The Science Laboratory Experiences of Utah's High School Students

A Research Report

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EXECUTIVE SUMMARY

The National Research Council's (2005) publication *America's Lab Report: Investigations in High School Science* provided the impetus for this report. In the NRC report, the experiences of high school students nationwide are described along with recommendations for improving and supporting these experiences for students. Since the NRC report was published and this project was initiated science laboratory experiences for students have received still greater prominence nationally as leaders of the National Science Teachers Association (NSTA) testified to the U.S. House of Representatives Subcommittee on Research and Science Education. Linda Froschauer, current NSTA President, articulated the organizations strong committee to laboratory experiences stating that "Science educators are firmly committed to the role of the laboratory in the teaching and learning of chemistry, physics, biology, and earth sciences (Froschauer, 2007, p. 2)". Froschauer further emphasized the importance of laboratory experiences by referring to leading science and science education organizations proclamations regarding the importance of laboratory experiences, stating

> The American Chemical Society is similarly committed to quality laboratory experiences: their *Guidelines for the Teaching of High School Chemistry* states "the laboratory experience must be an integral part of any meaningful chemistry program. ACS recommends that approximately thirty percent of instructional time should be devoted to laboratory work."
>
> The American Association for the Advancement of Science Project 2061 *Designs for Science Literacy* states "Learning science effectively… requires direct involvement with phenomena and much discussion of how to interpret observations."
>
> Both NSTA and the NRC believe that quality laboratory experiences provide students with opportunities to interact directly with natural phenomena and with data collected by others. Developmentally appropriate laboratory experiences that integrate labs, lecture, discussion, and reading about science are essential for students of all ages and ability levels (Froschauer, 2007, p. 2).

Beyond this testimony and the belief in the importance of science laboratory experiences for students expressed by the ACS, AAAS, and the NRC, the NSTA has recently revised and published a new position statement titled "The Integral Role of Laboratory Investigations in Science Instruction" which states

> For science to be taught properly and effectively, labs must be an integral part of the science curriculum . . .
>
> NSTA strongly believes that developmentally appropriate laboratory investigations are essential for students of all ages and ability levels . . .

> Inquiry-based laboratory investigations at every level should be at the core of the science program and should be woven into every lesson and concept strand (NSTA, 2007).

Utah science education leaders have expressed a commitment to science laboratories aligned to those articulated by these leading science organizations. As state science leaders sought to ensure that science laboratory investigations were aligned to the recommendations offered by the NRC (2005) report, they first sought to gain an accurate appraisal of the experience of Utah's high school students in the science laboratory. This research report emerged from these discussions as a mechanism to reveal the experience students in Utah currently are afforded, any disparities across the state, and mechanisms through which the state can provide additional support to teachers facilitating these experiences. This was accomplished through conducting classroom observations and teacher interviews from a stratified random sample of forty teachers across Utah and conducting a questionnaire/needs assessment targeting all 9-12 science teachers across the state.

In summary, this research and the findings are considered an initial step in the process for helping Utah's committed science teachers continually improve the science laboratory experiences of students. Teachers across the state opened up their classrooms and devoted their time both in interviews and through completing the questionnaire/needs assessment to help Utah better understand the current state and future directions that are needed to ensure that Utah students are provided with an exemplary science education. These efforts are intended to ensure that not are students interests in science and scientific careers cultivated, but perhaps as important, that Utah's future citizenry is capable of making informed decisions about scientific and technological issues that will impact Utah, the nation, and the world.

Results

The research results emerging from this project illuminate opportunities for growth in aligning science laboratory experiences to reform efforts in science education, ensuring that disparities found are eliminated so that all students in Utah have opportunities to engage in science laboratories, and providing for the resources and needs of science teachers to facilitate these experiences.

When considering the experiences of Utah's high school students these were on average described in manners only somewhat aligned to reformed teaching. Students were found carrying out experiences, collecting data, and drawing conclusions from their data, but they were not found asking questions/framing research questions or designing experiments.

This research did reveal disparities in the quality of science laboratory experiences of students. Districts serving populations of students from lower socioeconomic groups were found receiving instruction significantly less aligned to reformed teaching when compared to districts serving populations of students from higher socioeconomic groups. The teachers from districts serving populations of students from lower socioeconomic groups were also more frequently found expressing concerns for funding to support science laboratory experiences and requesting the Utah State Office of Education (USOE) offer specific labs that align to the core curriculum.

Teachers also revealed a need for professional development focused on facilitating laboratory experiences so that science process could also be emphasized and so that they could gain confidence in leading students in science laboratory experiences where students pose the question, design and carry out the procedures to master science core content and intended learning outcomes. School facilities, funding, class size, and additional preparation time were all factors that teachers believe influence the extent to which they were able to engage students in science laboratory experiences.

Conclusions

Opportunities for improving science laboratory experiences for students in Utah are revealed through the findings emerging from this research. These improvements center around 1) aligning instruction with reform efforts in science education supported by research in teaching, learning, and cognition, 2) ensuring that experiences are equally afforded to students regardless of school size, socioeconomic, and diversity indicators, and 3) heeding the call for support emerging from teachers concerning increase opportunities for professional development, funding, class size limits, administrative support, and sufficient preparation time. Utah teachers participating in this research have demonstrated professionalism and a commitment to students. Teachers have responded to the USOE's interest and commitment to science laboratory experiences by inviting researchers into their classrooms and sharing their perspectives, ideas, and philosophies about these experiences. It is hoped that this report will be accepted as a critique, defined as an analysis, of the current state of Utah high school students' science laboratory experiences aimed at appreciating the benefits students are receiving and seeking to ever improve these experiences.

Recommendations

Recommendation 1

The USOE, Districts, and Schools should provide professional development supportive of science laboratory experience aligned to national standards documents and the Intended Learning Outcomes (ILOs) outlined in the Utah Core Curriculum. Classroom observations and teacher interviews revealed that while some alignment can be found between experiences offered in science laboratories and national standards documents and the ILOs, improvement can and should be a continual focus. More specifics for enacting this recommendation are found in the full report.

Recommendation 2

The USOE, State Science Education Coordinator Committee Participant (SSECC), and the Science Education Research Committee (SERC), School Districts, School Administrators and teachers should work to ensure that all disparities in science laboratory experiences of students across the state are eliminated. Disparities did emerge in the research that points to differences in the science laboratory experiences of students across Utah. Continued research should be completed to better understand the extent to which disparities are occurring as well as the reasons the disparities exist. Additional research is needed to understand why differences emerged with respect to reform teaching when comparing districts serving student populations with differing socioeconomic groups. This additional research should also lead to recommendations for eliminating these disparities whether through increased professional development, funding, or other means. Additional research is also needed to better understand the increased reference to hands-on learning for districts serving students populations with higher diversity.

Recommendation 3

Measures should be implemented to ensure that teachers are supported to offer science laboratory experiences to students. Teachers across the state revealed several factors that they felt influence their ability to engage students in laboratory experiences. Care should be taken to address these perceived needs in a manner that leads to evidence collection that can be used to ascertain the benefits of the addressed teacher need. More specific recommendations for supporting teachers are found in the full report.

PURPOSE OF THE RESEARCH PROJECT

This project was designed to assess the current state of high school science laboratory experiences in Utah. As a result of the recent National Research Council's publication *America's Lab Report: Investigations in High School Science*, science educators across the nation are faced with the realization that high school science laboratory experiences are often disconnected or "isolated from the flow of science instruction" (NRC, 2005, p. 116), do not have students designing and carrying out their own experiments (NRC, 2005; O'Sullivan &Weiss, 1999; Windschitl, 2003), and are unlikely to lead to the science learning goals outlined for the inclusion of laboratory experiences in science. Additional findings of the NRC (2005) report indicate that racial, ethnic, and socioeconomic disparities exist when considering the amount of time different groups are afforded in the laboratory. This report has caught the attention of science education leaders in Utah and has prompted the initiation of this project designed to ascertain the current experiences of Utah's high school students in the science laboratory. This report is intended to provide an accurate account of the science laboratory experiences of Utah's high school students and to compare these to the experiences of student nationally. In addition, it is also intended to investigate any differences occurring between districts of differing sizes serving differing populations of racial, ethnic, and socioeconomic groups. It is expected that this project will lead to data specific to Utah that can serve to make recommendations for continually improving science laboratories for students.

Research Problem

While the National Research Council's (2005) report provides data to describe national trends in science laboratory experiences, little to no research has been completed in Utah to better understand students' experiences within the state. Before efforts can be developed to assist Utah (9-12) Science Teachers in continually improving the laboratory experiences for high school students, research is needed to *1) document the current experiences of Utah's high school students, 2) reveal any disparity in science laboratory experiences occurring between districts of differing sizes, and serving differing racial, ethnic, and socioeconomic groups, and 3) to reveal high school science teachers perceptions about these experience, as well as what is needed to improve these experiences.*

Research Objective

The following objectives guided this research:

1) Provide an accurate account of Utah's high school students in science laboratories

2) Identify any differences in the science laboratory experiences occurring between schools serving differing racial, ethnic, and socioeconomic groups.
3) Identify teachers perceived needs for improving science laboratory experiences.

Through identifying students' experience in Utah, identifying any differences occurring for populations of students, and identifying the teacher perceived needs for improving laboratory experiences across Utah, recommendations informed by data coming form Utah will be established for continually improving science laboratory experiences.

LITERATURE REVIEW

A research project investigating science laboratory experiences of high school students and the perceptions of science teachers facilitating these experiences is framed in the current literature available regarding teaching and learning in science and science laboratories. This section of the report reviews the relevant literature regarding teaching and learning. This literature will be used as a framework for the analyses of the research findings.

Introduction

With the publication of the National Research Council's (NRC) *America's Lab Report: Investigations in High School Science,* the current laboratory experiences of high school students were illuminated (2005). Along with this glimpse into the current experiences of students, came a call for increased focus on laboratory experiences with regard to the type of experiences most often afforded students. Within this report the following was accomplished:

- comparisons were made between access to laboratory experiences
- comparisons were made between the science laboratory experiences of differing racial, ethnic, and socioeconomic groups
- the resources necessary for teachers to accommodate student engagement in such laboratory experiences were identified.

While care was taken to refrain from using this report as a means for condemning those involved in ensuring that effective laboratory experiences are provided to high school students, many of the findings that emerged presented a less than satisfactory assessment of current conditions. The following are highlights of this less than satisfactory assessment:

- The quality of laboratory experiences is poor for most students . . . access to any type of laboratory experience is unevenly distributed.
- Most students, regardless of race or level of science class, participate in a range of laboratory experiences that are not based on design principles derived from recent research in science learning (NRC, 2005, p. 197).

With these findings, the report also offered recommendations for addressing the less than satisfactory conditions. The recommendations centered on partnerships between "teachers, scientists, cognitive psychologists, educational researchers, and school systems, working together" (NRC, 2005, p. 200) to design, implement, and assess innovative approaches to laboratory experiences.

Why an assessment of Utah high school students' current experiences in science is needed

To this point, it has been asserted through referencing the NRC (2005) report that on a national level, science laboratory experiences for students are less than satisfactory and that little to no information is available for ascertaining what, if any, difference exists in Utah. In this section, connections will be made regarding the deficiencies noted nationally to the information that is needed regarding these experiences in Utah. This will begin by describing current conditions found in our nation's schools. This will be followed by a description of how an assessment focused specifically on providing an accurate account of the conditions in Utah will lead to the identification of conditions that need to be addressed to continually improving laboratory instruction for high school students in the state.

Traditional approaches to engaging students in science laboratories experienced by America's high school students

The traditional approach to laboratory experiences identified by the NRC (2005) report reveals that these experience are 1) rarely designed with clear learning outcomes in mind; 2) rarely thoughtfully sequenced into the flow of science instruction; 3) rarely designed to integrate learning of the content of science with learning about the process of science; and 4) rarely incorporate ongoing student reflection and discussion. Tobin (1990) suggests that "the teacher's most important role is to facilitate learning by maintaining an environment in which students can make sense of what they are doing and receive challenges and assistance as required" (p. 414), but he goes on to assert that most teachers are too overly consumed by management in the laboratory to attend to these more important duties. This is a problem further supported by Hofstein & Lunetta (2004) when they state that "[s]everal studies have shown that often students and the teacher are preoccupied with the technical and manipulative details that consume most of their time and energy. Such preoccupation seriously limits the time they can devote to meaningful, conceptually driven inquiry" (p. 31). Additionally, Hofstein and Lunetta (1982) noted that typically the traditional laboratory experience is seen as a venue for illustrating, demonstrating, and verifying known concepts and laws.

In the NRC (2005) report, it is noted "that most laboratory experiences today are 'typical' laboratory experiences, isolated from the flow of science instruction. Because these typical laboratory experiences do not follow the design principles . . . they are unlikely to help students attain the science learning goals" (p. 117). The science learning goals referenced within the report that are not being met by "typical" laboratory experiences are:

- Enhancing mastery of subject matter
- Developing scientific reasoning
- Understanding the complexity and ambiguity of empirical work
- Developing practical skills
- Understanding of the nature of science
- Cultivating interest in science and interest in learning science
- Developing teamwork abilities (NRC, 2005, p. 117)

While the traditional laboratory experiences were tied to beliefs about teaching and learning present at the time these approaches were designed, these same approaches are out of step with current research on teaching, learning, and design principles that have revealed promise for increasing the effectiveness of laboratory experiences. The following section will outline the disparity between the existing national conditions identified in the NRC (2005) report and current research on teaching, learning, and design principles. This will be followed by the consideration of the research agenda's ability to provide an accurate and informative assessment of Utah's high school students' laboratory experiences.

Disparity between traditional laboratory approaches and research into teaching and learning

The initial problem that has historically hindered the effectiveness of laboratory experiences is a lack of agreed upon "definition and goals of high school laboratories" (NRC, 2005, p. 13). This initial problem may be worsened by the realization that just as there has historically been little agreement on the definitions and purposes of laboratory experiences, there has also been a lack of research into the effectiveness of the laboratory experiences that have been implemented (NRC, 2005). What was revealed by the NRC (2005) was the traditional focus of laboratories. They were seen "as secondary applications of concepts previously addressed by the teacher" (NRC, 2005, p. 25). Other researchers have noted additional problems of traditional laboratory experiences.

Research into teaching and learning as well as leading national science education organizations support a shift in science instruction away from laboratory experiences that illustrate, demonstrate, and verify known concepts and toward inquiry experiences (AAAS, 1993; Chang & Mao, 1999; Ertepinar & Geban, 1996; Hakkarainen, 2003; NRC, 1996; NRC, 2005; NSTA, 1998; Schwartz, Lederman, & Crawford, 2004). Inquiry, as described in the National Science Education Standards allows students to "describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others" (NRC, 1996, p. 2). Not only have leading national science education organizations called for inquiry instruction, they seem to have gone a step further by recognizing and promoting student inquiry in the science classroom as a central strategy for instruction at all grade levels (AAAS, 1993; NRC, 1996; NRC, 2005; NSTA, 1998, NSTA 2007). More specifically, research into inquiry instruction in the science classroom shows great promise for increasing students' understanding of science (Chang & Mao, 1999; Ertepinar & Geban, 1996; Hakkarainen, 2003), the nature of science (Schwartz, Lederman, & Crawford, 2004), and increasing students' interest and attitudes toward science (Cavallo & Laubach, 2001; Chang & Mao, 1999; Paris, Yambor, & Packard, 1998).

Not only have traditional laboratory experiences focused on instructional strategies that are less likely to meet science learning goals, the design principles typically employed where not found to be aligned with research on cognition and learning. The NRC (2005) report best explains traditional design principles most often employed: "Historically, laboratory experiences have been separate from the flow of classroom science instruction and often lacked clear learning goals. Because this approach remains common today, we refer to these isolated interactions with natural phenomenon as 'typical' laboratory experiences" (NRC, 2005, p. 78).

Based on the growing body of cognitive research available, the NRC (1999) produced a report titled "How People Learn" that outlined specifically four principles that support effective learning environments. These four principles were: 1) learner-centered environments: environments that take into consideration the prior knowledge students bring to the classroom; 2) knowledge-centered environments: environments that help students learn with understanding through engaging with scientific ideas and in doing science; 3) assessment to support learning: assessment used to support learning through feedback by the use of formative assessment; and 4) community-centered environments: environments that are characterized by opportunities and motivation to interact and hear peers. While these four principles do not dominate traditional laboratory experiences, the NRC (2005) report identified the "Integrated Instruction Unit Approach" as a more recently developed model of laboratory instruction that is guided by these four critical principles. The next section reveals more about this approach.

An integrated instructional unit approach to science laboratory experiences for high school students

The initial step the NRC (2005) report took in identifying laboratory experiences that are likely to meet learning goals of science laboratories was to provide the following definition of high school science laboratories:

> Laboratory experiences provide opportunities for students to interact directly with the material world (or with data drawn from the material world), using the tools, data collection techniques, models, and theories of science (NRC, 2005, p. 13).

With this definition articulated, the NRC was able to move forward in reviewing available literature on science laboratory experiences, design principles, and research on teaching, learning, and cognition to identify what they labeled the "Integrated Instruction Unit Approach" to science laboratory experiences. This approach is characterized as including the four critical principles that support effective learning environments outlined by the NRC (1999) and discussed in the previous section. These integrated instructional units

> interweave laboratory experiences with other types of science learning activities, including lectures, reading, and discussion. Students are engaged in framing research questions, designing, and executing experiments, gathering and analyzing data, and constructing arguments and conclusions as they carry out investigations. Diagnostic formative assessments are embedded into the instructional sequence and can be used to gauge students' developing understanding and to promote their self-reflection on their thinking (NRC, 2005, p. 82).

The laboratory experiences incorporated into the integrated instructional unit are selected based on research-derived considerations of what students will learn from the experiences and specifically linked to the other learning activities of the unit (NRC, 2005). These integrated instructional units are those units the NRC (2005) report suggests are most conducive to promoting attainment of learning goals for science laboratories.

RESEARCH QUESTIONS

The following research questions guided this research in meeting the research objectives for this project:

1. What are the experiences of Utah's high school students in science laboratories across the state?
2. What differences in science laboratory experiences, if any, are occurring between schools serving differing racial, ethnic, and socioeconomic groups?
3. What are the perceived needs for improving science laboratory experiences for Utah's high school students?

METHODS

The research methods section is introduced by the research questions and the methodologies employed to answer the questions. This is followed by a more detailed description of how each research methodology was carried out.

Research Question 1: *What are the experiences of Utah's high school students in science laboratories across the state?*

Classroom Observations drawn from a stratified random sample were first used to describe these experiences. These findings were additionally informed by the Teacher Interviews of each teacher identified in the stratified random sample. Finally, a Questionnaire/Needs Assessment was used to provide additional information about students' experiences. Triangulation occurred as findings from each of these methods were compared.

Research Question 2: *What differences in science laboratory experiences, if any, are occurring between schools serving differing racial, ethnic, and socioeconomic groups?*

This research question was answered through Classroom Observations and Teacher Interviews.

Research Question 3: *What are the perceived needs for improving science laboratory experiences for Utah's high school students?*

Questionnaire/needs assessment sent to all high school science teachers (9-12) across the state and Teacher Interviews form the stratified random sample were used to answer this research question.

Classroom Observations

Classroom observations were used to inform research questions 1 and 2. Stratified Random Sampling was used to select school districts from across Utah for completing classroom observations. Once classrooms were selected the three research project team members completed observations. Information about the research project team members can be found in Table 1.

Table 1: Research Project Team Members

Team Member	Short Bio
Dr. Todd Campbell	College of Education, Utah State University, is an Assistant Professor in Science Education with a Ph.D. in Science Education from the University of Iowa. He is an active member of the Utah State Office of Education State Science Education Coordinator Committee (SSECC) and the Science Education Research Committee (SERC) a subcommittee of the SSECC. His research is focused on teaching and learning in science, pre-service science teacher preparation, and technology used in teaching science (Campbell & Erdogan, 2005; Campbell & Worst, 2005; Campbell, 2006a; Campbell 2006b).
Mr. Jack Greene	A recently retired science teacher from Logan High School. He has taught in many high schools and several universities including St. Cloud State, Central Michigan, Weber State, and Utah State. He has involved his students in many "Citizen Science" projects and competitions. He currently works on projects for Utah State University, Logan High School, and the National Park Service.
Mrs. Mary Jane Seamons	Earned a BA in Physics Teaching from Brigham Young University. During her studies, she taught introductory physics labs at Snow College and at Brigham Young University. After graduation, she taught for a year in the Clark County School District.

The Institutional Review Board (IRB) for the protection of human participants at Utah State University reviewed and approved all phases of this research study. Approval was also received from each participating district and school. Finally informed consent forms were signed by each teacher participating in classroom observations and teacher interviews.

Research Instrument

The Reform Teaching Observation Rubric (RTOP) (Piburn, Sawada, Falconer, Turley, Benford, & Bloom, 2000) was used by the research project team members to complete classroom observations. The RTOP is an instrument constructed to measure "reformed" teaching as described by the national science standards documents (AAAS, 1989; NRC, 1996). The RTOP consists of 25 items divided into three subsets: *Lesson Design and Implementation*, *Content*, and *Classroom Culture*. *Content* and *Classroom Culture* are each divided into two smaller groups. *Content* is divided into *Propositional Knowledge* and *Procedural Knowledge*, while *Classroom Culture* is divided into *Communicative Interactions* and *Student/Teacher Relationships*. The *Design and Implementation* subset was designed to capture the "model for reformed teaching. It describes a lesson that begins with recognition of students' prior knowledge and preconceptions, that attempts to engage students as members of a learning community, that values a variety of solutions to problems, and that often takes its direction from ideas generated by students (Piburn et al. , 2000, p. 8)". The *Content* subset was designed to "assessed the quality of the content of the lesson, and . . . the process of inquiry" (Piburn et al. , 2000, p. 8). Finally, the *Classroom Culture* subset, was directed at "the climate of the classroom" (Piburn et al. , 2000, p. 9) . (Piburn, Sawada, Falconer, Turley, Benford, & Bloom, 2000) contains additional descriptions of each subset in the RTOP along with specific details for each indicators used in completing the classroom observations. The theoretical constructs guiding the design of the instrument, along with reliability and validity information and results of an exploratory factor analysis of the RTOP can be found in Piburn et al. (2000).

Because the RTOP was created using the national standards documents in science, it was found aligned to the recommendations for improving science laboratory experiences found in the National Research Council's (2005) report. This along with the established validity and reliability of the instrument provided the basis for its selection as a key instrument used in the project to reveal the experiences of Utah's high school students in science laboratories.

To become familiar with the RTOP instrument, the research project team members participated in a one day training session with a competent trainer/researcher experienced in using the instrument. The three project team members established inter-rater reliability with the RTOP through trial ratings of videocassettes from classrooms instructed by teachers not participating in the project. Inter-rater reliability was established at two stages in the project, once before beginning classroom observations and again two and one half months into the five month classroom observation window. At each stage inter-rater reliability was determined to be at or greater than .80.

Stratified Random Sampling

A stratified random sample was used in an effort to obtain as representative a sample of Utah (9-12) science teachers as possible, given the resources and budget of the present study. The following district-related characteristics were selected as stratifying factors in the sampling plan as it was also of interest to compare teachers on these district-level characteristics: district size (large vs. small), socioeconomic group (high versus low percent reduced lunch), and diversity indicators (high versus low percent white/Caucasian). The district characteristics categories were determined by taking the mean for the forty districts across the state for each characteristic (size, socioeconomic, diversity) and using this mean as a cutoff point to separate each district into high and low groups. The mean size of districts in Utah is 12,200 students. All districts serving student populations less than 12,200 students were categorized as small and all serving students populations with greater than 12,200 students were categorized as large. The percentage of students receiving free-reduced lunch in the districts was used to determine whether a district was categorized as a low or high socioeconomic district. The mean percentage of students eligible for free-reduced lunch across Utah was found to be thirty-nine percent. All districts serving student populations with less than thirty-nine percent of their students eligible for free-reduced lunch were categorized as high socioeconomic districts and all districts serving student populations with greater than thirty-nine percent of their students eligible for free-reduced lunch were categorized as low socioeconomic districts. Finally, the percentage of white population served by the districts was used to determine whether a district was categorized as a low or high diversity. The mean percentage of white population in schools across Utah was found to be eighty-five percent. All districts serving student populations with less than an eighty-five percent white population were categorized as high diversity districts and all districts serving student populations with greater than an eighty-five percent white population were categorized as low diversity districts.

All forty school districts in Utah were classified into the categories of a 3-way table that consisted of these three factors (see Table 2). No school districts were classified to two cells in the table. After schools were categorized and placed in Table 2 according to these three characteristics, the sample was obtained by randomly selecting two districts from each cell if more than two districts were in each cell, if there were two or less districts in a cell, no random selection occurred. This facilitated the selection of 12 districts. Within each selected district, two schools serving 9-12 students were randomly selected. If the districts selected had two or fewer schools serving 9-12 students, no random selection took place and instead each school was asked to participate. Within the schools selected, up to five teachers were randomly selected as possible participants and requests were made for a classroom observation of one class period whereby the selected teachers were facilitating a science laboratory experience. If the schools had less than five teachers, no random selection took place and instead a classroom observation of a science laboratory experience and teacher interview was requested of each teacher in the school.

Because all schools serving students with 9-12 students were included in the random selection process, in the end 12 districts participated. Within these districts 15 high schools, 1 K-12 School, and 3 junior high schools participated. Of the districts that were asked to participate eighty-six agreed (12/14 asked). Of the sixty-two teachers who were asked to participate forty (sixty-five percent) agreed. Of twenty-three teachers that did not participate, various reasons were cited from “not willing to participate” to teachers not facilitating a laboratory experience during the 5 month classroom observation sampling window.

Table 2: District Categorization and Numbers of Districts in each Category

	Small (Less than 12,200 Students)	Large (Greater than 12,200 Students)
Low Diversity (Greater than 85% White Student Population)		
High Socioeconomic Student Population (Less than 39% Free-Reduced Lunch)	10 Districts	7 Districts
Low Socioeconomic Student Population (Greater than 39% Free-Reduced Lunch)	15 Districts	0 Districts
High Diversity (Less than 85% White Student Population)		
High Socioeconomic Student Population (Less than 39% Free-Reduced Lunch)	2 Districts	0 Districts
Low Socioeconomic Student Population (Greater than 39% Free-Reduced Lunch)	2 Districts	4 Districts

Teacher Interviews

Teacher interviews were used to inform research questions 1, 2, and 3. Teacher Interviews were completed with the Stratified Random Sample of teachers selected for classroom observations. Once classrooms were selected for observations, the three research project team members first completed the classroom observations followed by the teacher interviews.

Research Instrument

The Teacher Interview Protocol was developed and used by the research project team members to complete the teacher interviews. The Teacher Interview Protocol was constructed to guide the interviews. It was used in conjunction with the RTOP to measure the extent to which laboratory experiences were aligned with the design principles recommended by the National Research Council (2005) report, specifically if

> 1) they are designed with clear learning outcomes in mind, 2) they are thoughtfully sequenced into the flow of science instruction, 3) they are designed to integrate learning of the content of science with learning about the process of science, and 4) they incorporate ongoing student reflection and discussion (NRC, 2005, p. 197).

The Teacher Interview Protocol was first developed by the research project team and piloted with a science faculty member not participating in the project. After initial piloting, the instrument was refined and finalized. A copy of the Teacher Interview Protocol can be found in Appendix 1.

To become familiar with the Teacher Interview Protocol and conducting interviews, the research project team members read and discussed literature about interviewing before agreeing on interviewing principles to guide the interviews (see Appendix 2). Each interview was audio taped so that interviews could be revisited during analysis to triangulate findings and/or answer any questions emerging about the interviewing process. Each project team member revisited the audiotapes after the interviews to summarize participants' responses for analysis.

All forty teachers agreeing to participate in the classroom observations participated in the teacher interviews.

After the interviews were completed the data was first analyzed to detect themes emerging from the forty teachers as a whole. Once these themes were determined, the interviews were then separated to look for any differences among the emerging themes occurring between groups. The analysis focused on groups was completed by first grouping according to whether the teacher interviewed taught in a small or large district. At the conclusion of this stage of analysis, the data was next sorted into two groups according to district socioeconomic status, low socioeconomic status and high socioeconomic status (each determined by the percentage students in the district receiving free and reduced lunch). The third and final stage of analysis was completed by sorting all of the data into two groups according to district diversity, high and low diversity (each determined by the percentage of white student population in the district).

Credibility of Analysis

Peer examination occurred at each stage of data analysis (Merriam, 1998). For all stages of qualitative analysis described, two researchers from the research project team worked together in analysis to achieve agreement on the emerging themes.

Questionnaire/Needs Assessment

The Questionnaire/Needs Assessment was used to inform research questions 1, 2, and 3. The Questionnaire/Needs Assessment was delivered online as the online survey URL was sent through email invitation to all 9-12 Science Teachers in the Utah.

Research Instrument

The Questionnaire/Needs Assessment was developed by the research team members in collaboration with the Science Education Research Committee (SERC). The SERC is a subcommittee of the State Science Education Curriculum Coordination Committee (SSECC) a committee organized by the Utah State Office of Education (USOE). Members of the SERC include district science specialists, university science educators, scientists, and USOE science specialists. Through feedback and discussion in collaboration with the SERC, the document went through at least three revisions before being finalized. The Questionnaire/Needs Assessment was constructed to identify the teachers' perception of Utah high school students' laboratory experiences and the perceived needs for improving laboratory experiences. A request to complete the questionnaire/needs assessment was sent via email to all 9-12 science teachers in Utah (with the exception of one large district). The instrument was completed online accessed via a URL included in the participation request email. Because this instrument was distributed to all 9-12 science teachers, it was also used to triangulate findings emerging from both the classroom observations and teacher interviews. A copy of the Questionnaire/Needs Assessment can be found in Appendix 3.

The questionnaire/needs assessment was sent to teachers from thirty-nine of the forty school districts or 693 (9-12) science teachers. One large school district with 53 (9-12) science teachers requested that their teachers not be included. Of the 693 emails sent requesting participation, 14 emails were returned. Follow-up emails were sent two times during the two month questionnaire/needs assessment sampling window. Of the 679 teachers sent the request to participate whose emails were not returned 211 teachers participated. This number represented a thirty-one percent response rate for the instrument (211/679). This response rate, while not high, is considered acceptable with thirty percent being the average rate for online surveys (DIIA, 2007). It is also important to note that teachers from thirty-two of the thirty nine districts surveyed did participate, signifying a high proportion of the districts were included.

After the Questionnaire/Needs Assessments were completed, the results were analyzed by the online survey instrument used with the exception of the two open ended questions in the survey. The open-ended questions completed as part of the instrument were analyzed to identify emerging themes. Peer examination occurred in the thematic analysis of the open-ended questions (Merriam, 1998). This was accomplished by ensuring that two researchers from the research project team worked together in analysis to achieve agreement on the themes emerging from each questions.

FINDINGS AND DISCUSSION

The research findings and discussion of the findings are presented for each research question.

Research Question 1: *What are the experiences of Utah's high school students in science laboratories across the state?*

Classroom Observations

Findings

The experiences of Utah's high school students were first revealed through the findings emerging from the Classroom Observations using the Reformed Teaching Observation Protocol (RTOP) The RTOP findings are described as the extent to which students were engaged in classroom's facilitated in a manner aligned with national standards documents. The RTOP instrument allows for scores from 0-100, with 0 not aligning to standards documents and 100 aligned to standards documents. A brief reminder here, alignment to standards documents entails facilitation characterized by lessons that begin "with recognition of students' prior knowledge and preconceptions that attempts to engage students as members of a learning community, that values a variety of solutions to problems, and that often takes its direction from ideas generated by students (Piburn et al., 2000, p. 8)".

Table 3 reveals the descriptive statistics for the sample as a whole. This table is followed by information about the percentage of teachers' total score for the RTOP found for the different ranges of scores: between 1) 1-33, 2) 34-65, and 3) 66-100 (Table 4).

Table 3: Descriptive statistics for the entire sample:

	Mean	**Median**	**SD**	**n**	**Max**	**Min**
RTOP total score	53.46	54	17.21	40	88	20
LESSON DESIGN	8.53	7	3.92	40	17	3
PROPOSITIONAL	14.1	14	3.51	40	19	4
PROCEDURAL	8.45	7.5	4.12	40	18	2
COMMUNICATIVE	9.85	10	3.68	40	16	3
S/T RELATIONS	12.55	13.5	4.62	40	20	3

Table 4: Percentage of teachers within specific ranges of scores for the RTOP

Score Range	Number of Teachers in Range	Percentage of Teachers in Range
1 – 33 points	*n* = 14	35%
34 – 65 points	*n* = 21	52.5%
66 – 100 points	*n* = 5	12.5%

To learn more about the RTOP results found and the experiences of students in the classroom, the RTOP results were divided into the different subsets of the instrument to elucidate any differences occurring between the different subsets involved in reformed teaching: 1) Lesson Design, 2) Propositional, 3) Procedural, 4) Communicative, and 5) S/T Relations. These subset scores were then compared to reveal whether or not statistically significant differences between participants' scores on the subsets existed.

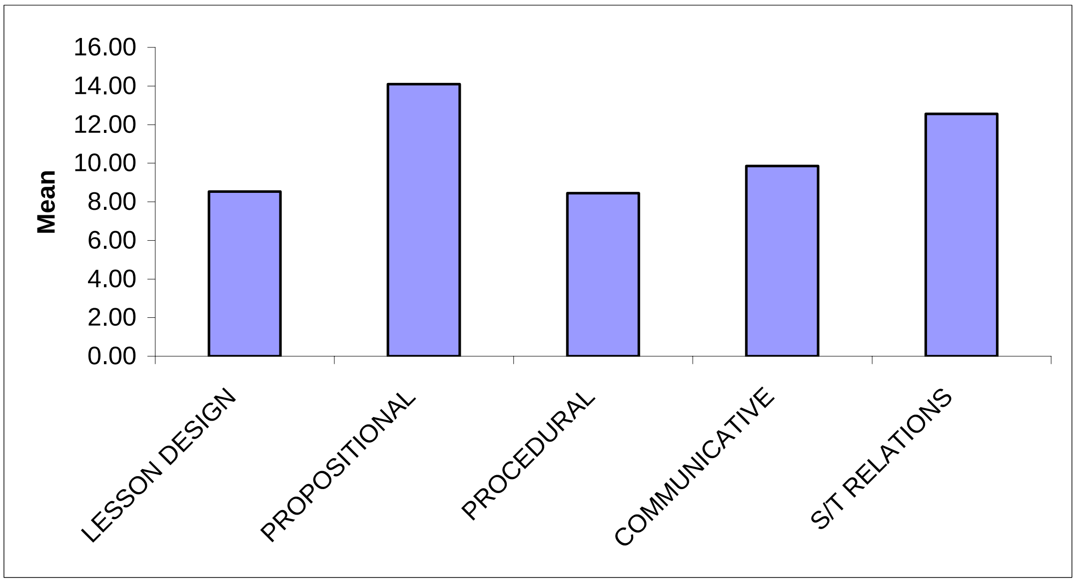
To complete this analysis, a one-way within-subjects (or repeated-measures) ANOVA was conducted to compare scores from the five RTOP subscales within the same teachers. Results indicated a significant overall effect, $F(4, 156) = 50.48$, $p < .0001$. Results of follow-up tests indicated that means from all pairs of subscales differed significantly from each other except for the comparison between Procedural and Lesson Design scores. See both Table 5 and the Figure 1 below.

Table 5: Comparison between different subscale scores in RTOP

TOTAL SAMPLE	**Results of post-hoc paired-samples *t*-tests for differences among subscales**

	PROPOSITIONAL	PROCEDURAL	COMMUNICATIVE	S/T RELATIONS
LESSON DESIGN	$t(39) = 8.21, p < .0001$	$t(39) = 0.16, p = .87$	$t(39) = 3.10, p < .01$	$t(39) = 7.59, p < .0001$
PROPOSITIONAL		$t(39) = 10.28, p < .0001$	$t(39) = 8.24, p < .0001$	$t(39) = 2.75, p < .01$
PROCEDURAL			$t(39) = 4.04, p < .001$	$t(39) = 7.98, p < .0001$
COMMUNICATIVE				$t(39) = 8.12, p < .0001$
S/T RELATIONS				

Figure 1: Average scores for each subscale of the RTOP (20 points possible)



Teacher Interviews

Findings

Additional information about the experiences of Utah's high school students were revealed through the findings emerging from the Teacher Interviews conducted with each of the teachers observed. The following six questions along with the findings from each of these questions follow.

What strategies are used to help students make connections between the science laboratory experiences and the other learning activities in the science unit?

On the whole, the teachers interviewed did not list individual strategies that they use to integrate the lab experiences into other activities. Almost all of the teachers listed instead how the labs are integrated into the unit as a whole.

More than half of the teachers interviewed stated that they use labs to reinforce the ideas and concepts that the students are learning from bookwork, lectures, movies, and other learning activities. About half as many of the teachers indicated that they use the labs as a way for the students to see some real-life application of what they are learning in class. Slightly fewer feel that in order to best grasp the attention of the students, they need to use the labs as an introduction to the concept that the students are set to study in the coming unit. These teachers expressed a feeling that when the students have a hands-on experience to refer back to during the course of the unit, they are more interested and have a better overall grasp of the subject. Still fewer use the labs as a sort of culmination of what the students have learned in a unit, the lab being the mortar that holds the concept together in the students' minds, usually occurring directly prior to the unit exam.

To what extent are the students engaged in the following instructional activities in this unit:

- *Framing research questions:*

Although a few of the teachers observed claimed to be involving the students in this process, during the observations we saw very few student-initiated research questions.

- *Designing and executing experiments:*

Almost a fourth of the teachers interviewed claimed that the students are involved in designing the lab experiments that they do in class. In our observations, we saw that among those classes where the students are designing their own labs, heavy guidance is given from the teacher in terms of the equipment to be used and the specific questions to be answered.

- *Gathering and analyzing data:*

Nearly every teacher interviewed agreed that the students participate in gathering and analyzing data during their labs. Mostly, the students gathered the data into tables and analyzed it, comparing it to the theory learned in other classroom activities.

- *Constructing arguments and conclusions as they carry out investigations:*

Almost all of the teachers said that their students do this regularly. From the interview statements, it seems as though the students, typically in groups, come to conclusions guided by teacher questions. Most of the arguments that come out of the labs seem to correlate with possible sources of error between the observed data and the expected outcome.

- *Reflection and discussion:*

Again, most of the teachers claimed that the students do a good deal of this. From our observations, we found that most of the discussion occurs between the lab groups or is teacher-directed following the lab activity.

Please explain how students were introduced to this science laboratory experience and explain any follow-up that occurs after this science laboratory experience.

The teachers interviewed seemed to answer this question in one of two ways: either to say what was being done directly before and after the lab period, or to say how the lab fit into the unit as a whole.

Most of the teachers said that the students were introduced to the lab experience by other learning activities, such as lecture, worksheets, and demonstrations. About half as many indicated that the students were introduced to the lab immediately previous to the lab day by doing some sort of pre-lab assignment. Sometimes these assignments were simply to read the lab, other times they were to draw the apparatus to be used, or to come prepared with a few written sentences describing the lab to come.

The responses for what happens after the labs seem to indicate that two approaches are used almost equally throughout the schools. Some of the teachers take the opportunity directly following a lab to describe some of the real-life application of the concepts and expertise that the students are learning. Other teachers use the time following a lab to discuss results and questions as a class.

A few of the teachers indicated that they use labs either to introduce a concept at the beginning of the unit or to put all the individual pieces together at the end of the unit.

In what ways are students assessed in this science unit?

The most prevalent method teachers interviewed used in assessing students was written exams, many of these called “end of unit tests”. These were described as paper and pencil tests that while, not labeled by the teachers in these terms were summative assessments. Teachers did discuss the use of formative assessment that was used to help them gauge what students might be struggling with during the science unit, but mention of formative assessment did not occur as frequently in the interviews and was mentioned by less than half of the respondents. Other ways students were assessed in the unit included those methods traditionally used such as homework assignments, quizzes, and worksheets. While mention was made of more recent educational assessment techniques such as the use of rubrics, performance assessments, and essay exams, this occurred infrequently with one to two participants describing their use out of the forty participants interviewed.

Laboratory work was used in assessing students in the science unit through the assessment of lab reports and lab activities and most commonly by including questions from the lab on the end of the unit tests. An emphasis in these assessments was placed on students abilities to follow procedures and getting the correct lab result. Teachers were also found assessing students participation in labs. While one teacher interviewed did discuss a mechanism she used for allowing students to assess themselves and their group members, more often participation grades were assigned based on teachers’ judgment about the extent to which students were participating in the lab.

A few teachers did share struggles that they have had in assessing lab work specifically. One teacher expressed concern for assessing students paired in groups to complete laboratories; whether to assess individuals or the groups collectively. Another teacher expressed a concern for the subjective manner that he assessed students in the laboratory, suggesting that he feels like he should have a more formal mechanism for assessing lab work.

In what ways are science content and process emphasized in this science unit?

While a few teachers mentioned integrating the teaching of science and process so that students are learning content as they are engaging in science processes and learning about these processes, most teachers responded to this question with two separate statements. Most of the teachers responded by saying that content is always there before going on to explain strategies that they use for teaching science processes. The overwhelming mechanism teachers identified for emphasizing science processes was a focus on the scientific method. A little less than one half of the respondents identified this mechanism.

Several of the teachers, when asked this interview question responded "I am not sure what you mean by emphasizing science process". Through this interview question, it became apparent through the emergence of only one dominant theme for emphasizing science process, the scientific method, that while different teachers implement different strategies ranging from learning about historical figures in science to focusing on process as one teacher stated "very little" that more differences occurred with regard to how teachers emphasized science processes. Also noticeable was that few teachers described more than one mechanism for this emphasis.

How would you define a science laboratory experience?

When analyzing teachers' response to this question, few broad commonalities were found in how teachers defined a science laboratory experience. Many times descriptive words were used to describe the experience rather than define it. Some of these descriptive words were as follows: exploratory, investigative, discovery. Little other articulation was provided with these descriptors to gain insight into what this meant for the student. A little over a quarter of the participants believed that the science laboratory experience was a hands-on experience.

Some of the teachers described what students would be doing in the science laboratory as their definition. A few teachers described this activity as developing questions, designing and carrying out experiments to collect data to make conclusions or answer their question. Other teachers' descriptions were similar, but differed in that they either did not include students in the development of questions. Other still did not involve students in developing questions or designing experiments. They described students carrying out experiments to collect data and make conclusions. Reasons given for not having students develop the questions or design procedures in some instances involved teachers beliefs that guided laboratories helped to ensure that students would make connections to the content of the unit. A group of teachers saw the lab as a reinforcement of the concepts or content from the classroom. A few teachers expressed a belief that science laboratory experiences were defined as the ability to follow directions. Still other teachers reasons for providing more teacher direction in question development and procedures involved not having time to allow this with just a few teachers expressing a belief that students were not ready or capable of these type activities.

One teacher found it difficult to define the science laboratory experience, because science laboratory experiences formed the framework for how she instructed her class stating

> Never make it separate from a science class. I don't like to say its lab day, because I feel like everyday is a lab day. Every class should be a science lab experience. They formulate their own questions based on one I start them out with or they come up with questions on their own, design and carry-out procedures to answer the questions"

The teacher making this statement was the teacher who, when observed, was rated highest of the forty classrooms based on reformed teaching as identified by the Reformed Teaching Observation Protocol (RTOP).

Two other teachers expressed the view that the science laboratory experience was the opportunity for students to engage in activities similar to those experienced by scientists and where focused on helping students understand more about what science is and how we arrive at what we declare as scientific understandings. From this question it became clear that teachers define science laboratory experiences in different ways and as a result of this implement them with different purposes in their classrooms.

<u>Questionnaire/Needs Assessment</u>

Findings

One of the five sections (ten questions) of the needs assessment was directed at better understanding the science laboratory experiences of Utah's high school students. These questions focused on what teachers' reported occurring in their classroom. The following are the ten questions asked followed by descriptive statistics of the teachers' responses:

In my classroom student background knowledge is identified before the laboratory work begins with a deliberate activity or discussion.			
Almost Never		4	2%

Seldom		9	4%
Sometimes		45	22%
Often		87	42%
Almost Always		63	30%
Total		208	100%
During science laboratory experiences in my classroom, students perform activities in groups and have responsibilities to the group.			
Almost Never		3	1%
Seldom		2	1%
Sometimes		16	8%
Often		76	37%
Almost Always		110	53%
Total		207	100%
In my classroom, laboratory work occurs before other more formal strategies (lecture, reading, writing or other learning activities)			
Almost Never		22	11%
Seldom		53	26%
Sometimes		104	50%
Often		17	8%
Almost Always		11	5%
Total		207	100%
The science laboratory experiences in my classroom encourage students to seek and value alternative modes of investigation or of problem solving.			
Almost Never		5	2%
Seldom		18	9%
Sometimes		93	45%
Often		69	33%
Almost Always		23	11%
Total		208	100%

The focus and direction of the science laboratory experiences in my classroom are often determined by ideas originating with students.			
Almost Never		33	16%
Seldom		81	39%
Sometimes		76	37%
Often		14	7%
Almost Always		4	2%
Total		208	100%

Students make predictions, estimations or hypothesis in science laboratory experiences in my classroom.			
Almost Never		4	2%
Seldom		2	1%
Sometimes		56	27%
Often		91	44%
Almost Always		54	26%
Total		207	100%

Students design procedures for testing their own predictions, estimations or hypothesis in science laboratory experiences in my classroom.			
Almost Never		19	9%
Seldom		57	28%
Sometimes		95	46%
Often		28	14%
Almost Always		8	4%
Total		207	100%

During science laboratory experiences in my classroom, students are encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence in science laboratory experiences.			
Almost Never		10	5%
Seldom		25	12%
Sometimes		85	41%
Often		68	33%
Almost Always		18	9%
Total		206	100%

Students in my science classes have an average of ________________________________ science laboratory experiences in a two week interval.			
Less than One		41	20%
One		81	39%
Two		59	28%
Three		18	9%
Greater than Three		11	5%
Total		210	100%

Please rank the following seven goals for science laboratory experiences in order of importance to you. (1 is Most Important and 7 is Least Important)							
Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.	1	2	3	4	5	6	7
Enhancing mastery of subject matter	36 23%	28 18%	27 17%	28 18%	8 5%	13 8%	16 10%
Developing scientific reasoning	24 16%	28 19%	31 21%	23 15%	26 17%	14 9%	4 3%
Understanding the complexity and ambiguity of empirical work	14 8%	11 7%	23 14%	15 9%	28 17%	18 11%	56 34%
Developing practical skills	18 11%	29 18%	22 14%	24 15%	29 18%	25 16%	13 8%
Understanding the nature of science	22 14%	29 18%	28 18%	22 14%	23 14%	27 17%	8 5%
Cultivating interest in science and interest in learning science	47 26%	29 16%	26 14%	27 15%	22 12%	21 12%	8 4%
Developing teamwork abilities	22 11%	32 15%	25 12%	21 10%	23 11%	40 19%	44 21%

Discussion

The classroom observations, teacher interviews, and questionnaire/needs assessment collectively provided insight into the experiences of Utah's high school students in science laboratories across the state. The classroom observations revealed that Utah students' experiences in science laboratories were somewhat aligned with reformed teaching as described by the standards documents (AAAS, 1989; NRC, 1996). This was evidenced in an average score approximately midway between reformed teaching and what might be considered more traditional facilitation. It is important to note that more teachers (35% with RTOP score between 1-33 compared to 12.5% with RTOP scores between 66-100) were observed facilitating instruction more aligned with traditional approaches to instruction. When parsing the RTOP average scores to compare classroom experiences in the areas measured by the different subscales, Figure 1 reveals a much higher average score for propositional knowledge when compared to other subscales associated with reformed teaching. The average scores for lesson design and procedural knowledge were approximately the same and the lowest of all subscales. When compared, a statistical difference was found between all subscales except lesson design and procedural knowledge.

These findings reveal a strong commitment and emphasis on propositional knowledge, one of two division of the RTOP Content subscale, that assessed "the quality of the content of the lesson" (Piburn et al., 2000, p. 8)". When comparing the propositional knowledge to the other smaller division of the content subscale, procedural knowledge, this commitment and emphasis was diminished. This procedural knowledge division of the content subscale revealed the quality of "the process of inquiry (Piburn et al., 2000, p. 8)" experienced by students.

As described earlier, the Lesson Design subscale of the RTOP was designed to assess "the model for reformed teaching. It describes a lesson that begins with recognition of students' prior knowledge and preconceptions, that attempts to engage students as members of a learning community, that values a variety of solutions to problems, and that often takes its direction from ideas generated by students (Piburn et al. , 2000, p. 8)." This subscale was found diminished in comparison to the propositional knowledge subscale and approximately equal to the procedural knowledge division of the Content subscale.

The National Research Council's (NRC) *America's Lab Report: Investigations in High School Science*, report stated that laboratory experiences were rarely thoughtfully sequenced into the flow of science instruction, The findings emerging from the teacher interviews reveal that Utah teachers were, to some extent, engaged in thoughtfully sequencing the laboratory experience into the flow of the unit, but the focus was more on what the NRC (2005) report describes "as secondary applications of concepts previously addressed by the teacher (NRC, 2005, p. 25)".

The NRC (2005) report also revealed that laboratory experiences were rarely designed to integrate learning of the content of science with learning about the process of science. The findings from this study revealed little difference in this area in Utah as was reflected in several teachers' response to the question *Please explain how science content and process are emphasized in the science unit*, "I am not sure what you mean by emphasizing science process". When teachers did discuss process, the strategy most often employed involved the scientific method. An emphasis questioned in science education literature, due to a possible misrepresentation of the nature of science linked to the scientific method (McComas, 2004; Schwartz, Lederman , & Crawford, 2004).

The NRC (2005) report also found that the initial problem that has historically hindered the effectiveness of laboratory experiences is a lack of agreed upon "definition and goals of high school laboratories" (p. 13). The wide variance of definitions emerging from Utah teachers revealed this as a possible problem present in Utah with it becoming clear that Utah teachers define science laboratory experiences in different ways and as a result of this implement them with different purposes in their classrooms.

The NRC (2005) report also recommended a focus on integrated instruction units. These integrated instructional units

> interweave laboratory experiences with other types of science learning activities, including lectures, reading, and discussion. Students are engaged in framing research questions, designing, and executing experiments, gathering and analyzing data, and constructing arguments and conclusions as they carry out investigations. Diagnostic formative assessments are embedded into the instructional sequence and can be used to gauge students' developing understanding and to promote their self-reflection on their thinking (NRC, 2005, p. 82).

The teacher interviews revealed that Utah high school students were engage in integrated instruction units on some level. The laboratory experiences were interweaved with other types of science learning activities including lectures, reading, and discussion, but students are not engaging in framing research questions, or commonly found designing experiments. The interviews did reveal that students are executing experiments, gathering and analyzing data, and constructing arguments, but these experiments were designed by the teacher. Finally, while formative assessment was reported as a way that teachers gauged students developing understanding during laboratories, much emphasis with assessment in the science unit was focused on "end of the unit exams" and whether or not students understood content. With assessment of laboratories tied to the extent to which procedures were followed, whether lab results were correct, or questions about the laboratory embedded in the "end of the unit exam" questions.

The questionnaire/needs assessment revealed findings similar to those emerging from both the classroom observations and the teacher interviews. Teacher interviews revealed little to no students framing research questions or designing their own experiments. The results from the classroom observations whereby lesson design and procedural knowledge subscales were found to be lowest on average were consistent with the teacher interview findings. When teachers were asked in the questionnaire/needs assessment whether *Students design procedures for testing their own predictions, estimations or hypothesis in science laboratory experiences in my classroom* seventy-four percent responded seldom or sometimes. While the report here by teachers may be a little more than what was revealed in classroom observations and in teacher interviews as far as the extent to which students are engaged in design, it is consistent in revealing Utah students do not engage in question framing and design to the extent suggested in standards documents aligned to reformed teaching and leading to attainment of science laboratory goals.

The questionnaire/needs assessment also revealed that seventy-four percent of teachers reported student sometimes or often engaging in generating conjectures, alternative solution strategies, and ways of interpreting evidence in science laboratory experiences. This was consistent with teacher interview reports that while students were not framing research questions and often not involved in design of experiments, they were involved with gathering and analyzing data, constructing arguments and conclusions, and reflection and discussion as part of their laboratory experiences.

Finally, the teachers' variability in rankings found when teachers were asked to rank the goals for science laboratory experiences outlined in the NRC (2005) further suggests differences noted earlier in the range of how teachers define laboratory experiences and the goals they have for engaging students in these experiences.

Research Question 2: *What differences in science laboratory experiences, if any, are occurring between schools serving differing racial, ethnic, and socioeconomic groups?*

<u>Classroom Observations</u>

Findings

Because the RTOP was used as a key indicator for revealing Utah's high school students science laboratory experiences, comparisons of scores were used to investigate the extent to which differences were occurring between differing sized districts serving differing racial, ethnic, and socioeconomic groups

The first comparison was made to determine whether or not statistically significant differences occurred between classrooms observed in large districts compared to small districts.

Descriptive statistics and results of these statistical analyses are presented in the Table 6 below. A series of independent-samples *t*-tests were conducted for each outcome variable from the RTOP. Results indicated that there were **no significant differences** between teachers from large and small school districts.

The second comparison was made to determine whether or not statistically significant differences occurred between districts serving students with low socioeconomic groups compared to districts serving students in higher socioeconomic groups (socioeconomic groups were determined by the percentage of students receiving free and reduced lunch)

Descriptive statistics and results of statistical analyses for this question are presented in Table 7 below. A series of independent-samples *t*-tests were conducted for each outcome variable from the RTOP. Results indicated that there were **significant differences** between teachers from districts serving students from high and low socioeconomic groups. For instance, significantly higher scores on the RTOP total score, and Propositional, Procedural, Communicative, and S/T Relations subscales were observed ($p < .05$) for the districts serving higher socioeconomic groups. There was **no significant**

difference between scores from teachers from districts serving students from high and low socioeconomic groups on the Lesson Design subscale.

Table 6: Descriptive statistics and statistical analysis results comparing district size

BY DISTRICT SIZE							
	Size	**Mean**	**Median**	**SD**	**n**	***T***	***p***
RTOP total score	Large	52.47	53.00	15.00	17	0.31	.76
	Small	54.22	57.00	18.98	23		
LESSON DESIGN	Large	8.18	7.00	3.59	17	0.48	.63
	Small	8.78	8.00	4.20	23		
PROPOSITIONAL	Large	14.71	14.00	3.20	17	0.94	.35
	Small	13.65	14.00	3.73	23		
PROCEDURAL	Large	7.82	7.00	3.96	17	0.82	.41
	Small	8.91	8.00	4.26	23		
COMMUNICATIVE	Large	9.65	9.00	3.67	17	0.30	.77
	Small	10.00	10.00	3.75	23		
S/T RELATIONS	Large	12.12	11.00	4.03	17	0.50	.62
	Small	12.87	14.00	5.08	23		

Table 7: Descriptive statistics and statistical analysis results comparing socioeconomic differences

BY REDUCED LUNCH							
	Reduced Lunch	**Mean**	**Median**	**SD**	**n**	***t***	***p***
RTOP total score	High	47.87	47.00	16.46	23	2.56	**.02**
	Low	61.06	66.00	15.59	17		
LESSON DESIGN	High	8.13	7.00	3.85	23	0.74	.47
	Low	9.06	7.00	4.05	17		
PROPOSITIONAL	High	12.83	12.00	3.41	23	2.92	**.01**
	Low	15.82	17.00	2.92	17		
PROCEDURAL	High	7.09	6.00	3.84	23	2.61	**.01**
	Low	10.29	11.00	3.85	17		
COMMUNICATIVE	High	8.78	8.00	3.64	23	2.24	**.03**
	Low	11.29	12.00	3.29	17		
S/T RELATIONS	High	11.04	10.00	4.46	23	2.57	**.01**
	Low	14.59	16.00	4.12	17		

The third comparison was made to determine whether or not statistically significant differences occurred between districts serving student populations with low diversity compared to districts serving student populations with high diversity (diversity was determined by the percentage of white students in each district)

Descriptive statistics and results of statistical analyses for this question are presented in the Table 8 below. A series of independent-samples *t*-tests were conducted for each outcome variable from the RTOP. Results indicated that there were **no significant differences** between teachers from districts serving student populations with high diversity versus low diversity student populations.

Table 8: Descriptive statistics and statistical analysis results comparing diversity differences

BY ETHNICITY							
	Ethnicity	**Mean**	**Median**	**SD**	**n**	***t***	***p***
RTOP total score	High White	57.14	63.00	18.68	14	0.99	.33
	Low White	51.50	51.00	16.41	26		
LESSON DESIGN	High White	9.29	8.50	3.79	14	0.90	.37
	Low White	8.12	6.00	3.99	26		
PROPOSITIONAL	High White	14.21	15.00	4.48	14	0.15	.88
	Low White	14.04	14.00	2.96	26		
PROCEDURAL	High White	9.21	10.50	4.14	14	0.86	.40
	Low White	8.04	7.00	4.13	26		
COMMUNICATIVE	High White	10.86	12.00	3.76	14	1.28	.21
	Low White	9.31	9.00	3.59	26		
S/T RELATIONS	High White	13.57	14.50	5.03	14	1.03	.31
	Low White	12.00	10.50	4.38	26		

Teacher Interview

Findings

The first noticeable differences in the reported findings between groups when interviews were separated according to district size, socioeconomic, or ethnic indicators, involved teachers from districts separated by those serving student populations with high diversity compared to those serving populations with low diversity. When comparing teachers' responses from districts serving large populations of diverse students compared to districts serving smaller populations of diverse students, almost half of the teachers from districts serving large populations of diverse students defined science laboratory experiences as hands-on experiences, while less than a quarter of the teachers form the districts serving smaller populations of diverse students defined science laboratory experiences in this manner.

Discussion

What differences in science laboratory experiences, if any, are occurring between schools serving differing racial, ethnic, and socioeconomic groups?

The classroom observations revealed that differences were occurring in the experiences of Utah's high school students when districts serving student populations with differing socioeconomic status were compared. A significant difference in was found with districts serving student populations with lower socioeconomic groups having experiences less aligned with reformed teaching. These significant differences were found in each subscale of the RTOP with the exception of the Lesson Design subscale. While no differences where found when comparing districts with respect to size or diversity differences, findings revealing difference based on socioeconomic differences are cause for attention. Because evidence has been gathered to support a relationship between increased RTOP scores and student academic performance (Piburn, Sawada, Falconer, Turley, Benford, Bloom, 2000, p. 24), there is need for additional attention to ensure that students from districts serving lower socioeconomic groups are not being underserved by their experiences in the science classroom.

Another indication that difference were occurring came from the teacher interviews when comparing districts serving populations with higher diversity. Teachers from districts serving higher diverse populations defined science laboratory experiences as hands-on experiences, more often than those serving less diverse populations. These differences were not found in classroom observations, but may hint at a difference in philosophy that teachers in Utah have developed or adopted when dealing with more diverse populations. Further investigation into the reason for this finding may help in better understanding whether this difference is beneficial in differentiating instruction based on the needs of students, or perhaps not beneficial if the differences are found tied to a deficit model of instruction.

Additional differences were identified as teachers responded to the final interview question "*As we conclude this interview, is there any additional information you prefer to add regarding science laboratory experiences?*". When comparing teachers' responses from small districts to those coming from large districts, the findings revealed that almost half of the teachers from small districts expressed a concern for lack of funding. This same concern surfaced in only around ten percent of the teachers from large districts. Teachers from small districts were also more likely to voice the request for the USOE to offer specific labs that align to the core curriculum. Just under half of the teachers from small schools made this request while very few form the large districts made this request.

Teacher interviews when separated into groups based on socioeconomic population served, also revealed the teachers from the schools serving students from lower socioeconomic groups were more often found revealing concerns about lack of funding. They were also more often found requesting the USOE offer specific labs that align to the core curriculum. Both of these findings were supported by teacher interviews where these concerns or requests were found emerging from approximately half of the teachers interviewed from this group. These concerns or requests were found infrequently coming from interviews with teachers serving populations of students from higher socioeconomic groupings.

Research Question 3: *What are the perceived needs for improving science laboratory experiences for Utah's high school students?*

Questionnaire/Needs Assessment

Three of the five sections (twenty questions) of the needs assessment were directed at better understanding the teachers' perceived needs for improving science laboratory experiences for Utah's high school students. These three sections focused on 1) Teacher Preparation for Laboratory Experiences, 2) Laboratory Facilities, Equipment, and Safety, and 3) Other influences and information about science laboratory experiences. The twenty questions, two of which were open-ended questions, focused on what teachers' perceived needs. The following are the twenty questions asked followed by descriptive statistics of the teachers' responses for all except the two open-ended questions. The findings of the two open-ended questions are reported following the questions and descriptive statistics:

Which statement best describes the preparation in science content knowledge you feel you received in your undergraduate education?			
Not Prepared		8	4%
Somewhat Prepared		45	21%
Prepared		70	33%
Very Prepared		87	41%
No Opinion		0	0%
Total		210	100%

Which statement best describes the preparation in science process knowledge you feel you received in your undergraduate education?			
Not Prepared		9	4%
Somewhat Prepared		68	32%
Prepared		88	42%
Very Prepared		46	22%
No Opinion		0	0%
Total		211	100%

Which statement best describes your confidence in leading students in science laboratory experiences where students are using laboratories tools and procedures, making observations, and gathering data?			
Not Confident		2	1%
Somewhat Confident		26	12%
Confident		71	34%
Very Confident		111	53%
No Opinion		1	0%
Total		211	100%

Which statement best describes your confidence in leading students in science laboratory experiences where students pose the question, design and carry out the procedures to master science core content and intended learning outcomes?			
Not Confident		23	11%
Somewhat Confident		49	23%
Confident		84	40%
Very Confident		51	24%
No Opinion		3	1%
Total		210	100%

Which statement best describes your confidence in assessing students in science laboratory experiences?			
Not Confident		2	1%
Somewhat Confident		32	15%
Confident		103	49%
Very Confident		71	34%
No Opinion		1	0%
Total		209	100%

For the next three questions, describe the extent you have been engaged in developing and refining curricula for science laboratory experiences?			
In your own classroom			
Not Engaged		2	1%
Somewhat Engaged		21	10%
Engaged		71	34%
Very Engaged		117	55%
No Opinion		0	0%
Total		211	100%
At the District level			
Not Engaged		104	50%
Somewhat Engaged		53	25%
Engaged		35	17%
Very Engaged		11	5%
No Opinion		7	3%
Total		210	100%
At the State level			
Not Engaged		145	69%
Somewhat Engaged		33	16%
Engaged		19	9%
Very Engaged		7	3%
No Opinion		6	3%
Total		210	100%

To what extent have you been engaged in professional development that emphasized science laboratory instruction?			
Not Engaged		39	18%
Somewhat Engaged		85	40%
Engaged		48	23%
Very Engaged		38	18%
No Opinion		1	0%
Total		211	100%

Section IV: Laboratory Facilities, Equipment, and Safety This section is designed to gather information about the laboratory facilities and equipment available to your students and the safety of science laboratory experiences in your classroom.

The following best describes the science laboratory facilities available to me and my students for laboratory experiences:

Science Classroom and Laboratory are Separate		63	30%
Integrated Science Classroom and Science Laboratory are not Separate		108	52%
I do not teach in a science room		18	9%
Other, please specify		20	10%
Total		209	100%

How would you describe the influence of your school's facility on science laboratory experiences for your students?

Seriously Inhibits		34	16%
Slightly Inhibits		40	19%
Neutral		38	18%
Slightly Enhances		41	20%
Greatly Enhances		57	27%
Total		210	100%

Which of the following equipment is available in the space your use to facilitate science laboratory experiences for students? (Mark all that apply)

Electricity		205	100%
Running Water		192	93%
Gas for Burners		152	74%
Hoods or Air Hoses to Remove Dangerous Fumes		83	40%

Do you feel your school provides enough funding for students' science laboratory experiences?		
Yes	91	44%
No	118	56%
Total	209	100%

Which statement best describes your confidence in providing a safe environment when facilitating science laboratory experiences?		
Not Confident	13	6%
Somewhat Confident	39	18%
Confident	89	42%
Very Confident	69	33%
No Opinion	1	0%
Total	211	100%

Which of the following reduces your ability to supervise effectively in when students are engaged in science laboratory experiences? (Please mark all that apply)		
Class Size	133	65%
Facilities	38	18%
School/District Policies	1	0%
Professional Development	8	4%
Other, please specify	26	13%
Total	206	100 %

***Section V: Other influences and information about science laboratory experiences*.**

Please describe your school administrations impact on science laboratory experiences in your classroom. [Open-ended question]
184 Responses

How would you describe the time you are allotted for preparation of science laboratory experiences during your regular workday?		
Inadequate	85	41%
Somewhat Inadequate	43	21%
Neutral	27	13%
Somewhat Adequate	30	14%
Adequate	23	11%
Total	208	100%

To what extent do you feel the Utah Core Curriculum is supportive of science laboratory experiences for students?			
Very Unsupportive		13	6%
Unsupportive		30	14%
Neutral		67	32%
Supportive		87	42%
Very Supportive		12	6%
Total		209	100%

To what extent do you feel the state accountability system is supportive of science laboratory experiences for students?			
Very Unsupportive		25	12%
Unsupportive		51	25%
Neutral		99	48%
Supportive		29	14%
Very Supportive		4	2%

Which of the following are used by students when engaging in science laboratory experiences in your classroom? (Please mark all that apply)			
Computers		101	53%
Sensors or Probes		98	52%
Simulations		95	50%
Internet		102	54%
Other, please specify		61	32%

Is there any additional information you prefer to add regarding science laboratory experiences? [Open-ended question]
95 Responses

Open-Ended Questions

Please describe your school administrations impact on science laboratory experiences in your classroom.

When teachers were asked to comment on their school administrations impact on science laboratory experiences the responses found were categorized into the following three themes: Supportive, Neutral, Unsupportive. The most common theme found was Supportive. Statements that were regarded as supportive encompassed differing levels of support, with many teachers claiming their school administration was very support of laboratory experiences. More teachers claimed that theirs were supportive, while a few remarked that their administration was only somewhat supportive. When teachers spoke of their administration being supportive, they often referred to the administration believing in the value of laboratory experiences, making funding available for such experiences, ensuring that facilities were provided for science laboratories, and maintaining class sizes that made it possible to engage students in their experiences.

While there were four times as many teachers stating that their administration was supportive of science laboratory experiences, there were still a substantial number of teachers who expressed a belief that their administration was unsupportive. For those teachers who felt their school administration was Unsupportive of science laboratory experiences, reasons cited were a focus on testing, funding shortfalls, and class size.

The final category emerging from teachers' responses was coded as Neutral. These Neutral responses occurred twice as often as those themed unsupportive. When responding to this question, teachers where found responding "no", "little impact", and "none". A few teachers expressed a belief that their school administration was unaware of science needs or not interested.

In summary, more teachers felt their school administration was supportive. After this, some teacher felt their administration was neutral or having little to no impact. Still fewer teachers felt their school administration was unsupportive. It is interesting, that those same reasons cited by some teachers for why they felt they were supported were also cited by those not feeling supported. This provides some understanding of what factors lead to teachers feeling supported; administration believing in the value of laboratory experiences, making funding available for such experiences, ensuring that facilities are provided for science laboratories, and maintaining class sizes in which laboratory experiences are feasible.

Is there any additional information you prefer to add regarding science laboratory experiences?

When teachers were asked if they would like to offer any additional information regarding science laboratory experiences issues with time, testing, funding, space, and training emerged. One quarter of those responding expressed a belief that not enough time was available for science laboratory experiences due to state core requirements and mandatory testing leading them, on some levels, to feel the need to teach to the test. While emerging from fewer teachers, but still common, lack of funding for equipment and supplies was noted. Also commonly revealed was a concern for too many students and too little space leading to safety concerns and less meaningful educational experience for students. Teachers also expressed a concern for lack of pre-service and in-service training for facilitating inquiry laboratory experiences.

<u>Teacher Interviews</u>

Findings

Additional information about the perceived needs for improving science laboratory experiences for Utah's high school students were revealed through the findings emerging from the final Teacher Interview question. The following question along with the findings from this question follows.

As we conclude this interview, is there any additional information you prefer to add regarding science laboratory experiences?

As we concluded our interviews with teachers from across the state, we wanted to allow teachers to share any additional information that they might want to communicate to the Utah State Office of Education (USOE). Of the forty teachers interviewed, all but 2 teachers took this opportunity to share. Three themes were most notable emerging from teachers. These were a concern for class size, a request for laboratory experiences offered by the USOE that align to the Utah Core curriculum, and a lack of funding for science laboratory experiences. While class size was not a concern for all teachers, at least a quarter of those interviewed expressed concern citing increased risk regarding students safety, inability to lead students in meaningfully engaging laboratories as the numbers increased, and a lack of space.

Another common theme emerging from just over a quarter of the teachers interviewed was a desire to have the USOE offer specific labs that align to the core curriculum. Teachers expressed a lack of time and in some cases creativity to develop laboratories themselves. A few teachers requested that in addition to these labs, equipment needed to conduct the labs also be made available to teachers across the state.

A concern for lack of funding to support laboratory experiences was also expressed by a quarter of the participants. A few of the teachers described how they have funded laboratory experiences through out-of-pocket contributions that they personally made, while others described forgoing experiences due to lack of funds. While this was considered on the of the central themes emerging from teachers when asked what else they would be interested in sharing about science laboratories, a few teachers wanted it known that they did not see these experiences necessarily requiring an inordinate amount of expense.

Another theme that did emerge from a small portion of those interviewed was a belief that the large amount of content in the core inhibited the amount of time they felt could be devoted to laboratory experiences. One teacher stated that “I know that if I wanted to increase my test scores, I should stop doing labs. I think the bang for the buck is, I could do direct instruction on pH quicker and kids could answer. We could do it rote.” While this teacher did state that he did believe the laboratory experiences provide learning which would “last longer” these thought seemed to best portray a perception about the core held by these teachers, however accurate or inaccurate the perception may be.

Finally, a few teachers expressed a concern for the amount of time required to prep for a science laboratory experience.

Discussion

Both the needs questionnaire/needs assessment and teacher interviews helped reveal Utah science teachers' perceived needs for improving science laboratory experiences for high school students. The discussion of these are organized according to the following categories: 1) Teacher Preparation for Laboratory Experiences, 2) Laboratory Facilities, Equipment, and Safety, and 3) Other influences and information about science laboratory experiences.

Teacher Preparation for Laboratory Experiences

Our research in this area was informed by both asking teachers the extent to which they felt comfortable regarding certain aspects of facilitating science laboratories and by responses offered by teachers when given a chance to share openly whatever they felt important about facilitating science laboratory experiences. When asked directly, teachers, for the most part, revealed confidence in the level of preparation they received in science content (seventy-four percent prepared or very prepared), ability to lead students in science laboratory experiences where students are using laboratories tools and procedures, making observations, and gathering data (eighty-seven percent confident or very confident), and in assessing students in science laboratory experiences (eighty-three percent confident or very confident).

While sixty-six percent of the teachers revealed that they felt prepared or very prepared through the science process knowledge they received in their undergraduate education, thirty-six percent of the teachers expressed that they felt either not prepared or only somewhat prepared. Similar findings were revealed when teachers were asked to identify their confidence in leading students in science laboratory experiences where students pose the question, design and carry out the procedures to master science core content and intended learning outcomes, with sixty-four percent expressing that they felt confident or very confident and thirty four percent expressing they felt not confident or somewhat confident. These findings suggest that, while not all teachers revealed this, many teachers have some reservations about the extent to which they feel prepared to lead students in laboratories whereby science process is emphasized alongside science content. This was further revealed as teachers responded to the open-ended question *Is there any additional information you prefer to add regarding science laboratory experiences?* Teachers expressed a concern for lack of pre-service and in-service training for facilitating inquiry laboratory experiences. This concern or focus was also illuminated as some teachers when interviewed revealed being unsure about what was meant by "science process" and most teachers relying predominately on the scientific method as the mechanism for emphasizing science process in science laboratories. Teachers also revealed in interviews, that for the most part students are not engaged in framing research questions or designing experiments. While other possible explanations might underlie teachers not engaging students in framing research questions and designing experiments, a lack of understanding of science process or belief in its importance might be connected to teachers not prioritizing these activities for students and instead focusing science laboratories more on what Hofstein and Lunetta (1982) described as traditional laboratory experience when teachers use them as a venue for illustrating, demonstrating, and verifying known concepts and laws. This focus, found in this research does not focus on science process as much as it is directed toward science content. Teacher did however on some levels seem cognizant of the importance of inquiry laboratories as there were requests for help from the Utah State Office of Education in identifying these type laboratories that are connected to the Utah Core Curriculum.

Laboratory Facilities, Equipment, and Safety

Eighty-two percent of the teachers responding to the questionnaire/needs assessment either taught in a science classroom whereby the science laboratory facilities were integrated as part of the classroom or had a separate laboratory classroom that they used. Nine percent of the teachers reported not teaching in a science classroom. Information about the facilities available to teachers was augmented by statements shared about whether they felt the laboratory facilities available inhibited or enhanced the laboratory experiences of their students. Forty-seven percent of the teachers reported feeling that their facilities enhanced or slightly enhanced students' experiences. Thirty-seven percent of teachers reported feeling their facilities either slightly inhibited or inhibited their students' experiences. A concern for facilities, equipment, and safety also emerged as teachers described their administrator support of science laboratory experiences as insufficient funding for equipment and supplies was noted and a concern for too many students and too little space leading to safety concerns emerged. These concerns were also found from a portion of the teachers interviewed as they were offered the opportunity at the end of the interview to share additional information about science laboratory experience. One of the emerging themes coming from teachers was a lack of funding for science laboratory experiences. While class size was not a concern for all teachers, at least a quarter of those interviewed expressed concern stating that they felt class size issues were resulting in increased safety risks for students and issues with space for students to participate in science laboratory experiences. Additionally, sixty-five percent of the teachers responding to the needs assessment identified class size as the factor which reduces their ability to effectively supervise students engaged in these experiences.

Other influences and information about science laboratory experiences

This section reflects teachers beliefs about the influence of the Utah State Office of Education (USOE) influence on science laboratory experiences of students as well as additional findings not addressed in other sections. When teachers were asked to describe the influence they felt the core curriculum had on the science laboratory experience offered to students, forty-eight percent of teachers reported feeling the core supported (supportive or very supportive) these experiences, with only twenty-percent feeling the core was not supportive of lab experiences (very unsupportive or unsupportive). It is interesting to not that a large percentage (thirty-two percent) expressed a neutral opinion. This provides interesting information the USOE might use to reflect upon as the extent to which science laboratory experiences are valued is reassessed. While USOE funding of this research signals a commitment to science laboratory experiences, this commitment may not be as evident to teachers across the state as is depicted in the large percentage of neutral responses.

When teachers were asked to express the extent to which the state accountability system is supportive of science laboratory experiences for students only sixteen percent of teachers felt it was supportive (supportive or very supportive). Thirty-seven percent of teachers felt the state accountability system was not supportive (very unsupportive or unsupportive) of these experiences. Approximately half (forty-eight percent) of the teachers expressed a neutral opinion to this question. Teacher interviews revealed a small portion of teachers believing that the large amount of content in the core inhibited the amount of time they felt could be devoted to laboratory experiences. These findings also support the need for continued reflection from the USOE as the commitment to laboratory experiences is considered alongside the message that is being conveyed by teachers through their perception of the extent to which accountability is aligned to this emphasis.

Teacher interviews revealed that a majority of teachers interviewed did feel supported in offering laboratory experiences to students. When comparing factors connected to feelings of support to those connected to feelings of not being supportive (offered by a smaller portion of teachers interviewed), administration believing in the value of laboratory experiences, making funding available for such experiences, ensuring that facilities are provided for science laboratories, and maintaining class sizes in which laboratory experiences are feasible were factors that influenced these feeling.

Sixty-two percent of teacher felt the time allotted for preparation of science laboratory experiences during your regular workday was inadequate (inadequate or somewhat inadequate). This opinion also surfaced in the teacher interviews. Finally, minimal preparation time was expressed as a problem by teachers and should be considered as a possible factor related to the quality and amount of science laboratory experiences offered to students.

CONCLUSION

The National Research Council's (2005) report *America's Lab Report: Investigations in High School Science* provided an assessment of the current state of science laboratory experiences for high school students across America. This research focused on the current state of science laboratory experiences for high school students across Utah. The The traditional approach to laboratory experiences identified by the NRC (2005) report revealed that science laboratory experience are rarely thoughtfully sequenced into the flow of science instruction; rarely designed to integrate learning of the content of science with learning about the process of science; and rarely incorporate ongoing student reflection and discussion. This research revealed that Utah teachers were engaged in thoughtfully sequencing science laboratories for their students in the flow of their science instruction, but for the most part these experiences were focused more on the learning of science content exclusively, neglecting learning about the process of science. This was evidenced through classroom observations when significantly higher scores for the propositional knowledge content subscale division were found when compared to the procedural knowledge division and through teacher interviews that revealed confusion on behalf of some teachers when asked about process or most teachers focusing solely on the scientific method as science process.

Hofstein and Lunetta (1982) noted that typically the traditional laboratory experience is seen as a venue for illustrating, demonstrating, and verifying known concepts and laws. The NRC (2005) recognized these same problems as traditional laboratory experiences were seen "as secondary applications of concepts previously addressed by the teacher" (NRC, 2005, p. 25). This same emphasis was found in Utah with more than half of the teachers interviewed stating that they use labs to reinforce the ideas and concepts that the students are learning from bookwork, lectures, movies, and other learning activities. Research into teaching and learning as well as leading national science education organizations support a shift in science instruction away from laboratory experiences that illustrate, demonstrate, and verify known concepts and toward inquiry experiences (AAAS, 1993; Chang & Mao, 1999; Ertepinar & Geban, 1996; Hakkarainen, 2003; NRC, 1996; NRC, 2005; NSTA, 1998; Schwartz, Lederman, & Crawford, 2004,). Inquiry, as described in the National Science Education Standards allows students to "describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others" (NRC, 1996, p. 2). Students in Utah were not found engaging in science laboratories in a manner consistent with this definition of inquiry. Students were found carrying out experiments, collecting data, and drawing conclusions from their data, but they were not found asking questions or framing questions or designing experiments. The question emerging from this research is *To what extent do Utah Students loose the established benefits of inquiry experiences when these experiences are truncated, distilled, or limited to carrying out laboratories that have been designed for them?* While inquiry instruction in the science classroom shows great promise for increasing students' understanding of science (Chang & Mao, 1999; Ertepinar & Geban, 1996; Hakkarainen, 2003), the nature of science (Schwartz, Lederman, & Crawford, 2004), and increasing students' interest and attitudes toward science (Cavallo & Laubach, 2001; Chang & Mao, 1999; Paris, Yambor, & Packard, 1998) it is uncertain to what extent this promise is realized when inquiry instruction is limited in the manner found most prevalent in the experiences observed in Utah.

The NRC (2005) report found that the initial problem that has historically hindered the effectiveness of laboratory experiences is a lack of agreed upon "definition and goals of high school laboratories" (NRC, 2005, p. 13). When teachers in our study were asked to define science laboratory experience and rank the importance of the science laboratory experiences in meeting certain goals, varying definitions and intentions were observed. As Utah State Office of Education (USOE) looks to strengthen its commitment to the science laboratory experiences of high school students, helping teachers come to some consensus as to what constitutes a science laboratory experience and why they are important might be considered a step toward overcoming this initial problem identified by the NRC (2005) report.

When the growing body of research available in cognitive research is examined as a lens for viewing the experiences of students in Utah, additional insight can be gained. The

NRC (1999) produced a report titled "How People Learn" that outlined specifically four principles that support effective learning environments. These four principles were: 1) learner-centered environments: environments that take into consideration the prior knowledge students bring to the classroom; 2) knowledge-centered environments: environments that help students learn with understanding through engaging with scientific ideas and in doing science; 3) assessment to support learning: assessment used to support learning through feedback by the use of formative assessment; and 4) community-centered environments: environments that are characterized by opportunities and motivation to interact and hear peers. In this research when considering learner-centered environments: environments that take into consideration the prior knowledge students bring to the classroom, the Lesson Design and Implementation subscale of the Reformed Teaching Observation Protocol used in making classroom observations emerged as subscale whereby facilitation was least aligned to reformed teaching. As knowledge centered environments are considered, environments that help students learn with understanding through engaging with scientific ideas and in doing science, student were found consistently engaging in labs focused on scientific ideas and content, but not normally found engaging in doing science, not to the extent that they asked their own questions and designed procedures to begin to answer those questions. Utah teachers did identify formative assessment as a method used to help students learn. Finally, when considering the extent to which students in Utah's high school science laboratory experience are offered opportunities and motivation to interact and hear peers the findings emerging from classroom observations across the state revealed that the communicative subscale of the RTOP were somewhat low and significantly lower than the propositional knowledge division of the content subscale which identify the quality of the content emphasized. The communicative subscale of the RTOP assess the classroom culture and focused on the extent to which student were involved in communicating their ideas to others and whether a significant amount of student talk occurred between and among groups of students. These findings related to Utah science laboratory instruction and its alignment to the four NRC (1999) principles reveal opportunities for improvement focused on learner-centered environments, knowledge-centered environments, assessment to support learning, and community-centered environments.

The NRC (2005) report defined science laboratory experiences in the following manner:

> Laboratory experiences provide opportunities for students to interact directly with the material world (or with data drawn from the material world), using the tools, data collection techniques, models, and theories of science (NRC, 2005, p. 13).

Based in this definition which Utah teachers are engaging students in science laboratory experiences. The NRC definition does not require students' development of questions and procedures but instead focuses on interacting with materials, using tools, models, and theories of science. This study revealed that student experiences, although limited to carrying out established protocols, are engaging in science in a way that has them meeting criteria identified in this definition.

The establishment of an agreed upon definition of science laboratory experiences allowed the NRC to move forward in reviewing available literature on science laboratory experiences, design principles, and research on teaching, learning, and cognition to identify what they labeled the "Integrated Instruction Unit Approach" to science laboratory experiences. This approach is characterized as including the four critical principles that support effective learning environments outlined by the NRC (1999) and discussed in the previous section. These integrated instructional units

> interweave laboratory experiences with other types of science learning activities, including lectures, reading, and discussion. Students are engaged in framing research questions, designing, and executing experiments, gathering and analyzing data, and constructing arguments and conclusions as they carry out investigations. Diagnostic formative assessments are embedded into the instructional sequence and can be used to gauge students' developing understanding and to promote their self-reflection on their thinking (NRC, 2005, p. 82).

Utah students were found engaging in science laboratory experiences that were interweaved into other science learning activities. They were not engaged in framing research questions and designing, but they did engage in executing experiments, gathering and analyzing data, and constructing arguments and conclusions as they carry out investigations. Teachers were also found articulating methods of formative assessment used to gauge students' developing understanding and to promote their self-reflection on their thinking.

Through the research completed in this project focused on whether variances of experiences students encountered across the state, on some levels, the findings in Utah mirrored those found nationally. The NRC (2005) report indicated that racial, ethnic, and socioeconomic disparities exist when considering the amount of time different groups are afforded in the laboratory (NRC, 2005). While differences in the amount of time different groups were afforded in the laboratory did not emerge from this study, the findings did reveal disparities in the quality of the science laboratory experiences of students. Districts serving populations of students from lower socioeconomic groups were found receiving instruction significantly less aligned to reformed teaching when compared to districts serving populations of students from higher socioeconomic groups. The teachers from districts serving populations of students from lower socioeconomic groups were also more frequently found expressing concerns for funding to support science laboratory experiences and requesting the USOE offer specific labs that align to the core curriculum.

Teacher interviews also revealed differences emerging from teacher interviews whereby teachers from districts serving a more diverse student population defining science laboratory experiences as hands-on more so than their counterparts from districts serving less diverse student populations. Teachers from small districts like those from districts serving populations of students from lower socioeconomic groups also expressed more concern for funding to support science laboratory experiences.

The current research also sought the elucidate teachers perceived needs for continually improving science laboratory experiences for Utah's high school students. The findings suggest that teachers are more confident in the science content preparation received in their undergraduate training, their ability to lead students in science laboratory experiences where students are using laboratories tools and procedures, making observations, and gathering data, and in assessing students in science laboratory experiences. A significant group of teachers were less confident in the science process preparation received in their undergraduate training, in leading students in science laboratory experiences where students pose the question, design and carry out the procedures to master science core content and intended learning outcomes. These findings suggest that, while not all teachers revealed this, many teachers have some reservations about the extent to which they feel prepared to lead students in laboratories whereby science process is emphasized alongside science content.

When considering teacher perceived needs as they pertain to laboratory facilities, equipment, and safety, a great majority of teachers had facilities for engaging students in science laboratory experience although there was a small percentage that did not (approximately ten percent). While a majority had facilities this same majority did not express the feeling that their facilities greatly enhance their students' experiences. These findings may be tied to teachers concern for facilities, equipment, and safety emerging as teachers described their administrator support of science laboratory experiences as insufficient funding for equipment and supplies was noted and a concern for too many students and too little space leading to safety concerns emerged. While class size was not a concern for all teachers, a portion of the teachers expressed concern stating that they felt class size issues were resulting in increased safety risks for students and issues with space for students to participate in science laboratory experiences. Teachers identified class size as the factor which reduces their ability to effectively supervise students engaged in these experiences.

Alongside class size and funding concerns expressed by teachers, equal portions of teachers identified the USOE core curriculum supportive, not supportive, or neutral in its influence on the science laboratory experience offered to students. When teachers described the extent to which the state accountability system supported offering science laboratory experiences to students, fewer teachers believed the system was supportive as compared to those believing it was unsupportive. A greater portion did not express a belief either way. These findings will help the USOE reflect on the support offered by the core curriculum and the accountability system in supporting science laboratory experiences. Either the core and accountability system is such that is does not support science laboratory experiences to the extent supported by the National Research Council and research in teaching and learning, or the core and accountability system is not perceived by teachers in the manner in which they are intended to support such experiences.

This research revealed that the majority of teachers did feel administrative support for offering student science laboratory experiences. While not all teachers expressed this feeling of support, administration believing in the value of laboratory experiences, making funding available for such experiences, ensuring that facilities are provided for science laboratories, and maintaining class sizes in which laboratory experiences are feasible were factors that influenced these feeling in both cases.

Sixty-two percent of teacher felt the time allotted for preparation of science laboratory experiences during your regular workday was inadequate (inadequate or somewhat inadequate). This opinion also surfaced in the teacher interviews. Finally, minimal preparation time was expressed as a problem by teachers and should be considered as a possible factor related to the quality and amount of science laboratory experiences offered to students.

Lastly, teachers did not feel they had enough time to prepare for engaging students in science laboratory experiences. Both the National Research Council and the Utah State Office of Education recognize the importance of science laboratory experiences for students. As teachers engage students in experiences, this engagement unlike other modalities of instruction, takes additional time for teachers to prepare. Teachers in Utah recognize the time commitment necessary to offer such experiences and have expressed a belief that this time is currently not offered.

Opportunities for improving science laboratory experiences for students in Utah are revealed through the findings emerging from this research. These improvements center around 1) aligning instruction with reform efforts in science education supported by research in teaching, learning, and cognition, 2) ensuring that experiences are equally afforded to students regardless of school size, economic, and diversity indicators, and 3) heading the call for support emerging from teachers perceived needs in the area of professional development, funding, class size limits, administrative support and sufficient preparation time. Utah teachers participating in this research have demonstrated professionalism and a commitment to students. Teachers have opened the doors of their classroom and offered their perspectives, ideas, and philosophies. It is hoped that this report will be accepted as a critique, defined as an analysis, of the current state of Utah high school students' science laboratory experiences aimed at appreciating the benefits students are receiving and seeking to ever improve these experiences.

RECOMMENDATIONS

The Intended Learning Outcomes (ILOs) for students found in each of the four main disciplines of high school science are as follows:

- Use science process and thinking skills.
- Manifest science interests and attitudes.
- Understand important science concepts and principles.
- Communicate effectively using science language and reasoning.
- Demonstrate awareness of the social and historical aspects of science.
- Understand the nature of science.

These are the envisioned outcomes resulting from students' engagement in science instruction aligned to the Core. Inquiry instruction has shown great promise in increasing students' understanding of science (Chang & Mao, 1999; Ertepinar & Geban, 1996; Hakkarainen, 2003), the nature of science (Schwartz, Lederman, & Crawford, 2004), and increasing students' interest and attitudes toward science (Cavallo & Laubach, 2001; Chang & Mao, 1999; Paris, Yambor, & Packard, 1998). Inquiry instruction also aligns with science laboratory experiences to the extent that these experience involve

> making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results (NRC, 1996 p. 23).

Through aligning science laboratory experiences with inquiry instruction these experiences can be instrumental in helping to achieve the ILOs for Utah high school students.

The recommendations made in this report are intended for all bodies charged with ensuring Utah's high school students receive exemplary instruction in science. These bodies include the Utah State Legislators, the Utah Office of Education, Higher Education Science Education Faculty, School Administrators, and High School Science Teachers. Aikenhead and Huntley (1997) stated "School science happens within school and community cultures and only rarely can teachers and students work outside those pervasive cultures . . . As a consequence, we recognize that our recommendations to help teachers become more effective science teachers . . . are hollow without the support of their community and school (p.64)." The recommendations that follow are offered through this same realization. The challenge is for all charged with education in Utah to examine these recommendations and create an environment in which they can be implemented. The recommendations are organized according to the findings emerging from each research question.

Recommendation 1

The USOE, Districts, and Schools should provide professional development supportive of science laboratory experience aligned to national standards documents and the Intended Learning Outcomes (ILOs) outlined in the Utah Core Curriculum. Classroom observations and teachers interviews revealed that while some alignment can be found between experiences offered in science laboratories and national standards documents and the ILOs, improvement can and should be a continual focus.

- 1.1 Professional development is needed that is aligned with reform efforts in science education and focused on science laboratory experiences. These should also contain components that assess the impact on student learning in the classrooms. Content and process should be a focus of these professional development experiences so that Utah teachers move beyond a sole focus on content in science laboratory experiences. Science process should be a focus of the professional development opportunities with teachers engaging in science in a way that will have them learning about science and engaging in the process of science. Finally, these experiences should also engage the teachers as producers of knowledge and materials that can be implemented in the classroom and shared with other teachers across Utah.

- 1.2 The USOE, State Science Education Coordinator Committee (SSECC), Science Education Research Committee (SERC), Science Specialists, and Teachers should work to collect and make examples of science laboratory experiences aligned to reform efforts and the Utah Core Curriculum available to all teachers across the state. This effort will not only offer teachers a model for developing or revising other science laboratory experiences, it will also help to reiterate the importance of science laboratory experiences in the science core curriculum.
- 1.3 The USOE, SSECC, SERC, Science Specialists, and Teachers should ensure that the core curriculum and the state accountability system is supportive of science laboratory experiences and a mechanism is put in place to ensure that teachers perceive this emphasis. This will ensure that teachers feel empowered to engage students in science laboratory experiences.

Recommendation 2

The USOE, State Science Education Coordinator Committee Participant (SSECC), and the Science Education Research Committee (SERC), School Districts, School Administrators and teachers should work to ensure that all disparities in science laboratory experiences of students across the state are eliminated. Disparities did emerge in the research that points to differences in the science laboratory experiences of students across Utah. Continued research should be completed to better understand the extent to which disparities are occurring as well as the reasons the disparities exist. Additional research is needed to understand why differences emerged with respect to reform teaching when comparing districts serving student populations with differing socioeconomic groups. This additional research should also lead to recommendations for eliminating these disparities whether through increased professional development, funding, or other means. Additional research is also needed to better understand the increased reference to hands-on learning for districts serving students populations with higher diversity.

Recommendation 3

Measures should be implemented to ensure that teachers are supported to offer science laboratory experiences to students. Teachers across the state revealed several factors that they felt influence their ability to engage students in laboratory experiences. Care should be taken to address these perceived needs in a manner that leads to evidence collection that can be used to ascertain the benefits of the addressed teacher need.

- 3.1 Professional development should be developed and offered that helps teachers emphasize both science content and process when engaging students in science laboratory experiences. This can and should be connected to the professional development recommended in recommendation 1.1 earlier. Consideration should be given to including consideration of the nature of science beyond an emphasis on the scientific method.
- 3.2 Additional assessment of the facilities available for students to complete laboratory experience should be done. Recommendations should be developed so that teachers across the state have access to facilities needed to engage students in science laboratory experiences. A funding mechanism should also be established alongside these facility recommendations to ensure that districts and schools are able to comply with the recommendations.
- 3.3 Class size should be regulated so that facilities provide the needed space for conducting these experiences and to allow teachers to manage these experiences to ensure safety concerns are minimized. Recommendations should be developed through the collaborative efforts of the USOE, SSECC, SERC, Science Specialists, School Administrators, and Science Teachers so that class size does not inhibit teachers' ability to facilitate such experiences for students. A funding mechanism should also be established alongside these class size guidelines to ensure that districts and schools are able to comply with the recommendations.
- 3.4 Guidelines should be established through the collaborative efforts of the USOE, SSECC, SERC, Science Specialists, School Administrators, and Science Teachers to ensure that a sufficient amount of funding and supplies are available to each teacher. A funding mechanism should be established alongside these guidelines to ensure that districts and schools are able to comply.
- 3.5 Administrators should be made aware of the following key factors identified in this report that influenced whether teachers felt supported by their school administration: administration believing in the value of laboratory experiences, making funding available for such experiences, ensuring that facilities are provided for science laboratories, and maintaining class sizes in which laboratory experiences are feasible. Other recommendations emerging from this report if implemented will help administrators offer support in many of these areas. A mechanism should also be established to ensure that administrators recognize the importance of science laboratory experiences as they are aligned to the Utah Core Curriculum and the state accountability system. Possible mechanisms would have administrators involved in professional development of science teachers, SSECC meetings, or participating in guideline and policy meetings to establish conditions suitable for teachers to facilitate science laboratory experiences. Efforts can also be considered whereby administration meetings are shaped to include a science component.
- 3.6 Guidelines should be established through the collaborative efforts of the USOE, SSECC, SERC, Science Specialists, School Administrators, and Science Teachers to ensure that sufficient time is available to each teacher to prepare for science laboratory experiences. Recommendations established by the NSTA can be consulted as these guidelines are shaped. A funding mechanism should

be established alongside these guidelines to ensure that districts and schools are able to comply.

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APPENDIX 1

Teacher Interview Protocol

Science Laboratory Integration into Science Instruction Teacher Interview Protocol Interviewer Notes

Curriculum Unit Discussed: _______________Teacher Observed: ___________________________________

Project Team Member completing Observation ____________________________________

1.	What strategies are used to help students make connections between the science laboratory experiences and the other learning activities in the science unit?
2.	To what extent are the students engaged in the following instructional activities in this unit: 1) Framing research questions, 2) Designing and executing experiments, 3) Gathering and analyzing data, and 4) Constructing arguments and conclusions as they carry out investigations? 5) Reflection and discussion
3.	Please explain how students where introduced to this science laboratory experience and explain any follow-up that occurs after this science laboratory experience.

4.	In what ways are students assessed in this science unit?
5.	In what ways are science content and process emphasized in this science unit?
6.	How would you define a science laboratory experience?
7.	As we conclude this interview, is there any additional information you prefer to add regarding science laboratory experiences?

APPENDIX 2

Interviewing Principles

1. While it might be alright to right short notes during the interview, I think I would better solicit genuine answers if I could focus on what was being said by the interviewee. I would suggest relying on the tape to capture the answers. This will allow you to focus on the interview, show that you are listening, and to further probe when interested in what has been shared. The interview should be comfortable, but it should remain a focused time to gather the responses of the teacher. I think we should be careful not to engage in sharing stories. We want to say enough to get the teacher to share, but not so much that this objective is diluted by comparisons of experiences.
2. During the interview, be cognizant of the time (20-30 min max) and try to move the interview forward when needed to stay with this deadline. Also be sensitive to what is being shared, but be ready to bring the interviewee back to the focus of the interview if the participants are straying too far off topic.

APPENDIX 3

Questionnaire/Needs Assessment

Utah High School Science Laboratoy Needs Assessment

Section I: Demographics

1 What is your school district name?

2 How many years of teaching experience do you have?

- 0-3 Years
- 4-5 years
- greater than 5 years

3 Which of the following teaching certifications do you hold? (Please check all that apply)

- Biological Science
- Physical Science
- Environmental Science
- Other, please specify

4 Which of the following subjects do you currently teach? (Please check all that apply)

- Earth Systems
- Biology
- Chemistry
- Environmental Science
- AP Biology
- AP Chemistry
- AP Environmental Science
- Other, please specify

5 Which of the following grade levels do you teach? (Please check all that apply)

- Grade 9
- Grade 10
- Grade 11
- Grade 12

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Survey Page 1

Utah High School Science Laboratoy Needs Assessment

Defining Science Laboratory Experiences
For the purpose of this survey, science laboratory experiences are defined as experiences that "provide opportunities for students to interact directly with the material world (or with data drawn from the material world) using the tools, data collection techniques, models and theories of science." (National Research Council, 2005, p.13)

Section II: Students' Science Laboratory Experiences (Lesson Design and Implementation, Science Content, Classroom Culture and Quantity of Laboratory Experiences)

After reading each of the following statements, please select the answer which best captures your response

6 In my classroom student background knowledge is identified before the laboratory work begins with a deliberate activity or discussion.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

7 During science laboratory experiences in my classroom, students perform activities in groups and have responsibilities to the group.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

8 In my classroom, laboratory work occurs before other more formal strategies (lecture, reading, writing or other learning activities)

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

9 The science laboratory experiences in my classroom encourage students to seek and value alternative modes of investigation or of problem solving.

- Almost Never
- Seldom
- Sometimes
- Often

- Almost Always

10 The focus and direction of the science laboratory experiences in my classroom are often determined by ideas originating with students.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

11 Students make predictions, estimations or hypothesis in science laboratory experiences in my classroom.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

12 Students design procedures for testing their own predictions, estimations or hypothesis in science laboratory experiences in my classroom.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

13 During science laboratory experiences in my classroom, students are encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence in science laboratory experiences.

- Almost Never
- Seldom
- Sometimes
- Often
- Almost Always

14 Students in my science classes have an average of ______________________________ science laboratory experiences in a two week interval.

- Less than One
- One
- Two
- Three
- Greater than Three

15 Please rank the following seven goals for science laboratory experiences in order of importance to you. (1 is Most Important and 7 is Least Important)

	1	2	3	4	5	6	7
Enhancing mastery of subject matter	○	○	○	○	○	○	○
Developing scientific reasoning	○	○	○	○	○	○	○
Understanding the complexity and ambiguity of empirical work	○	○	○	○	○	○	○
Developing practical skills	○	○	○	○	○	○	○
Understanding the nature of science	○	○	○	○	○	○	○
Cultivating interest in science and interest in learning science	○	○	○	○	○	○	○
Developing teamwork abilities	○	○	○	○	○	○	○

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Survey Page 2

Utah High School Science Laboratoy Needs Assessment

Section III: Teacher Preparation for Laboratory Experiences

This section is designed to gather information about your preparation for facilitating science laboratory experiences in your classroom.

16 Which statement best describes the preparation in science content knowledge you feel you received in your undergraduate education?

- Not Prepared
- Somewhat Prepared
- Prepared
- Very Prepared
- No Opinion

17 Which statement best describes the preparation in science process knowledge you feel you received in your undergraduate education?

- Not Prepared
- Somewhat Prepared
- Prepared
- Very Prepared
- No Opinion

18 Which statement best describes your confidence in leading students in science laboratory experiences where students are using laboratories tools and procedures, making observations, and gathering data?

- Not Confident
- Somewhat Confident
- Confident
- Very Confident
- No Opinion

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19 Which statement best describes your confidence in leading students in science laboratory experiences where students pose the question, design and carry out the procedures to master science core content and intended learning outcomes?

- Not Confident
- Somewhat Confident
- Confident
- Very Confident
- No Opinion

---

20 Which statement best describes your confidence in assessing students in science laboratory experiences?

- Not Confident
- Somewhat Confident
- Confident
- Very Confident
- No Opinion

For the next three questions, describe the extent you have been engaged in developing and refining curricula for science laboratory experiences?

---

21 In your own classroom

- Not Engaged
- Somewhat Engaged
- Engaged
- Very Engaged
- No Opinion

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22 At the District level

- Not Engaged
- Somewhat Engaged
- Engaged
- Very Engaged
- No Opinion

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23 At the State level

- Not Engaged
- Somewhat Engaged
- Engaged
- Very Engaged
- No Opinion

24 To what extent have you been engaged in professional development that emphasized science laboratory instruction?

- Not Engaged
- Somewhat Engaged
- Engaged
- Very Engaged
- No Opinion

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Survey Page 3

Utah High School Science Laboratoy Needs Assessment

Section IV: Laboratory Facilities, Equipment, and Safety
This section is designed to gather information about the laboratory facilities and equipment available to your students and the safety of science laboratory experiences in your classroom.

25 The following best describes the science laboratory facilities available to me and my students for laboratory experiences:

- Science Classroom and Laboratory are Separate
- Integrated Science Classroom and Science Laboratory are not Separate
- I do not teach in a science room
- Other, please specify

26 How would you describe the influence of your school's facility on science laboratory experiences for your students?

- Seriously Inhibits
- Slightly Inhibits
- neutral
- Slightly Enhances
- Greatly Enhances

27 Which of the following equipment is available in the space your use to facilitate science laboratory experiences for students? (Mark all that apply)

- Electricity
- Running Water
- Gas for Burners
- Hoods or Air Hoses to Remove Dangerous Fumes

28 Do you feel your school provides enough funding for students' science laboratory experiences?

YES NO

29 Which statement best describes your confidence in providing a safe environment when facilitating science laboratory experiences?

- Not Confident
- Somewhat Confident
- Confident
- Very Confident
- No Opinion

30 Which of the following reduces your ability to supervise effectively in when students are engaged in science laboratory experiences? (Please mark all that apply)

- Class Size
- Facilities
- School/District Policies
- Professional Development
- Other, please specify

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Survey Page 4

Utah High School Science Laboratoy Needs Assessment

Section V: Other influences and information about science laboratory experiences.

31 Please describe your school administrations impact on science laboratory experiences in your classroom.

32 How would you describe the time you are alloted for preparation of science laboratory experiences during your regular workday?

- Inadequate
- Somewhat Inadequate
- Neutral
- Somewhat Adequate
- Adequate

33 To what extent do you feel the Utah Core Curriculim is supportive of science laboratory experiences for students?

- Very Unsupportive
- Unsupportive
- Neutral
- Supportive
- Very Supportive

34 To what extent do you feel the state accountability system is supportive of science laboratory experiences for students?

- Very Unsupportive
- Unsupportive
- Neutral
- Supportive
- Very Supportive

35 Which of the following are used by students when engaging in science laboratory experiences in your classroom? (Please mark all that apply)

- Computers
- Sensors or Probes
- Simulations
- Internet
- Other, please specify

36 Is there any additional information you prefer to add regarding science laboratory experiences?

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