if any, of inquiry-based learning in your classroom?
A	Teaching science is always fun with hands-on experiments as well theoretical material.
B	My philosophy regarding teaching Science is that Science is a basic, fundamental subject. Children must learn about the world around them. Our curriculum is based on inquiry-based learning. We’ll start out with a question at the beginning of a lesson (eg. – What is matter?) and we will investigate this.
C	Science should be taught to develop an awareness, understanding and appreciation of the world around the children. Children should be engaged in actively constructing ideas, demonstrating and learning the skills of questioning, forming hypothesis, testing and drawing conclusions, evaluating their own results and communicating the

Teacher	How do you describe your teaching philosophy regarding teaching Science? What is the role, if any, of inquiry-based learning in your classroom?
	findings effectively. I also believe that science and technology should be complimenting each other.
D	My mission as a teacher is to teach the student responsibility, and accountability while making learning fun and interesting. Science is all around us, and once students realize this, it makes them life learners. Inquiry-based learning is a key element in my classroom. Every lesson has an assignment that is inquiry based.

Table 2 details the current curriculum. This gives the study guidance on what types of virtual labs can augment the learning environment.

Table 2. School Curriculum

Teacher	Describe the curriculum here [at school].
A	Pearson common core
B	The curriculum at IAD is more challenging than other Islamic schools that I have taught at. The curriculum encourages inquiry-based learning. In regards to Science, the experiments are built into the student manual and are relevant to the topic being taught.
C	We use Pearson’s Interactive Science Curriculum which I think is engaging and targets all learners in a relevant way. The students are taught Life Science, Science, Engineering, and Technology, Earth Science, and Physical Science.
D	Interactive Science Pearson: Grade 4: Covers the basis of earth science, general biology, life science. Grade 5: Covers with more depth earth science, general biology, life science, and begins introducing the concepts of physical science. Grade 6: Physical Science: Introduces the history of the atom, the periodic table, reactions, discusses the concepts of physics, Newton’s Laws, Electrochemistry, Simple machines, and lenses. Grade 7: Life Science: Plants, animals, cells, digestion, respiration, and circulation. Blood types and genealogy are also introduced. Grade 8: Earth Science: Water Cycle, Rock Cycle, Aging and Dating of fossils, Volcanoes, Earthquakes, Tectonic Plates and movement, Layers of the Earth.

Curriculum and Instruction

The use of experiments is already built into the curriculum at IAD as reported by the teachers. Engaging the student in those experiments appears to be an issue. Almost all teachers showed some frustration in demonstrating class experiments without a science lab. Three teachers out of four indicated that they have used the school's kitchen to demonstrate some experiments (Table 4). The kitchen provided a work space, sink, and stove. Two teachers noted that they sometimes must go outside when the outside temperature is needed for a demonstration. Additionally, two teachers noted that they had to supply the materials necessary for experiments. Teacher C wrote that "I bring my own supplies many times and we have some tools at the school." For the concepts of acids and bases one teacher used a red cabbage dye as an indicator and the students used it on various household items and liquids. One teacher was already using limited web sites on her own laptop for experiments.

Table 3 provides insight into each teacher's strategy to engage the students. Virtual labs can align with these strategies to provide similar but richer lab experiences.

Table 3. Teaching Strategy

Teacher	What types of teaching strategies or instructional methods are used when you design a lesson using science experiments?
A	Envision, explain, explore, demonstrate myscienceonline.com- stem activities.
B	KWL charts are helpful to determine the level of knowledge of science concepts and vocabulary.
C	Students many times although not at all times participate in observing, predicting, investigating in groups, noting the observations and discussing and comparing the results after the experiment.

Teacher	What types of teaching strategies or instructional methods are used when you design a lesson using science experiments?
D	Fun! Students should be engaged in a lesson. I look for lessons that are interesting and stray away from the norm. Computer based videos, games, labs, chemical labs (kitchen chemistry). Inquiry Based Learning, The Flipped Classroom Concept, projects, and WebQuests are also used.

Table 4 describes the challenges for each teacher to provide lab experiences without adequate facilities. These challenges could be overcome with the use of the virtual lab.

Table 4. Conducting Science Experiments

Teacher	With the lack of a Science lab here [at school] how do you conduct science experiments?
A	I would like to call it classroom demo science experiment. Mostly I demonstrate it first then students take turns but lack of material, equipment, and space in class room makes it frustrating. Sometimes we just watch the steps online and students complete /observe it at home.
B	Science experiments are taught in the classroom and occasionally in the kitchen, when needed. We've also done experiments outside regarding temperature, etc.
C	I bring my own supplies many times and we have some tools at the school. Yes, it is extra work. Also we need to go to the kitchen or outside to conduct many of our experiments since we do not have a lab of our own. It takes time off from our learning.
D	In class experiments are usually used. For example: For my 5th graders, pertaining to the concepts of simple machines: pulleys, gears, etc. I asked them to create simple machines with house hold items, then bring them into class, where they then have to create an experiment for their classmates. For my 6th graders, Newton's Law, they were to create 5 different experiments w/any objects that would enable them exhibit Newton's laws of Physics, balloons, inclines, toy cars, etc. were used during the experiment. For the concepts of acids and bases, with 6th grade and 7/8th grade (They completed their curriculum and began high school chemistry) a red cabbage dye was used (completely non toxic) as an indicator and the students used it on various household items and liquids to begin comparing and contrasting different items and learned to classify acids and bases. Computer and virtual labs, with the use of our laptops, are also conducted using Phet (especially for hard to explain concepts), or other educationally based websites and other online resources. We have the use of the multipurpose hall and the outside if the weather is appropriate.

Based on the teachers' responses it is clear that that they have struggled with the lack of science labs. Several negative comments such as frustrating, issues regarding temperature, their own supplies, and extra work were used in the responses to convey the struggles.

Technology

The technology section provided a great deal of insight as to the comfort level, use, and concerns about using technology in the science classroom. All teachers noted a very high comfort level using technology in the classroom. This will be a great asset to implementing virtual labs. Although the list of technology used in the classroom appears comprehensive, only two of the teachers feel they are using the technology on a regular basis (Table 5). One teacher noted "I present many of my lessons on MS* PowerPoint or on Apple's Keynote, this allows me to post lessons online giving students who are unable to copy notes in class for various reasons access to all the concepts being taught."

Table 5 provides a listing of what technology is already employed at the IAD. If technology already exists, it will make implementing virtual labs easier.

Table 5. Technology Used

Teacher	What types of technology are you using during your instruction? And how often do you use it?
A	Laptop, TV ,iPad, stop watch, white board, etc. 3 to 4 days a week
B	Laptops and the flat screen TV. An overhead projector. I don't use it enough. Roughly once a month.
C	Laptop and television rarely. We use digital animation tools provided by Pearson.
D	I present many of my lessons on MS PowerPoint or on Apple's Keynote, this allows me to post lessons online giving students who are unable to copy notes in class for various reasons access to all the concepts being taught. Edmodo, a classroom and instruction website, and Engrade, an online gradebook, are also used. Edmodo gives me the opportunity to assign, discuss and create online assignments, or quizzes. Online or virtual labs. A written handout usually accompanies a virtual lab. This allows visual learners an opportunity to "guess" at different concepts without it being harmful, if I were to conduct the experiment live. It also allow students to see things and picture things they may not know how to see otherwise, for example when going over volcanology showing how a volcano forms over the years through tectonic movement is really difficult to visualize however; http://phet.colorado.edu/en/simulation/plate-tectonics would allow them to see time progression and allow them to easily grasp the picture.

The teachers were very direct about what they believed they needed in order to support technology in the science classroom. Table 6 summarizes those ideas. As one may already surmise, the things that the teachers felt were needed to meet their needs they also identified as barriers. The descriptions varied when asked how significant technology was on student engagement (Table 7); however, all teachers indicated that the impact would be significant and positive. One teacher remarked that "...it really arouses curiosity and develops interest in the children and prepares them for the future real life experiences." When asked what they felt the major barriers were to using virtual lab technology, most remarked on the lack of resources, both in physical space and money, to purchase software or equipment (Table 8).

Table 6 summarizes how the teachers see they can implement the virtual lab in their classroom. This will be considered in the final recommendation.

Table 6. Ideal Implementation of Technology

Teacher	Can you describe an ideal implementation of technology in your science classroom?
A	Extra large class room, corner1- hands-on experiment area with water, sink, counters, Corner 2 - computer lab area, corner 3 safety equipment closet(material) + show my work area, corner 4 with boards, smart boards , tv, seats theoretical, instructional area .
B	We have two smart boards, however no one has received training on how to use them. I would love to do a lesson utilizing the smart board. The students would love it, it would be a terrific experience for them.
C	I would say easy access to computers and internet without wasting time. I would like to have all the digital tools that meet the National Science Education Standards
D	Just learning to iron out the kinks and adjust to new technologies. Maybe even purchasing tablets to download apps that wouldn't have all the simple issues.

Overall, the teachers appear to be willing and ready to implement technology in the classroom as soon as it is made available to them, but without proper training they feel at a loss. One teacher reported (Table 6) “We have two smartboards, however no one has received training on how to use them. I would love to do a lesson utilizing the smart board. The students would love it, it would be a terrific experience for them.”

Table 7 provides us with the justification for that technology by listing how the teachers feel the technology can impact engagement (a significant factor in the teacher’s philosophy and strategy).

Table 7. Significance of Student Engagement/Achievement

Teacher	How significant do you feel is the impact of technology on student engagement? How about student achievement?
A	Very significant. About 50% achievement.
B	Students are engaged when using technology. They often request it.
C	It is important. It really arouses curiosity and develops interest in the children and prepares them for the future real life experiences.
D	I didn't teach prior to the use of technology and have always used it as a base for learning. I believe that any scientist should become used to researching, exploring, and using technology as a tool for relaying information. Many students understand the topics and concepts better if they have completed the labs/the WebQuests online.

Table 8 informs us as to the perceived barriers for the teachers when trying to implement learning events in the classroom using technology. Each should be considered in the final recommendation.

Table 8. Barriers

Teacher	What are the primary barriers for using technology in your classroom?
A	Unavailability of materials on time and lack of space
B	Time constraints. It takes a long time to get students set up on laptops. A few times the websites that I have taken them to have had broken links.
C	There is no television in my classroom. It takes time for me to bring it and connect to the laptop each time I have to use it. There is not enough time.
D	The cost of monitoring software is expensive. Many times unmotivated students will stray from the instructional sites to see something else. I have to constantly be moving around to make sure all students are on task. Battery life. Laptops are constantly losing power, giving students the hardships of needing to acquire a charger to continue their work. Different software needed to run labs, whether it is Shockwave, Flash player, Bluelight, Java downloading the software on each instrument is time consuming, and they must be updated periodically to keep them functional.

Table 9 informs us as to how and to what degree the teachers currently use the technology tools in their classes. This provides insight as to what extent the staff is ready to implement virtual labs.

Table 9. Technology in Use

Teacher	What types of technology are you using during your instruction? And how often do you use it?
A	Laptop, TV ,iPad, stop watch, white board, etc. 3 to 4 days a week
B	Laptops and the flat screen TV. An overhead projector. I don't use it enough. Roughly once a month.
C	Laptop and television rarely. We use digital animation tools provided by Pearson.
D	I present many of my lessons on MS PowerPoint or on Apple's Keynote, this allows me to post lessons online giving students who are unable to copy notes in class for various reasons access to all the concepts being taught. Edmodo, a classroom and instruction website, and Engrade, an online gradebook, are also used. Edmodo gives me the opportunity to assign, discuss and create online assignments, or quizzes. Online or virtual labs. A written handout usually accompanies a virtual lab. This allows visual learners an opportunity to "guess" at different concepts without it being harmful, if I were to conduct the experiment live. It also allow students to see things and picture things they may not know how to see otherwise, for example when going over volcanology showing how a volcano forms over the years through tectonic movement is really difficult to visualize however; http://phet.colorado.edu/en/simulation/plate-tectonics would allow them to see time progression and allow them to easily grasp the picture.

Virtual Labs

When asked what they thought of virtual labs, the responses were favorable. Two teachers had highly positive remarks (Table 10 and Table 12). All of the teachers listed several ways that they could incorporate virtual labs into their current classrooms and curriculum. One teacher felt that the virtual lab "will prepare students for the future." Teacher D specifically noted how online activities increase student learning, stating that "many students understand the topics and concepts better if they have completed the labs/the Web Quests online" (Table 10). Teacher A supported the

idea that technology aids in her students’ learning when she provided an estimate that “about 50%” of her students’ achievement could be attributed to the use of technology in the classroom.

The teachers listed many benefits of incorporating technology into the learning process (Table 16). Some benefits of note were "Enhancement in the subject," "Student engagement may increase," and "We could do more labs than usual, teachers can save money, and time, be able to use a lot of expensive resources online to provide high quality education to the children. Teachers can have remote access to many interesting websites." There can be drawbacks to using a new methodology; however, the only drawback noted by the teachers was that they felt the students may need extra assistance getting used to the new tools. The teachers felt that they too need some assistance, in terms of training on the equipment and tools and on how to use those tools to their advantage in creating effective learning environments (Table 17).

In assessing to what extent the teachers are ready to implement virtual labs at the IAD we can look to tables Table 10-13. Table 10 provides teacher views on using virtual labs; the starting point of readiness to incorporate virtual labs.

Table 10. View on Science Virtual Labs

Teacher	What is your view on Science Virtual labs?
A	Hopefully very helpful.
B	It’s an interesting concept.
C	Science Virtual labs are an efficient way of providing the students the opportunity to practice skills of designing and conducting virtual investigations, and enhance their critical thinking skills with hands-on work. They will also prepare the students for the future They are cost effective.
D	I love them!

Table 11 reports how the teachers feel the virtual lab is or is not a fit with their teaching philosophy. This provides insight as to how ready the teachers are to implement virtual labs.

Table 11. Fit with Teaching Philosophy

Teacher	How do Science Virtual labs fit or do not fit within your teaching philosophy?
A	We can use it as a stem activity. Sections in our science books with stem activities according to topic or background; it's really helpful to open their mind creatively. U can find these activities in text or teachers manuals. U can consult our books.
B	A virtual lab utilizing a smart board sounds very engaging. Although, I know students like hands-on experiments, as well.
C	I see them fit well provided we have easy access to the technology.
D	Virtual Labs should be used where physical labs cannot be for cost reasons or safety reasons.

Table 12 shows us how they intend to design their instruction using virtual labs. Teacher enthusiasm is high.

Table 12. Interest in Virtual Labs

Teacher	Would you be interested in designing your science curriculum using Virtual Science labs? Why or why not?
A	Yes I am excited to take part in designing.
B	Yes, occasionally. I'd like students to have access to both virtual labs, as well as hands-on labs.
C	Yes.
D	I already utilize virtual science labs whenever I can to teach abstract topics.

Table 13 shows how the teachers are already thinking about how to implement the virtual labs into their classes.

Table 13. How to Integrate

Teacher	If Yes, in what ways do you think you can integrate Virtual Science labs in your curriculum?
A	I can use Pearson and Harcourt text books and customize it according to our needs.
B	I think virtual labs could be a fit in any area of science.
C	...for some of the concepts especially to arouse curiosity in the little minds, to help them think like scientists, to enhance their problem solving skills, and to enable them to connect different concepts by using hands-on activities. We can also cut the cost of having a real Lab.
D	

Table 14 indicates how comfortable the teachers are with the idea of incorporating current assessment methods with the virtual labs.

Table 14. Assessments Methods

Teacher	What methods of assessment will you use in conjunction with Virtual Science labs to gage student-learning outcomes?
A	Oral, written, multiple choice, observation
B	Students can organize test results to see if they prove or disprove their hypothesis. Have students explain in their own words the results of the experiment.
C	Pre and Post paper-pencil tests, question answers, informal observation, assess problem solving skills by observing the experiments.
D	Formal lab reports and/or student worksheets will usually accompany a virtual lab.

Table 15 lists the teacher concerns that should be addressed from the teachers' point of view in order to make a successful program with virtual labs.

Table 15. Concerns

Teacher	What, if any, are your major concerns about incorporating Virtual Science labs into your teaching?
A	Please include definitions, vocabulary, related experiments, background of a topic. + some Muslim scientists and their work according to the topic, if u can, just a request.
B	Setting up laptops, etc. is time consuming. The desire to have the students to hands-on experiments.
C	Some students may need extra help with the use of computers.
D	None

Table 16 shows us the perceived benefits of virtual labs, further supporting the willingness to incorporate virtual labs into their current curriculum.

Table 16. Benefits

Teacher	What benefits do teachers perceive in their attempts to incorporate Virtual Science labs in the Science curriculum?
A	Enhancement in the subject
B	Student engagement may increase. We could do more labs than usual.
C	Teachers can save money, and time, be able to use a lot of expensive resources online to provide high quality education to the children. Teachers can have remote access to many interesting websites.
D	It gives the student the advantage of grasping abstract topics and ideas, or things difficult to see. It also allows students to realize that the Internet and technology has more uses than they believed possible.

Table 17 shows us how the teachers felt they need to be supported in order to implement virtual labs. This should be considered in the final recommendation.

Table 17. Support Needed

Teacher	What types of support would you like to receive as you try to incorporate virtual science in your curriculum?
A	Please consult our common core curriculum+ Pearson latest science edition.
B	A teacher training showing us exactly how to utilize the virtual lab to maximize student learning.
C	Demonstration of use of the resources and different tools helpful for the elementary students. Students would at the Lower grade levels might need some train before they can really follow the instructions.
D	Assistance with computer (laptop) maintenance for example the downloading of software, the charging of the devices, etc.

Table 18 shows us the important factors that would encourage teachers to incorporate virtual labs. This should be considered in the final recommendation.

Table 18. Factors to Determine Plan for Virtual Science Labs

Teacher	Identify the most important factors that will determine whether you continue to plan for and use Virtual Science labs in your curriculum.
A	Experiments. Demonstrate the experiment, almost all the experiments that go with our topics because we do not have science lab and it's very inconvenient to shop for every little experiment.
B	Time and whether I receive training on how to incorporate it in the curriculum to get maximum benefit for the students.
C	Ease of working with the students and efficient use of time and being able to manage the whole class.
D	I will use virtual labs in my curriculum, as long as I am provided the technologies to do so.

Personal Technology Use

Results indicate that all of the teachers use technology on a daily basis as personal tools and devices. Table 19 lists the types of devices used by each teacher at home. Using technology at home, as well as in the classroom, demonstrates a high comfort level with technology use.

Table 19. Technology Use

Teacher	What technologies do you use on your own or at home?
A	Laptop, iPad, etc.
B	iPhone, iPad, laptop
C	Social media, web tools, teacher websites, free classroom management tools and resources online, phone apps, digital media tools
D	Everything I can use (and I can afford). I have a tablet (iPad 4 Air), a MacBook Pro, a smartphone (LG Nexus), a smart TV (Samsung). I all of these as resources to improve my teaching strategies and to enhance each of my students' learning experiences.

Administrator Results

The responses from the IAD administrator were very informative. The first question asked for demographic information which gives us the overall enrollment figures. Pre-K through Kindergarten is 42% of the overall enrollment, grades 1 through 6 represent 48% of the enrollment, and grades 7 and 8 make up the remaining

10% of the enrollment. This study focused on the upper grade levels so it is apparent that the study's recommendations will impact over half of the current student body.

As reported by the Administrator, the school provides a mobile computer lab that contains 15 laptops. Any teacher can schedule to use the lab for their classes. At this time there are no plans to increase the number of computers available. The teachers and students can access the internet via the computers in the mobile lab. This means that the technology is available, but because it is shared among several teachers, the total time available is limited.

The administrator provided the following information about the technology available: "IAD has an advanced and well maintained Wi-Fi network. All classroom facilities have access to the internet. LCD TV screens are available in each classroom. Mobile TV displays are available on each floor. About 40% of our 23 employees are computer proficient and can use technology in the classroom. The school has a technology development plan." Based on this information, it is evident that the school fully supports technology in the classroom.

IAD has the same issue providing space for science labs as reported in the literature and the problem worsens with increased enrollment. At this time there is no immediate plan to increase the overall space available.

Several survey questions asked about limitations and barriers to implementing virtual labs. The feedback was consistent with the literature, citing the ability to make training available, technology support, and funding. In addition, the administrator echoed the concern that the students may need assistance with computer literacy to be successful with virtual labs.

The administrator's concern about training the teachers came up in two responses indicating that it is an issue he takes very seriously. He felt there may only be training on the specific technology deployed, leading the investigator to conclude that there may not be enough resources to train the teachers on success factors in using the technology effectively.

Summary of Results

All teachers in this study mentioned that the impact of technology on student engagement is significant. Teacher A stated clearly that it was "very significant." Teacher B said that "students are engaged when using technology (Table 7). They often request it"(Table 7). Teacher C stated "it is important. It really arouses curiosity and develops interest in the children" (Table 7). Responses to other questions supported the teachers' belief that educational technology enhances student learning and positively impacts the student's engagement. Teacher C's response included a statement that supports this when she stated that "I also believe that science and technology should be complimenting each other" (Table 7). From the responses it is apparent that the teachers are ready and prepared to add technology to the science classroom.

The administrator's responses indicated that he is ready to support the implementation of virtual labs as long as concerns about the financing and support of the tools can be addressed. It appears that the solution must be low or no cost so as not to burden the school or the families financially. Training the staff on new tools is an important aspect that the administration and the teachers would look for in an implementation plan.

Chapter 3

CONCLUSION AND RECOMMENDATIONS

The literature has shown us that the lab experience is a valuable part of the science curriculum (NBPTS, 2013, Wolf, 2010, National Research Council, 1997 & 2012). The National Research Council (2012) stressed the inclusion of laboratory investigations in the science curriculum. The literature also supports the use of virtual labs as an effective substitute for classroom labs (Babateen, 2011, National Science Teachers Association, 2008). Pyatt and Simms (2011) found evidence that virtual labs were as good, if not better than physical lab experiences in some respects. Although not identical in experience to a live lab, the virtual lab has been shown to provide the student with an effective laboratory experience in situations where the live lab is not possible (Kolloffel, 2013, Joseph, 2012, Pyatt & Sims, 2011). The live lab experience is not regularly possible at the IAD. When lab work is performed it is minimal and requires the teachers to supply the materials (Table 4). The financial and physical resources are not available at this time to provide wet labs. The investigator found ample examples of virtual labs that are appropriate for the IAD classes that provide a base of resources for the final recommendation.

The results of the IAD teacher interviews indicate that the teachers are well-prepared for, and supportive of, the implementation of virtual labs to improve the science education curriculum (Table 5, 7, 10 and 11), answering the key question: To

what extent is the staff at the IAD ready to support virtual labs? The administrator interview results also show solid support for implementing virtual labs within the current budget and fiscal constraints. The IAD has the computer resources (15 laptops in a mobile computer lab) needed to support virtual labs in the classroom, without relying on student owned computers. The investigator believes that with the support of the literature and the readiness of the IAD administration and teachers, a recommendation to implement virtual labs into the curriculum can be made. However, the recommendation cannot be made without also addressing the concerns noted by the administrator and teachers at the IAD: aligning implementation efforts with best practices, cost effectiveness, training, and sufficient time to re-plan lessons.

Recommendations

In comparing the IAD case to Abel's success factors (2005) of executive leadership and faculty and academic support, the investigator can say that the IAD has strong support for using virtual labs. The faculty and academic leadership, though small in number, are fully supportive of the program. As found in the interview responses, the administrator and the faculty all demonstrate a commitment to improving the program overall. The investigator assumes that they will demonstrate the same commitment to the implementation of virtual labs.

Based on the review of literature, findings from teacher and administrator interviews, and sensitivity to concerns and challenges noted by the IAD staff, the investigator makes the following recommendations for the 2015/2016 school year.

1. Implement the use of virtual labs to the 7th and 8th grade science classes.

2. Incorporate quality, free virtual labs located on the internet into the current science curriculum during the summer of 2015.
 3. Market the implementation of the virtual labs throughout the 2015/2016 school year.
 4. Enhance the budget for ongoing improvement.
1. Implement the use of virtual labs to the 7th and 8th grade science classes.

Although not addressed in the literature, implementing a new technology across an entire enterprise with no additional technical support can be a challenge. In order to ensure that the virtual labs are implemented successfully a narrow focus is recommended. Focusing the implementation efforts narrowly will allow the IAD to concentrate on the resources necessary to support a successful implementation. The investigator recommends starting with the 7th and 8th grade curriculums because the students require less teacher support than the younger grades, which would allow the lab work to be the focus rather than how to use a computer. As soon as the teachers and the administrator are confident in the implementation's success, they can enhance additional grade level curriculums to include virtual science labs.

2. Incorporate free, quality virtual labs located on the internet into the current science curriculum during the summer of 2015.

The investigator took success factors for course quality, student services/technology infrastructure, and training into consideration when choosing online virtual lab sites for this recommendation.

Quality: There are a large number of virtual science labs available on the internet, both for free and for a charge. Based on the needs of the IAD, only free

virtual labs were considered for this recommendation. The quality of the labs was of high importance in the review process. The investigator validated that the virtual labs met the current educational standards as set forth by generally accepted governing bodies such as the National Board for Professional Teaching Standards, National Research Council, National Science Teachers Association, and the Partnership for 21st Century Skills. The investigator determined the governing body or authorship of the programs as a second measure of quality. For instance, the investigator chose websites that are developed and maintained by an accredited college or university rather than websites developed by individual high school teachers. The investigator took the teaching philosophy of the IAD staff (Table 1) into account to ensure that the teachers would readily accept the recommended websites.

Student Services/Technology Infrastructure: Both the teachers (Tables 8 and 15) and the administrator noted concerns about the technical support required for new software and hardware. Using programs from the web requires less technical support for the teacher and the students because the program resides on the internet. Student services and technology infrastructure support is named as a best practice (Able, 2005) and as a factor influencing successful implementations. As for hardware, the technology and infrastructure are already in place at the IAD in the form of the mobile computer labs and a good internet connection. However, both the administrator and the teachers noted their concern for any issues that may arise with the virtual lab software. This recommendation utilizes existing internet sites that only require a few plug-ins, reducing the impact on student services and existing infrastructure. The recommendation includes ample time before the school year

begins to give the teachers the opportunity to review the recommended virtual labs so that they are comfortable that the technology is installed smoothly and all links work as expected.

The time allotted before the school year also gives the teachers the opportunity to update their lesson plans to include the new virtual labs. Teachers must become familiar with using the virtual lab and take advantage of the many learning resources available via the websites. The recommended alignment of virtual labs to the current 7th and 8th grade science curriculum follows this section.

Training: Training to support the staff and students is another success factor for the implementation. The investigator assessed each recommended virtual lab for the amount and type of teacher training available.

This recommendation also suggests weekly meetings to monitor progress. Because of the small, intimate nature of the school, the IAD should have little trouble with communication during the implementation; however, regularly scheduled meetings as part of a formal process will ensure that communication is not overlooked. Formal communication is necessary in any implementation plan to discuss successes and failures along the way. Issues must be addressed immediately in order to develop changes in strategy and keep the program moving forward.

3. Market the implementation of the virtual labs throughout the 2015/2016 school year.

Marketing the program is also noted as a success factor. The IAD Administrator should choose at least two school events where the teachers can showcase successes, demonstrating to parents, teachers, and other administrators how

much richer and valuable the children's learning experiences are at the IAD. Parental support in program advances is always welcomed when it comes to budget discussions, raising funds for future enhancements, and increasing overall enrollment. Showcasing the program's success to the other teachers can inspire other implementation efforts going forward.

4. Enhance the budget for ongoing improvement.

Financial resources and planning is another success factor for implementation. The financial constraints at the IAD make it challenging but not impossible to locate resources. To grow the program, the IAD administrator should look to include additional monitors and computers for the virtual labs in each classroom in upcoming budgets. It will not take long for the teachers to locate additional internet resources to add to the program, so software costs should be added to the budget over time.

Teachers and administrators should investigate the possibility of grant money to increase technology at the IAD, enhance the program offerings, and offset future costs. The following websites are examples of sites that offer technology grants:

- <http://www.fundforteachers.org/funding-opportunities/grants-technology.php>
- <http://www.edutopia.org/grants-and-resources>

Curriculum Alignment

The investigator recommends the virtual labs listed in Table 20 for the IAD science curriculum because they passed the quality review for alignment to accepted standards, governance by accredited organizations, free service, and adequate training for the teachers. It is difficult to locate virtual labs that detail all of the required

information for the quality review, so a few virtual labs were included in the list because the governing organizations met the criteria.

Table 20 provides the list of websites offering quality virtual labs for inclusion in the curriculum.

Table 20. Selected Virtual Labs

URL	Details
<p>http://phet.colorado.edu</p>	<p>PhET Interactive Simulations project [the Physics Education Technology project] Website Description: “Teachers can use PhET online while connecting to the internet. They also can have a full install of the website to their computers or they have the option to download a select of simulations they need to a CD, USB, or a hard drive. Teachers can easily browse simulations by selection categories that filtered their needs: type of simulation (lab/HW/ Qs/Demo/other) level (K-5 /MS/ HS/ Un-G/ G/ other) and language option.” Grade level: K-5, Middle and High school, College Discipline: Physics, Biology, Chemistry, Earth science, Math Overseeing body: University of Colorado Boulder</p>
<p>http://mw.concord.org/modeler</p>	<p>Molecular Workbench Website Description: “Visual, Interactive Simulations for Teaching & Learning Science. While it presents many existing simulations that are ready to use in the classroom, it is, however, also a modeling tool for teachers and students to create their own simulations and share them with collaborators. The user interfaces of simulations in MW can be customized for students of different levels (from grade 6-16). This unique feature enables it to support a wide range of instructional strategies such as inquiry-based, discovery-based, and problem-based learning.” Grade level: Grades 6-16 Discipline: Physics, Chemistry, Biology, Biotechnology, Nanotechnology Overseeing body: The Concord Consortium</p>

URL	Details
<p>http://www.sciencecourseware.org</p>	<p>Science Courseware Project Website Description: “The Virtual Courseware Project produces interactive, online simulations for the life science laboratory or for earth science field studies. The activities are designed to enhance an existing curriculum and include online assessments. It is divided into four sections: VCISE Virtual Courseware for Inquiry-based Science Education / Biology Labs On-Line/ Geology Labs On-Line/ Earth and Environmental Science. Students make observations, propose hypotheses, design experiments, collect and analyze data generated by the simulation, and synthesize and communicate results through an electronic notebook and an online report.” Grade level: Middle, high school, and college Discipline: Biology, geology, earth and environmental sciences Overseeing body: The U.S. National Science Foundation and the California State University.</p>
<p>http://www.glencoe.com</p>	<p>Glencoe Online Learning Center Website Description: “Glencoe is the leading provider of secondary learning materials. Glencoe/McGraw-Hill have partnered to provide Glencoe Online Science that features a wide variety of resources that support its line of textbooks. From innovative Web projects such as the Internet Bio labs to engaging WebQuests, games, and quizzes, Glencoe Online Science offers students interactive choices that help them learn.” Grade level: All grades Discipline: Biology, Chemistry, Integrated Science, Life Science, Earth Science: Physical Science, Physics, AP, Honors and Electives Overseeing body: McGraw-Hill Education</p>

URL	Details
<p>www.Challenger.org</p>	<p>Challenger Learning Center Website Description: “Challenger Learning Centers – gives students the chance to become astronauts and engineers and solve real-world problems as they share the thrill of discovery on missions through the Solar System. Using space simulation and role-playing strategies, students bring their classroom studies to life and cultivate the skills needed for future success. Learning Centers reach into communities around the globe, engaging more than 400,000 middle school-age students and 40,000 educators each year. Challenger Center’s teaching model is an effective approach to strengthen knowledge and interest in Science, Technology, Engineering, and Mathematics (STEM).” Grade level: 6-9 grade Discipline: Space science, Earth science, Engineering Overseeing body: NASA /Federal Aviation Administration/ The National Institute of Aerospace/ National Oceanic and Atmospheric Administration (NOAA)/ US Department of Education</p>
<p>www.learner.org</p>	<p>Annenberg Learner: Teacher resources and professional development across curriculum Website Description: “Annenberg Learner's mission is to "Advance Excellent Teaching in American Schools.” Annenberg Learner pursued this mission for more than three decades by funding and distributing multimedia resources for teachers (K-12 and college levels) to teach their subjects and to stay up-to-date in their fields.” Grade level: K-5, Middle and High school, and College level Discipline: Arts, Foreign Language, Literature and Language Arts, Mathematics, Science, Social Studies and History Overseeing body: The Annenberg Foundation</p>

URL	Details
<p>www.classzone.com</p>	<p>ClassZone Website Description: “Through ClassZone, students will stay sharp-minded with online puzzles, current events coverage, and quizzes, while teachers can access up-to-date tools for daily lesson plans as well as resources to enhance their professional development.” This website supports the Houghton Mifflin Harcourt curriculum. The site begins with a selection of books for the study level. By clicking each book a list of chapters and support resources, including simulations and virtual labs, is made available. Grade level: Middle and High school Discipline: Arts, Math, Science, Social Studies, World Languages Overseeing body: Houghton Mifflin Harcourt</p>
<p>www.wiley.com</p>	<p>Wiley's Global Research Website Description: “Wiley's Global Research business is a provider of content-enabled solutions to improve outcomes in research, education and professional practice with online tools, journals, books, databases, reference works and laboratory protocols. With strengths in every major academic, scientific and professional field, and strong brands including Wiley Blackwell and Wiley VCH, Wiley proudly partners with over 800 prestigious societies representing two million members.” Grade level: Not specified Discipline: Numerous disciplines Overseeing body: Wiley research</p>
<p>www.cimss.ssec.wisc.edu</p>	<p>Cooperative Institute for Meteorological Satellite Studies Website Description: “The CIMSS mission includes three goals: Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system sciences that exploit the use of satellite technology; Serve as a center at which scientists and engineers working on problems of mutual interest can focus on satellite-related research in atmospheric and earth system science; and Stimulate the training of scientists and engineers in the disciplines involved in atmospheric and earth science.” Grade level: K-12 Discipline: Earth system sciences Overseeing body: University of Wisconsin-Madison/ Space Science and Engineering Center (SSEC)/ National Oceanic and Atmospheric Administration (NOAA)/ NASA.</p>

URL	Details
<p>www.forces.si.edu</p>	<p>The Smithsonian’s National Museum of Natural History Website Description: “This collection of educational activities and printable is designed to bring our museum exhibitions into your home or classroom. The lesson plans are designed to be interdisciplinary, interactive and fun, to assist you and your students in increasing your knowledge and understanding about scientific inquiry and the forces interacting on our planet. Each activity is designed to meet specific National Science and Geography Educational Standards. The activities fit under most education requirements for Environmental Science curriculum. However, they also fit within other National Standards as listed within their standards correlation charts. Each activity is also completely independent and can be used individually or in combination with the other activities on our web site. It is our hope that use of these activities inspires you, your families, and your students to learn more about science and our dynamic planet.” Grade level: Not specified Discipline: Not specified Overseeing body: The Smithsonian’s National Museum of Natural History and National Science and Geography Educational Standards</p>
<p>scied.ucar.edu</p>	<p>UCAR Center for Science Education Website Description: “The University Corporation for Atmospheric Research (UCAR) Center for Science Education is comprised of staff with expertise in the atmospheric and related sciences and science education. We are passionate about the importance of our mission and strive for excellence in all aspects of our work. Major program areas include formal (K-12) education, informal education and school and public programs, education technology, and undergraduate education.” Grade level: K-12 Discipline: Weather, Climate, Atmospheric science, and space weather education Overseeing body: The National Science Foundation</p>

URL	Details
www.pbs.org	<p>NOVA Website Description: “NOVA is the highest rated science series on television and the most watched documentary series on public television. It is also one of television's most acclaimed series, having won every major television award, most of them many times over.” Grade level: Not specified Discipline: Life science, Earth and space science, Physical science, Technology and engineering Overseeing body: Cancer Treatment Centers of America/ the David H. Koch Fund for Science, the Corporation for Public Broadcasting, and PBS viewers.</p>

Most, but not all, virtual lab websites offer some form of teacher training. The offerings are listed in Table 21, below.

Table 21. Training Offered

Web Site	Training Offered
http://phet.colorado.edu	PhET offers training supports for teachers in form of workshops that are available virtually, online, and in person.
http://mw.concord.org/mode/ler	Teachers can refer to the online MW’s manual in addition to the blog for more support.
http://www.sciencecourseware.org	Not specified
http://www.glencoe.com	Not specified
www.Challenger.org	The site seems does not have a professional development section but it does offer some materials as teachers resources
www.learner.org	Offer a professional development for teachers
www.classzone.com	Not specified
www.wiley.com	Not specified
www.cimss.ssec.wisc.edu	Variety of formal and informal education training and workshops.
www.forces.si.edu	Not specified
scied.ucar.edu	UCAR offer variety of event s for professional development for teachers
www.pbs.org	Professional development online

Technology requirements for the selected virtual labs are minimal and align to the current computer labs at the IAD. The required technology is found in Table 22, below.

Table 22. System Requirements

Web Site	Requirements
http://phet.colorado.edu	Simulations need Java, Flash, and a web browser: It is recommend laptops or netbooks with a minimum of 1024x800 screen resolution for using our simulations.
http://mw.concord.org/modeler	Windows, Mac OS X v10.4+, and Linux. The only requirement is that the Java Runtime Environment (JRE) of Java 2 Platform, Standard Edition (J2SE) v1.5 or higher version must be installed
http://www.sciencecourseware.org	The activities require Macromedia Flash Player 8 or Java applets and many functions require that pop-up blockers be disabled.
http://www.glencoe.com	Not specified
www.Challenger.org	Adobe Flash plug-in
www.learner.org	Adobe Flash plug-in
www.classzone.com	Not specified
www.wiley.com	Adobe Flash plug-in
www.cimss.ssec.wisc.edu	Need HTML5 and require an up-to-date browser, Java and Flash
www.forces.si.edu	Adobe Flash plug-in
scied.ucar.edu	Adobe flash player
www.pbs.org	Adobe Flash plug-in

The individual lab modules from the recommended sites are aligned to the current IAD 7th and 8th grade curriculums in Table 23. Both 7th and 8th grade science classes utilize the same textbook. Not every lesson could be aligned to a virtual lab. For example, there were learning modules on how earthquakes happen but no virtual lab was available where students could to test the forces that cause earthquakes.

In reviewing each of the virtual labs the researcher was pleased to find many online learning modules with which the IAD teachers could augment their current

text. Those modules are not noted in the tables contained in this recommendation but should be reviewed by the teachers as the implementation effort matures.

Table 23. Alignment to Curriculum

Lessons	Recommended virtual lab
Chapter 1: Introducing to Earth	
Lesson 1: The Earth System	http://www.challenger.org/climate/ccearth4u/ccearth4u.html
Lesson 2: Earth’s Interior	https://www.learner.org/interactives/dynamicearth/structure.html
Lesson 6: Topographic Maps	http://www.classzone.com/books/earth_science/terc/content/investigations/es0307/es0307page02.cfm
Chapter 2: Minerals and Rocks	
Lesson 2: Classifying Rocks	http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES04/ES04.html
Lesson 5: Metamorphic Rocks	http://www.wiley.com/college/strahler/0471669695/interactivities/flash/mineralogy/mineralogy.htm
Chapter 3: Plate Tectonics	
Lesson 1: Drifting Continents	https://www.learner.org/interactives/dynamicearth/plate.html
Lesson 2: Sea-Floor Spreading	https://phet.colorado.edu/en/simulation/plate-tectonics
Lesson 3: The Theory of Plate Tectonics	https://phet.colorado.edu/en/simulation/wave-on-a-string
Chapter 4: Earthquakes	No labs recommended
Chapter 5: Volcanoes	
Lesson 3: Volcanic Landforms	http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES10/ES10.swf
Chapter 6: Weathering and Soil	
Lesson 1: Rocks and Weathering	http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES07/ES07.html AND http://www.glencoe.com/sites/common_assets/science/virtual_labs/E06/E06.html

Lessons	Recommended virtual lab
Chapter 7: Erosion and Deposition	
Lesson 1: Mass Movement	https://phet.colorado.edu/en/simulation/glaciers
Lesson 2: Water Erosion	http://www.sciencecourseware.org/VirtualRiver/
Chapter 8: A trip through Geologic Time	
Lesson 1: Fossils and OR Lesson 2: The Relative Age of Rocks	http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES12/ES12.html
Chapter 9: Energy Resources	
Lesson 1: Fossil Fuels	http://www.glencoe.com/sites/common_assets/science/virtual_labs/PS13/PS13.html
Lesson 3: Energy Use and Conservation	http://www.pbs.org/wgbh/nova/labs/lab/energy/research
Chapter 10: Water No labs recommended	
Chapter 11: the Atmosphere	
Lesson 2: Air Pressure	http://cimss.ssec.wisc.edu/wxfest/Tornado/tornado.html
Lesson 3: Layers of the Atmosphere OR Lesson 4: Energy in the Earth's Atmosphere	http://forces.si.edu/atmosphere/interactive/atmosphere.html
Chapter 12: Weather	
Lesson 5: Storms	http://scied.ucar.edu/make-thunderstorm
Chapter 13: Climate and Climate Change	
Lesson 1: What causes climate? OR Lesson 2: Climate regions OR Lesson 3: Changes in climate	https://phet.colorado.edu/en/simulation/greenhouse
Lesson 4: Human activities and climate change	http://concord.org/stem-resources/what-future-earths-climate
Chapter 14: Earth, Moon, and Sun No labs recommended	
Chapter 15: The Solar System	
Lesson 2: Introducing the solar system	http://www.pbs.org/wgbh/nova/space/tour-solar-system.html
Chapter 16: Star, Galaxies, and the Universe	
Lesson 1: Telescopes OR Lesson2: The scale of the universe OR Lesson5: Star Systems and Galaxies OR	http://phet.colorado.edu/en/simulation/gravity-and-orbits
Chapter17: Land, Air, and Water Resources No labs recommended	

The 7th and 8th grade students are in one science classroom, using the same 8th grade level textbook. The only differentiation made by the teacher is that the 8th graders are given more lab assignments than the 7th grade students and the teacher requires more rigor from the 8th grade assignments for grading purposes. To provide guidance on how to incorporate the labs into the science curriculum, the following example is provided for Lesson 1, <http://www.challenger.org/climate/ccearth4u/ccearth4u.html>.

Within Chapter 1: Introducing to Earth, and after the *Parts of the Earth System* section of Lesson 1, provide access to the lab. Both 7th and 8th grade students are assigned to review the *New to the Site*: “Learn about our Carbon Temperature Model” lab. Both 7th and 8th grade students will complete the Deforestation lab. The 7th graders are assigned to complete *Challenge 1* while 8th graders are assigned to complete *Challenges 1 and 2*. Challenges are questions posed to the students that they are to answer at the end of the lab. Extra credit may be given if students in either grade complete *Challenge 3*. At the end of each challenge the students will print and submit their lab results. Additionally, the 8th grade students are assigned to review the *Resources: Read more about the Earth’s Systems* link and then choose the link to “Tropical Deforestation.” The 8th graders will read the material and write a report on what they learned, using the teacher’s current standards for report writing. The teacher needs to incorporate the results in her grading system for the lesson.

The teacher may need to adjust the overall length of time spent on the lesson to incorporate the challenges and resource report. The teacher ultimately makes the decisions on how much of the recommendation they choose to incorporate to fit her

scheduling needs. But the example is a good base from which to begin incorporating the labs into the overall curriculum.

As the implementation of the virtual labs matures, teachers will identify additional resources that they can incorporate into the curriculum. They should always review the details of the virtual lab to ensure that they are referencing virtual labs developed by known and recognized sources for quality and alignment to current educational standards. Each year there are additional resources and technology enhancements to virtual labs and the technology needed to deliver virtual labs. It is possible to incorporate those incrementally to reduce the impact on the curriculum and the budget at the IAD. Once virtual labs are incorporated into the IAD science curriculum, the researcher is confident that the administration, teachers, and parents will find them to be a valuable resource that should remain as part of the overall quality program offered at the IAD.

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Appendix A
IRB APPROVALS

IRB Study Approval



RESEARCH OFFICE

210 Hallihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: May 27, 2014

TO: Nada AlZahrani
FROM: University of Delaware IRB

STUDY TITLE: [601308-1] DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE

SUBMISSION TYPE: New Project

ACTION: APPROVED

APPROVAL DATE: May 27, 2014

EXPIRATION DATE: May 26, 2015

REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # (7)

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Famese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.

Teacher Consent Approval

UD IRB Approval from 05/27/2014 to 05/26/2015

Consent Form

Introduction and Purpose:

My name is Nada AlZahrani and I am a graduate student at University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*. This project will be conducted under the supervision of *Professor Fred Hofstetter*. I would like to invite you to take part in my research study, which concerns science teachers' vision regarding the use of virtual labs, their experiences of acquiring technology skills, and their science curriculum instructional technology design at the Islamic Academy of Delaware.

Procedures:

If you agree to participate in my research, I will conduct an email interview you by e-mailing my interview questions to you. The interview will include 20 questions regarding your experiences in teaching science and using technology. This will take about an hour to complete. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering.

Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses. I may choose to contact you by e-mail, or by telephone or possibly meet with you as needed.

Benefits:

You will get no direct benefit from being a part of this study. But helping to carry out this research has a chance to tell us a lot about the potential of the use of virtual labs in the absence of science labs. If so, that could be of future benefit to you or the institution as a whole and benefit the Islamic Academy of Delaware. Your time for this study is deeply appreciated and highly valuable.

Cost Compensation:

Participation in this study is entirely voluntary will involve no costs or payments to you. However you may be able to gain insights into the deployment of a virtual science laboratory at your institution in the process of reviewing answers to the questions provided.

Risks/Discomforts:

There are thus no risks in participating in this interview. You are free to decline to answer any questions you don't wish to answer, or to stop the interview at any time. The answers that you provide will be used only for the purposes of this study and will not be shared with anyone else in your current institution or at the University of Delaware.

Confidentiality:

All statements made in response to this email interview will remain confidential and will be disclosed only with your permission. Your participation in this interview is completely voluntary. Your responses will remain confidential and will be used to develop a better understanding of how you view the use of virtual labs and how to use them effectively.

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware and the Islamic Academy of Delaware.

- If you agree to join this study, please sign your name.

For any questions about this study, please feel free to contact the advisor *Professor Fred Hofstetter* at fth@udel.edu or the please contact the Principal Investigator, *Nada AlZahrani* at Nadaz@Udel.edu

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

- I agree to participate in a research study. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences.

Yes No

- I grant permission for the data generated from this interview to be used in the researcher's publications on this topic.

Yes No

Signature of Participant

Date

Printed Name of Participant

Interviewer's signature

Principal Consent Approval

UD IRB Approval from 05/27/2014 to 05/26/2015

Consent Form

Introduction and Purpose:

My name is Nada AlZahrani and I am a graduate student at University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*. This project will be conducted under the supervision of *Professor Fred Hofstetter*. I would like to invite you to take part in my research study, which concerns the Islamic Academy of Delaware's commitment to technology integration. This is in line with the Institute Principal's perception of Virtual Science labs, and how Virtual Science labs could be leveraged to improve student experiences and learning environment.

Procedures:

If you agree to participate in my research, I will conduct an email interview with you by e-mailing my interview questions to you. The interview will include 11 questions regarding your experiences at the Islamic Academy of Delaware Science education and technology development. The interview will take about an hour to complete. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering. Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses. I may choose to contact you by e-mail, or by telephone or possibly meet with you as needed.

Benefits:

You will get no direct benefit from being a part of this study. But helping to carry out this research has a chance to tell us a lot about the potential of the use of virtual labs in the absence of science labs. If so, that could be of future benefit to you or the institution as a whole and benefit the Islamic Academy of Delaware. Your time for this study is deeply appreciated and highly valuable.

Cost Compensation:

Participation in this study is entirely voluntary will involve no costs or payments to you. However you may be able to gain insights into the deployment of a virtual science laboratory at your institution in the process of reviewing answers to the questions provided.

Risks/Discomforts:

There are thus no risks in participating in this interview. You are free to decline to answer any questions you don't wish to answer, or to stop the interview at any time. The answers that you provide will be used only for the purposes of this study and will not be shared with anyone else in your current institution or at the University of Delaware.

Confidentiality:

All statements made in response to this email interview will remain confidential and will be disclosed only with your permission. Your participation in this interview is completely voluntary. Your responses will remain confidential and will be used to develop a better understanding of how you view the use of virtual labs and how to use them effectively.

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware and the Islamic Academy of Delaware.

- If you agree to join this study, please sign your name.

For any questions about this study, please feel free to contact the advisor *Professor Fred Hofstetter* at fth@udel.edu or the please contact the Principal Investigator, *Nada AlZahrani* at Nadar@Udel.edu

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

- I agree to participate in a research study. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences.

___Yes ___No

-I grant permission for the data generated from this interview to be used in the researcher's publications on this topic.

___Yes ___No

Signature of Participant

Date

Printed Name of Participant

Interviewer's signature

Appendix B

PERMISSION (LETTER OF COOPERATION) TO CONDUCT THIS STUDY

[December 11, 2013]

Islamic Academy of Delaware [IAD]
28, Salem Church Road
Newark DE - 19713.
Tel: (302) 455-9988
For attention: IAD Principal & Administrator

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

Dear Mr.Nidal Abuasi,

I am writing to request permission to conduct a research study at your school. I am currently enrolled in the Ed.D Education Leadership program at University of Delaware in Newark, DE, and I am in the process of writing my Executive Position Paper [EPP]. The study is entitled [*DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*]. This project will be conducted under the supervision of [Professor Fred Hofstetter].

I am hereby seeking your consent to interview Islamic Academy of Delaware Science teachers and the administrator. I have provided you with a copy of my Executive Position Paper [EPP] proposal.

Your approval to conduct this study will be greatly appreciated. If you require any further information, please do not hesitate to contact me at:
e-Mail address: Nadaz@Udel.edu

Thank you for your time and consideration in this matter.

Yours sincerely,

[Nada AlZahrani]

Ed.D Education Leadership [Technology, Curriculum, and Higher Ed]
College of Education and Human Development
University of Delaware

Appendix C

INTERVIEW QUESTIONS - TEACHERS

Interview Protocol

DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE

Interviewee:	Date:
Occupation:	Time:

Thank you for your participation in this study. You have been selected to participate because you are one of the Science teachers in the Islamic Academy of Delaware, and I am interested in examining science teachers' vision regarding the use of virtual labs.

I am a graduate student at the University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*.

The purpose of this study is to investigate the feasibility and possible use of virtual Science labs. My research will be based on email interview questions. After this interview, I am hoping to be able to determine science teachers' vision regarding the use of virtual labs, their experiences of acquiring technology skills, and their science curriculum instructional technology design. The interview will include 20 questions regarding your experiences in teaching science and using technology. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering. Your responses can be typed directly in the document or you may print and fill in the interview questions by hand. This will take about an hour to complete. At this point I do not plan to meet with you face-to-face but if clarity on a particular answer is needed, I will follow up with a telephone call or face-to-face conversation with you.

All statements made in response to this email interview will be kept confidential. Your participation in this interview is completely voluntary. Your responses will remain confidential and will be used to develop a better understanding of how you and your peers view the use of virtual labs and what might influence it.

Thank you for your willingness to participate in this study. If at any time you have questions or concerns regarding the study and the interview questions, please do not hesitate to contact me. I look forward to reading your responses and would appreciate receiving them by June 2, 2014.

Please do not hesitate to contact me at: email address: Nadaz@Udel.edu

Yours sincerely,
Nada AlZahrani
Ed.D Education Leadership
[Technology, Curriculum, and Higher Ed]
College of Education and Human Development
University of Delaware

Science teacher interview:

Teacher Background and Philosophy:

- 1) First, let's start with your educational and professional background; tell me about your highest degree obtained/ field of study/ teaching experiences.
- 2) How do you describe your teaching philosophy regarding teaching Science? What is the role, if any, of inquiry-based learning in your classroom?

Curriculum and Instruction- Science in General:

- 3) Describe the curriculum here [at school]
- 4) What types of teaching strategies or instructional methods are used when you design a lesson using science experiments?
- 5) With the lack of a Science lab here [at school] how do you conduct science experiments?

Technology:

- 6) What types of technology are you using during your instruction? And how often do you use it?
- 7) Can you rate your comfort level with using technology during your instruction from (1-10).
- 8) How significant do you feel is the impact of technology on student engagement? How about student achievement?
- 9) Could you describe your experiences in acquiring technology knowledge and skills?
- 10) What are the primary barriers for using technology in your classroom?
- 11) Can you describe an ideal implementation of technology in your science classroom?

Virtual Labs:

- 12) What is your view on Science Virtual labs?
- 13) How do Science Virtual labs fit or do not fit within your teaching philosophy?
- 14) Would you be interested in designing your science curriculum using Virtual Science labs? Why or why not?
-If yes, in what ways do you think you can integrate Virtual Science labs in your curriculum?
- 15) What methods of assessment will you use in conjunction with Virtual Science labs to gauge student-learning outcomes?
- 16) What, if any, are your major concerns about incorporating Virtual Science labs into your teaching?
- 17) What benefits do teachers perceive in their attempts to incorporate Virtual Science labs in the Science curriculum?
- 18) What types of support would you like to receive as you try to incorporate virtual science in your curriculum?
- 19) Identify the most important factors that will determine whether you continue to plan for and use Virtual Science labs in your curriculum.

Personal Technology Use:

- 20) Finally, What technologies do you use on your own or at home?

Thank you so much for your participation in this project. Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses.

Appendix D

INTERVIEW QUESTIONS - PRINCIPAL

Principal Interview Protocol

DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE

Interviewee:	Date:
Occupation:	Time:

Thank you for your participation in this study. You have been selected to participate because you represent the Islamic Academy of Delaware [IAD] administration, and I am interested in examining IAD regarding the use of virtual labs.

I am a graduate student at the University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*.

The purpose of this interview is to ascertain the school’s commitment to technology integration, to comprehend the principal’s perception of Virtual Science labs, and to identify how Virtual Science labs could be leveraged to better administer IAD to improve student learning. My research will be based on email interview questions. The interview will include 11 questions regarding your experiences in IAD Science education and technology development. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering. Your responses can be typed directly in the document or you may print and fill in the interview questions by hand. This will take about an hour to complete. At this point I do not plan to meet with you face-to-face but if clarity on a particular answer is needed, I will follow up with a telephone call or face-to-face conversation with you.

All statements made in response to this email interview will be kept confidential. Your participation in this interview is completely voluntary.

Thank you for your willingness to participate in this study. If at any time you have questions or concerns regarding the study and the interview questions, please do not hesitate to contact me. I look forward to reading your responses and would appreciate receiving them by June 2, 2014.

Please do not hesitate to contact me at: email address: Nadaz@Udel.edu

Yours sincerely,

Nada AlZahrani

Ed.D. Education Leadership

[Technology, Curriculum, and Higher Ed]

College of Education and Human Development

University of Delaware

Interview Questions:

1. Tell me about your experience as the Islamic Academy of Delaware administrator.
2. Can you share some of the IAD demographic information?
 - Site size.
 - Financing, annual payments, and funding.
 - Number of enrolled students/students on the waiting list.
 - Total number of teaching staff/science teachers.
 - Classroom size and technology resources (computers/internet).
 - Number of mobile technology devices (laptops/tablets).
 - Future facility plans.
3. As with any other private school, there are some challenges to deal with; can you list some that you couldn't overcome through your experience at IAD?
4. One of these challenges is the lack of a Science laboratory. What are the reasons behind this issue?
5. How could teachers overcome the lack of a Science laboratory regarding curriculum experiments?
6. Describe the current state of IAD technology use. Does the school have a technology development plan?
7. Suppose we wanted to implement Virtual Science labs as a temporary solution, what constraints or problems would we need to consider in advance?
8. What types of limitations could hold teachers from incorporating Virtual Science labs in the Science curriculum?
9. There are many cost-free Virtual Science labs on the web, what kind of training would your teachers need?
10. I have identified a subscription based online Virtual Science lab website at <http://www.labster.com/>; the subscription costs \$50 per student/ per semester; do you think IAD and students can support the pricing?
11. What are IAD's future plans with regard to implementing or establishing a Science laboratory?

Thank you so much for your participation in this project. Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses.

Appendix E
TEACHER CONSENT FORM

Introduction and Purpose:

My name is Nada AlZahrani and I am a graduate student at University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*. This project will be conducted under the supervision of *Professor Fred Hofstetter*. I would like to invite you to take part in my research study, which concerns science teachers' vision regarding the use of virtual labs, their experiences of acquiring technology skills, and their science curriculum instructional technology design at the Islamic Academy of Delaware.

Procedures:

If you agree to participate in my research, I will conduct an email interview you by e-mailing my interview questions to you. The interview will include 20 questions regarding your experiences in teaching science and using technology. This will take about an hour to complete. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering.

Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses. I may choose to contact you by e-mail, or by telephone or possibly meet with you as needed.

Benefits:

You will get no direct benefit from being a part of this study. But helping to carry out this research has a chance to tell us a lot about the potential of the use of virtual labs in the absence of science labs. If so, that could be of future benefit to you or the institution as a whole and benefit the Islamic Academy of Delaware. Your time for this study is deeply appreciated and highly valuable.

Cost Compensation:

Participation in this study is entirely voluntary will involve no costs or payments to you. However you may be able to gain insights into the deployment of a virtual science laboratory at your institution in the process of reviewing answers to the questions provided.

Risks/Discomforts:

There are thus no risks in participating in this interview. You are free to decline to answer any questions you don't wish to answer, or to stop the interview at any time. The answers that you provide will be used only for the purposes of this study and will not be shared with anyone else in your current institution or at the University of Delaware.

Confidentiality:

All statements made in response to this email interview will remain confidential and will be disclosed only with your permission. Your participation in this interview is completely voluntary. Your responses will remain confidential and will be used to develop a better understanding of how you view the use of virtual labs and how to use them effectively.

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware and the Islamic Academy of Delaware.

- If you agree to join this study, please sign your name.

For any questions about this study, please feel free to contact the advisor *Professor Fred Hofstetter* at fth@udel.edu or the please contact the Principal Investigator, *Nada AlZahrani* at Nadaz@Udel.edu

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

- I agree to participate in a research study. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences.

Yes No

-I grant permission for the data generated from this interview to be used in the researcher's publications on this topic.

Yes No

Signature of Participant Date

Printed Name of Participant

Interviewer's signature

Participant Initials _____

Appendix F
PRINCIPAL CONSENT FORM

Introduction and Purpose:

My name is Nada AlZahrani and I am a graduate student at University of Delaware conducting my study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled *DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE*. This project will be conducted under the supervision of *Professor Fred Hofstetter*. I would like to invite you to take part in my research study, which concerns the Islamic Academy of Delaware's commitment to technology integration. This is in line with the Institute Principal's perception of Virtual Science labs, and how Virtual Science labs could be leveraged to improve student experiences and learning environment.

Procedures:

If you agree to participate in my research, I will conduct an email interview with you by e-mailing my interview questions to you. The interview will include 11 questions regarding your experiences at the Islamic Academy of Delaware Science education and technology development. The interview will take about an hour to complete. There are no right or wrong answers to any of my questions. If you prefer not to address a question, you may refrain from answering.

Please add any additional information or anecdotes that you think may help to increase my understanding. In order to increase the quality of my research, I may need to contact you with follow-up questions after reviewing your responses. I may choose to contact you by e-mail, or by telephone or possibly meet with you as needed.

Benefits:

You will get no direct benefit from being a part of this study. But helping to carry out this research has a chance to tell us a lot about the potential of the use of virtual labs in the absence of science labs. If so, that could be of future benefit to you or the institution as a whole and benefit the Islamic Academy of Delaware. Your time for this study is deeply appreciated and highly valuable.

Cost Compensation:

Participation in this study is entirely voluntary will involve no costs or payments to you. However you may be able to gain insights into the deployment of a virtual science laboratory at your institution in the process of reviewing answers to the questions provided.

Risks/Discomforts:

There are thus no risks in participating in this interview. You are free to decline to answer any questions you don't wish to answer, or to stop the interview at any time. The answers that you provide will be used only for the purposes of this study and will not be shared with anyone else in your current institution or at the University of Delaware.

Confidentiality:

All statements made in response to this email interview will remain confidential and will be disclosed only with your permission. Your participation in this interview is completely voluntary. Your responses will remain confidential and will be used to develop a better understanding of how you view the use of virtual labs and how to use them effectively.

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware and the Islamic Academy of Delaware.

- If you agree to join this study, please sign your name.

For any questions about this study, please feel free to contact the advisor *Professor Fred Hofstetter* at fth@udel.edu or the please contact the Principal Investigator, *Nada AlZahrani* at Nadaz@Udel.edu

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

- I agree to participate in a research study. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences.

Yes No

-I grant permission for the data generated from this interview to be used in the researcher's publications on this topic.

Yes No

Signature of Participant Date

Printed Name of Participant

Participant Initials _____

Appendix G

EMAIL COMMUNICATIONS

Teacher Invitation

Previously, you have received a consent form to participate in my research. Please read carefully, print and sign the form. If you have any question regarding the consent form please consent me directly at Nadaz@udel.edu or by phone: (302)750-1683.

Once you have done that, you can start answering the interview questions that are on the attachment. The purpose of this interview is to ascertain the school's commitment to technology integration, to comprehend the principal's perception of Virtual Science labs, and to identify how Virtual Science labs could be leveraged to better administer IAD to improve student learning.

Your responses can be typed directly into the document then reply to my email with an attachment of your responses. You may also print and fill in the interview questions by hand. This will take about an hour to complete. The interview will include 11 questions regarding your experiences in IAD Science education and technology development.

Principal Invitation

This is an e-mail invitation for you as the Islamic Academy of Delaware [IAD] administration.

My name is Nada AlZahrani and I am a graduate student at University of Delaware conducting my Study in partial fulfillment of the requirements for the doctoral degree of Education. The study is entitled DESIGNING VIRTUAL SCIENCE LABS FOR THE ISLAMIC ACADEMY OF DELAWARE. This project will be conducted under the supervision of Professor Fred Hofstetter.

I would like to invite you to take part in my research study, which concerns the use of Virtual Science labs and Science curriculum instructional technology design at the Islamic Academy of Delaware. I am sending you a consent form as an attachment, please read carefully and sign the form if you agree to participate.

You will receive a separate email including the interview questions in a word document. Your responses can be typed directly in the document or you may print and fill in the interview questions by hand. This will take about an hour to complete.

At this point I do not plan to meet with you face-to-face but if clarity on a particular answer is needed, I will follow up with a telephone call or face-to-face conversation with you.