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Research Experiences for Undergraduates:

An Evaluation of Affective Impact

Brian N. Chantry

An evaluation report submitted to the faculty of  
Brigham Young University  
in partial fulfillment of the requirements for the degree of

Master of Science

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December 2009

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## ABSTRACT

### Research Experiences for Undergraduates: An Evaluation of Affective Impact

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Master of Science

Each year the National Science Foundation (NSF) grants funding for universities in the United States to provide a Research Experiences for Undergraduates (REU) summer program. The Department of Physics and Astronomy at Brigham Young University (BYU) has been a recipient of NSF REU grants for several years. This year the administrators of the REU program at BYU requested an evaluation be conducted to determine if their program was effective at helping participants have a significant research experience, as well as determine the impact the program is having on student's attitudes towards the field of physics, graduate school, and research. This report contains the findings of the evaluation and recommendations for program improvement.

Keywords: evaluation, REU, affective characteristics, physics

## ACKNOWLEDGEMENTS

I would like to acknowledge the members of my committee, Dr. Randy Davies, Dr. Charles Graham, and Dr. Larry Seawright for their patience and guidance through this experience both in and out of the program. I would also like to acknowledge Dr. David Williams who got me started down the path of evaluation and encouraged me along the way.

I am grateful to my sweetheart, Jennifer who has been an unwavering support to me throughout my education, regardless of the demands or the challenges. She always reminded me that I could do it.

Ultimately, I would like to acknowledge my Father's hand in all that I am blessed with. He has made me capable of more than I could have done on my own.

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## **Chapter 1: Introduction**

The National Science Foundation (NSF) provides funding for research projects in a variety of science areas. When funding is provided, they often require that an evaluation be performed to measure the success of the program that they are supporting. The Department of Physics and Astronomy at Brigham Young University (BYU) has been the recipient of NSF funds to support a Research Experiences for Undergraduates (REU) program for several years. Previously, REU program leaders have conducted internal evaluations of this program. This is the first time the evaluation was conducted by an external evaluator. This formal external evaluation included a continuation of previously implemented data collection efforts to be used for longitudinal comparison, along with a more in-depth look at specific effects the program had on affective characteristics of the participants.

### **Evaluand**

The evaluand for this evaluation was the REU physics program at BYU. REU participants apply to various sites around the country and participate in research projects from all areas of the sciences. The NSF website provides prospective participants with a list of institutions to consider for their research experience. NSF expects that participants in a REU program will participate in ongoing research with university faculty or in research projects established specifically for this experience. Students accepted to REU programs can expect to participate in research on the campus of the host institution with a group of about ten undergraduate students. They will work closely with university faculty on one project over the summer. The REU program at BYU hand selects students from the pool of applicants. Selected participants receive a \$4,500 stipend, round trip travel expenses, and room and board (Brigham

Young University, n.d.). The selection criteria are based on several factors such as scientific research and aptitude, geography, match with faculty interests, gender and minority status. The last two are used because of the underrepresentation of women and certain minorities in the field of physics (e.g., Hispanics, Native Americans, and African Americans). Of the 150 applicants from various institutions of higher education, 13 students were selected to participate in the REU summer program at BYU in 2009, the year this evaluation was conducted.

The REU physics program at BYU began in 1998 and consists of four components: (1) introduction and orientation, (2) participation in research experiences, (3) informal interactions with faculty and other students, and (4) communication through oral and written reports. Participation in research experiences is given the most emphasis through workshops, a student prospectus, a hands-on research experience, and a reporting component. The evaluation period included the REU experience from June 8 to August 14, 2009.

### **Evaluator Background**

As an administrator at Brigham Young University, the evaluator for this project works with incoming freshman students to ease their transition from high school to the university. Student attitude seems to be a principle factor in the success of the program for the participant. This evaluation focused on the attitudes of participants, but more specifically how the physics REU affected participant attitudes towards the field of physics, research, and graduate school.

The evaluator has worked in evaluating educational programs at BYU for the past six years. This allowed for less of a learning curve to understand institutional factors and implications that may have otherwise affected the evaluation. An example of this was the knowledge of campus and the proximity of the evaluator's workplace to the physics labs.

Participants were able to leave the location where their research and physics learning was taking place to attend an interview at an external site. It was anticipated that this assisted participants in feeling more like the evaluation was being conducted externally.

One final aspect of the evaluator's background that contributed to the effectiveness of the evaluation is the graduate level course work completed in the areas of evaluation, both quantitative and qualitative, as well as assessment techniques related to affective characteristics.

### **Stakeholders**

The key stakeholders in this evaluation were the REU administrators at BYU, and the faculty mentors who participate in the REU program. Doctor Steven Turley, a member of the Department of Physics and Astronomy and the program director, requested the evaluation. Another stakeholder identified by the client is the National Science Foundation, which will receive evaluation findings through the client at the end of the three year grant cycle. NSF provides indirect funding for undergraduates to participate in this research experience and is therefore interested in the effectiveness of the programs it sponsors. One additional stakeholder group that was identified through the evaluation, and stands to benefit from the evaluand, are the university faculty and participants from institutions other than BYU. Though this last group is not directly influenced by the REU program, they do stand to benefit from the achieved outcomes of the program through the added experience and knowledge of their students who may bring more diversity to the classroom upon returning to their home institution (Chaplin, Manske & Cruise, 1998; Ward, Bennett & Bauer, 2002).

This evaluation primarily addressed the needs of the client (i.e., the REU administrators) but also addresses some needs identified in the literature. For example, this evaluation will give

more support and insights to an area of research already explored at a broader level, but also provide more anecdotal data of individuals which seems to be lacking in the published literature.

The REU administrators are the most likely stakeholders to utilize the evaluation findings. Their purpose for initiating the evaluation was to improve their program. It is expected that this report will be made public (perhaps on the program website) so that future participants, grantors, and administrators of similar programs may benefit from it as well.

Students are also stakeholders but typically do not have a voice in how the program is conducted. However, through the formative efforts of this program's administrators and the interviews conducted through this evaluation, students were given a voice that may influence how the program is run in the future.

### **Stakeholder Issues and Concerns**

Through consultation with the client, it was determined that the most important purpose for conducting this evaluation was to satisfy requirements from NSF. On their website, NSF's stated goal of the REU program is to promote the progress of science specifically by supporting, "active research participation by undergraduate students" through the REU program (National Science Foundation, n.d.). The NSF's evaluation requirement is intended to ensure that the program is working well and that the program is achieving its objectives and goals.

The REU administrators were also interested in formative feedback regarding their program. They wanted the evaluation to specifically focus on identifying the program's influence on affective characteristics of the participants (i.e., students' attitudes towards the field of physics in general, research in this field, and graduate school in this subject area). Stakeholders are unsure what effect, if any, the program had on these attitudes.

Finally, evaluation data was also to be collected according to a previously established evaluation plan implemented by the REU administrators at this site. Not only did these data provide valuable qualitative data interpretation, but they also provided an opportunity for longitudinal data analysis for the program's impact.

### **Prior Evaluations**

Every year, the Department of Physics and Astronomy collects survey data at the end of the summer when the REU program ends. That data was mainly used for program improvement and to gain understanding of participant interests. The data was maintained in paper format as it was administered and collected.

The beginning of this summer provided a good time to begin an evaluation as participants for the 2009 program were just arriving on campus. The REU program at this site had also begun a new, three year grant cycle from the National Science Foundation. Implementing an evaluation at the beginning of this grant established a baseline for evaluation data analysis that can be continued for the next two years.

## Chapter 2: Literature Review

Because of the involvement of the National Science foundation, REU programs are researched and evaluated to judge their effectiveness. Most published evaluations address a single REU site, but a few national studies are available for overall comparisons of sites. The following literature review looks at the findings of these evaluations and notes the more frequent issues or limitations encountered when working with REU type programs.

### Previous Findings

While each research experience program is unique (e.g., their time frame, sponsoring academic institution, funding, presentation of science knowledge, types of research and instructional activities) all have the same desired general outcome. They all want to provide a positive research experience for their participants. By and large these programs are found to be successful at achieving this general goal, but there seems to be other positive unintended outcomes being reported as well.

**Student Attitudes toward Research.** Research experiences are found to have a positive effect on participant attitudes towards research and their confidence in their research skills (Alexander, Foertsch, Daffinrud & Tapia 2000; Kardash, 2000; Russell, Hancock & McCullough, 2007; Van der Spiegel, Santiago-Aviles & Zemel 1997). It is also found that participants feel they have an increased understanding of how to conduct research (Russell et al., 2007; Seymour, Hunter, Laursen & DeAntoni, 2004; Ward et al., 2002).

**Career Choice.** Findings related to graduate school and career interests are also prominent in the evaluation literature. Several studies reported increased participant awareness of what graduate school really is since many of these experiences take on a graduate school feel



with their research (Russell et al., 2007; Ward et al., 2002). REUs are also found to encourage participants to continue on to graduate school working in the same area as their REU research experience (Granger, Amoussou, Labrador, Perry & Busum, 2006; Van der Spiegel et al., 1997). For many students, the REU experience has been found to shed light on their specific interest in a science related career (Russell et al., 2007; Seymour et al., 2002). Lopatto (2007) states further that this experience can have a polarizing effect. Participants either move toward or away from a particular career based on their REU experience.

**Faculty Mentors.** Faculty mentors have been cited as a positive asset to the REU type programs. Mentoring situations help participants learn to network with other faculty and students, and that it is ok to collaborate with colleagues for assistance (Alexander et al., 2000; Page, Abramson & Jacobs-Lawson, 2004; Seymour et al., 2002). Some evaluations stress that the level of commitment of faculty mentors is important to the success of the program (Lopatto, 2007; Van der Spiegel et al., 1997).

**Benefits and Insights.** Other findings include increased retention rates for undergraduates (Gregerman, Lerner, Hippel, Jonides & Nagda, 1998) and increased involvement in underrepresented groups such as women and ethnic minorities (Granger et al., 2006; Gregerman et al. 1998). A few participants benefit from co-authoring papers and presentations with faculty (Van der Spiegel et al., 1997; Seymour et al., 2002). Finally, participants who are truly interested in the program were most likely to experience positive outcomes (Russell et al., 2007; Van der Spiegel et al., 1997).

## Issues in REU Programs

There are four key issues or limitations that have presented themselves through a review of the literature. These issues involve concerns stakeholder have and hope to rectify with REU type programs. They include (1) working with underrepresented populations in the sciences, (2) the lack of a control or comparison group for research programs, (3) concerns of validity of results due to the self reporting nature of the studies, and (4) the importance of apprenticeship by faculty mentors to program success.

**Underrepresented Populations in the Sciences.** It has been reported that African Americans, Hispanics, and Native Americans along with women are underrepresented in the field of science in general (Alexander et al. 2000; Lopatto, 2004, 2007). The administrators of this REU site have noticed the same trend in their researched population. The Colorado Learning Attitudes about Science Survey (CLASS) has also shown large gender differences in attitude which the authors suggest is relevant to the problem of attracting women to the field of physics (Adams, 2006). This underrepresentation in the area of research programs within the sciences is said to be a result of culture differences. For example, the lack of Hispanics in research causes other Hispanics to not want to take part as well. If more of the underrepresented population were participating, perhaps an increased number from that group would join (Gregerman et al., 1998). Russell et al. (2007) warn administrators that they should not, “structure their programs differently for unique racial/ethnic minorities or women” (p. 549) but rather they should focus on helping students to become enthusiastic early on about the program. This will help the program be successful.

**Lack of control group.** By far the most frequently cited issue in this kind of research is the lack of a control group (Kardash, 2000; Lopatto, 2003, 2007; Olade, 2003; Seymour et al.,

2004; Ward et al., 2002). Seymour et al. (2004) suggest that the trouble in acquiring a control group comes from the small sample size of participants at a site, along with self-selection and faculty-selection criteria of those who participate. Participants self-elect to participate in the program, thus showing potential interest in the type of experience REU program provide. Those admitted to the program are selected because their qualities stood out above those that are turned down. Those that are denied admission should not be used as a quasi-control group because the subjects are not similar, and thus not comparable to the treatment group. Because many participants have been exposed to some form of research in the past, a quasi-control group comparison might actually be comparing how much treatment instead of comparing treatment and the lack thereof (Lopatto, 2003). A random assignment of students to an undergraduate control group would not likely meet ethical and fairness concerns because of the treatment the control group would be denied (Lopatto, 2007).

There are some proposed solutions to this issue, but they have not been implemented in the reviewed literature. One is to form a control group from other science majors who have similar backgrounds but have not had a research experience (Kardash, 2000). The other suggestion is that perhaps past undergraduates with research experience but did not participate in a summer research program might serve as an adequate control (Ward et al., 2002). As a result of the challenges and practical realities of implementing random controlled trials, evaluations of REU programs are typically case studies.

**Validity Constraints Due to Self-Reporting.** There are several authors that identify the validity of collected data as limitations to their research of REU programs. Validity is in question because of the self-reporting nature of attitudinal and personal experience measurement instruments (Kardash, 2000; Lopatto, 2004, 2007; Ward et al., 2002). In most cases, it is

suggested that this issue invalid data collection instruments can be overcome, or was overcome, by the gathering of supplemental qualitative information. Lopatto (2007) recommends that observational data or mentor assessments should be used to better understand the data. Kardash (2000) also believes that using faculty mentor assessments of the participants is a way to overcome this challenge. In separate studies of the same populations, qualitative data collected by Seymour et al. (2004) seemed to have supported conclusions made from quantitative data collected by Lopatto (2004). Another study only had access to participant's final essays for analysis where students evaluated the program and shared their gains. While this was helpful to understand the quantitative data they suggest that in the future, faculty evaluations can also be used to better understand student attitudes (Ward et al., 2002).

**Importance of Apprenticeship of Faculty Mentors.** The apprenticeship experience with faculty passing their knowledge and experience on to students in the research setting has been identified by several authors as a large, and in some cases the largest, contribution of these research programs (Alexander et al., 2000; Gregerman et al., 1998; Lopatto, 2003; Page et al., 2004; Van der Spiegel et al., 1997). One author found this partnership as benefitting African Americans most, but that Hispanic and White students not in their first year of study also benefitted (Gregerman et al., 1998). One identified benefit from these apprenticeships, is the networks that participants form with faculty and other students that may help them later on in their careers (Page et al., 2004). Alexander et al. (2000) found that the "Spend a Summer with a Scientist" program at Rice University had a positive impact on participants in attending and completing graduate school because of the experience they had with their mentors. Next to student commitment, it is the commitment of the faculty mentors and the level of guidance they provide that is the biggest contributor to program quality (Van der Spiegel et al., 1997).

### **Chapter 3: Evaluation Design**

This evaluation employed an objectives-oriented evaluation approach (Fitzpatrick, Sanders, and Worthen, 2004). To achieve the purposes of the evaluation, surveys, interviews, observations, and analysis of participant reports were utilized to determine the degree to which program objectives were being met and to provide formative feedback to the client regarding how the program might be improved.

#### **Evaluation Questions**

In consultation with REU project leaders, two questions were selected to guide this evaluation. They were (1) Was the physics REU at Brigham Young University achieving its primary aim of helping student participants in the physics program progress to the point that they could have significant independent research experience by the end of the summer, and (2) How did the physics REU at Brigham Young University affect participant feelings towards the field of physics in general, research in this field, and graduate school in this subject area? In this document the first question is referred to as the “Program Success Question,” and the second is referred to as the “Participant Attitudes Question.”

These questions were chosen because of their relevance to the clients NSF proposal. The National Science Foundation wanted to know the answer to the program success question to justify the grant monies provided to this REU site. This question is the highest priority for these stakeholders. The participant attitudes question addresses interest expressed by the REU administrators in their proposal to NSF. This question is of lower priority, but still of great interest. By answering this question, the stakeholders hoped to gain insights into whether their program made a difference in a student’s attitude towards physics, research, and graduate school.

## **Evaluation Criteria and Standards**

Criteria for the program success question were selected based on the values of the two major stakeholders. These two stakeholders, the client and the NSF, are mainly interested in the effectiveness of the program to help students have a significant research experience by the end of the summer. These criteria and the coinciding standard for this evaluation question are summarized in Table 1.

As circumstances may exist that cause one or more of these criteria to fail for any given participant, most of these criteria must have been met in order for the program to have been successful for that participant. This standard was established after considering the varied experiences of past participants and understanding that the program cannot be all things to all people. Some participants may not like certain aspects of the program, but meeting most of the criteria was considered acceptable.

Criteria for evaluating the different facets of the participant attitudes question regarding changes in attitude toward physics, research, and graduate school were assessed by measuring student attitudes at different points of their experience in the program. These included a pre-experience assessment administered near the beginning of the program, a post-experience assessment administered at the end of the program, and a follow up assessment administered approximately six weeks after the participants completed the program. These criteria and the coinciding standard for this question are summarized in Table 2.

The standard for judging the criteria for this second question was determined by the observation of a positive change in student attitudes in each of the three areas, physics, research, and graduate school. If a positive gain was observed in each of the three areas for all participants by the end of the summer, the program was judged to have been successful. Follow up data was

also collected and used for research purposes and was not used in the criteria since the program no longer had a direct connection to the student's attitudes.

Table 1

*Summary of Program Success Question Criteria and Standard*

Criterion	Standard
1. The participant should have found some value in the mini-classes	1. Most of these criteria must have been met in order for the program to have been successful for that participant
2. There should have been a positive relationship established between the faculty mentor and the participant	
3. The program positively influenced the participants decision to undertake graduate study in a related field	
4. The participant was considering, somewhat interested, or very interested in the field as a career	
5. The participant was very confident or somewhat confident in their ability to be successful in a physics career	
6. The participant was glad to have picked BYU for their REU experience	

Table 2

*Summary of Participant Attitudes Question Criteria and Standard*

Criterion	Standard
1. The participant had a positive gain in attitude towards the field of Physics	1. A positive gain was observed in each of the three criteria for the program to be judged successful at having a positive effect on student attitudes
2. The participant had a positive gain in attitude towards research	
3. The participant had a positive gain in attitude towards graduate school	

**Data Collection**

Data for this evaluation was collected through surveys, interviews, observations, and textual analysis of participant research reports. While each distinct survey was intended to measure a specific attribute or answer a specific evaluation question, the other methods (interviews, observations, and textual analysis) were useful for providing additional points of view to better understand the survey data. A summary of these instruments and methods can be found in Table 3.

Before data collection began, participants were asked to sign a consent form (see Appendix A) and were given the opportunity to opt out of the evaluation at any time. Subjects were notified of procedures, risks, benefits, confidentiality, and compensation before they signed.

Four different surveys were implemented in this evaluation. Each survey was administered by a member of the evaluation team during a common class time when all participants were required to be present. The paper and pencil surveys were then collected



without ever being viewed or handled by the REU administrators. These data were later transcribed into a digital format for analysis. Random spot checks were done by another evaluation team member to verify accuracy of data entry.

Table 3

*Summary of Data Collection Response Rates*

Instrument/Method	# Completed
CLASS (pre)	11
CLASS (post)	12
Attitudes and Factors Affecting Research Utilization survey (pre)	11
Attitudes and Factors Affecting Research Utilization survey (post)	12
Attitudes toward Graduate Studies Survey (pre)	11
Attitudes toward Graduate Studies Survey (post)	12
REU Survey	12
Interviews	10
Proposals	13
Final Presentations	9

The Colorado Learning Attitudes about Science Survey (CLASS), version 3 (see Appendix B) was the first of three attitudinal surveys administered. This 42 item survey has been used in research to measure university student attitudes about physics and physics learning and has been validated by the authors using methods such as interviews, reliability studies, and statistical analysis (Adams et al., 2006). This survey was administered at the beginning and the end of the program with 10 of 12 participants completing both surveys. This instrument measures attitudes in nine areas. They are (1) personal interest - do students feel a personal

interest in /connection to physics, (2) real world connection - seeing the connection between physics and real life, (3) general problem solving ability, (4) problem solving confidence, (5) problem solving sophistication, (6) sense making/effort - how worthwhile the amount of effort needed to make sense of things is, (7) conceptual understanding - understanding that physics is coherent and is about making sense, drawing connections, and reasoning not memorizing, (8) applied conceptual understanding - understanding and applying a conceptual approach and reasoning in problem solving, not memorizing or following problem solving recipes, and (9) an overall assessment of attitude toward science. These nine areas were taken from the grading tool provided by the authors of the survey.

Section B of the Attitudes and Factors Affecting Research Utilization survey was also used (see Appendix C). Section A of this survey gathered demographic information that was not needed for this evaluation, while section B focused on attitudes towards research. Originally used to measure attitudes of graduate and undergraduate nurses, this instrument was developed based on the literature and tested by the author (Olade, 2003). It was adapted to physics by changing the prompt to focus the participant on physics research and then administered once at the beginning and once at the end of the program.

A third attitudinal survey instrument was used by permission of its authors. The Attitudes toward Graduate Studies Survey was developed refined and validated by several researchers at the New Jersey Institute of Technology (Capinelli et. al., 2007). Though designed to be used in measuring attitudes in undergraduate engineering students, the survey authors felt it to be applicable in physics as well. This survey was also administered at the same time as the two previously mentioned, once at the beginning and once at the end of the program. The instrument measured participant attitude towards graduate school in seven areas. They are: (1) barriers to

graduation, (2) career options, (3) engineering skills, (4) gender issues, (5) interest in grad school (e.g., the research requirements for a graduate degree would be beneficial for a career in engineering), (6) no interest in grad school (e.g., The benefits of pursuing a graduate degree are not worth the effort), and (7) interest in engineering.

The fourth survey was the REU Survey developed and utilized by the REU administrators at this site (see Appendix D). One reason for implementing this survey was because of its use in past evaluations of the REU program at BYU. The continued use of this instrument was intended to provide longitudinal data for analysis. Another reason was its ability to measure participant experiences. Since change is not being measured with this instrument, it was only administered at the end of the program.

**Interviews.** Each REU participant was invited to participate in an individual interview with the evaluator (see Appendix E for guiding interview questions). Each interview was recorded (audio only) with permission from the participant, then later transcribed. Interviews were conducted in a conference room in a separate building from where participants were conducting their REU research, but still on the university campus. This location was chosen because it was believed that it might help participants speak more freely than they might if they thought the REU administrators or faculty mentors might be able to overhear.

**Research proposals.** As part of their REU experience, participants were required to write a proposal for the research they planned to do during the summer. Copies of these proposals written at the beginning of the program were obtained from the REU administrators.

**Observations.** Observational data was collected from the individual participants' final presentation of their research experience. These reports were presented during the last week of the program and videotaped with student permission for later analysis. The evaluator had

planned to attend mid-program report presentations by the participants. Unfortunately due to a miscommunication with the REU administration, the evaluator was not informed of the presentations until after they had taken place. The evaluation also planned to request data from the faculty mentors about their observations of the participants and their experience. After discussion with the client it was determined that the request for these data would be most successful if it were to go through Dr. Turley, the REU program administrator. It was believed that faculty would be more receptive to an invitation from a colleague and the administrator of the program than from the evaluator. Faculty responses were to be sent directly to the evaluator. However, these observations were never received and therefore not utilized in this evaluation.

### **Data Analysis Procedures**

Quantitative data collected in pre- and post-surveys were summarized using descriptive statistics and t tests. The paired t test comparisons of pre post surveys were meant to identify any changes in participant attitudes. Other data collected (i.e., interviews, student proposals, and final presentation observations) were examined to gain further insight and understanding of quantitative results. Because of the small number of participants (n=13), data was not disaggregated by ethnicity as done by larger national studies. However, since the gender division was about half, differences among men and women were explored.

Qualitative data from interviews and observation notes were transcribed, segmented and coded. Coded data was categorized and quantified to determine the strength of patterns or themes that emerged. Open ended data collected from the REU survey was summarized by question.

The program success question was addressed through data collected mainly from the REU survey, participant proposals, observations of final presentations, and individual interviews.

The attitudinal surveys (CLASS, the Attitudes and Factors Affecting Research Utilization survey, and the Attitudes toward Graduate Studies Survey) were mainly used to answer the participant attitudes question. However interviews, the REU survey, and observations of final presentations were used to verify attitudinal survey findings.

### **Report to Stakeholders**

There are three main reports to stakeholders that have or will result from this evaluation, an interim report, a final report, and an executive summary.

The interim report was emailed to Dr. Steve Turley who represents the client. The purpose of this report was to share with the client initial findings of answers to both evaluation questions. It was the intention of the evaluator to solicit feedback and insight from the client as a stakeholder to validate or clarify evaluation findings. The client did not response to this request. No final recommendations were made in the interim report.

The final report along with an executive summary of the report will be completed near the end of this year and will contain findings from the interim report as well as final evaluation of the program against established criteria and recommendations. This report will also include research findings from follow up data collected from current and past participants regarding attitude change. The final report will be presented to the client in person so that questions about the report may be addressed. The client might consider posting the final report on its REU website. It is anticipated that the report will be used by the client in reporting to NSF and others the client feels might be interested.

The evaluator's work with the undergraduate population both through first-year programs and the teaching of freshman seminars to prospective science students provided an area of

concern for bias because of previous observations and experiences with undergraduates. This concern was addressed by having the interviews transcribed for others to read through and interpret if needed. When possible, the evaluator restated his understanding for the participant to affirm or clarify their intentions.

### **Required Resources**

Survey instruments that were administered via paper required access to a computer, printer and photocopier. The evaluator was responsible for the copying of all paper instruments. Surveys were administered in a classroom during a common class time that was arranged by the REU program. The time of the evaluator (who administered the surveys at the beginning of the program) and an assistant (a student employee of the Center for Teaching and Learning who administered the surveys at the end of the program) was used to administer these surveys. Evaluator team members were employed to digitize the surveys. It was important to use team members who took their time and were accurate in digitizing the data so that mistakes were not introduced into the dataset. Spot checks of the data were later conducted by the evaluator to increase confidence in the accuracy of the data set.

Individual interviews required a room and a digital audio recording device provided by the evaluator, so that transcriptions could be made for analysis. The evaluator conducted all interviews in the department conference room. Strategies from graduate level classes taken by the evaluator, past interviewing experience, and not being directly connected to the REU made the evaluator the best candidate for carrying out interviews of the subjects.

Audio video equipment was obtained by the Center for Teaching and Learning (CTL) to record final presentations of REU participants. An evaluation team member attended and recorded the presentations.

Computers were used by the evaluator and other team members for the analysis of data, report writing, transcription, and video conversion and analysis. The CTL provided access to computers with required software for converting video to an MOV format and playing audio WMA files for transcription. The movie files were copied on to a DVD for the use of the evaluator while the audio file transcriptions were converted to PDF using Adobe and emailed to the evaluator. It was important to utilize a team member who was meticulous and took the necessary time to transcribe all of the audio files to assure accurate data. SPSS and Microsoft Excel were used for data analysis. The evaluator conducted this analysis as directed by the authors of the survey instruments, and past experience with data analysis.

Email was used by the evaluator, other team members, and the client to communicate, distribute information, and invite participants for interviews.

## **Chapter 4: Findings**

Findings are presented based on the two evaluation questions established at the onset of this evaluation. These questions are (1) is the physics REU program at Brigham Young University achieving its primary aim, to help student participants in the physics program progress to the point that they can have a significant independent research experience by the end of the summer (the program success question), and (2) How does the physics REU at Brigham Young University affect participant feelings towards the field of physics in general, research in this field, and graduate school in this subject area (the participant attitudes question)?

The findings presented in this document are solely from the evaluator. Client insight and interpretation of findings from the interim report were not provided.

### **Aspects of the Program Success Question**

To answer the Program Success question, data from the REU survey, interviews with individual participants, and final presentations were analyzed. Mini-classes, mentoring, graduate school, the research experience, and physics as a career were all areas looked at. These areas were used to establish the criteria described previously in Table 1. The final section (i.e., suggestions for improvement), though it does not tie directly to criteria specified for evaluating this question, was included for its formative value to program administrators. All these data provided participant perceptions of the usefulness and/or effectiveness of these program components.

As stated earlier, most of these criteria must have been met in order for the program to have been. The criteria include (1) the participant should have found some value in the mini-classes, (2) there should have been a positive relationship established between the faculty mentor



and the participant (3) the program positively influenced the participants decision to undertake graduate study in a related field, (4) the participant was considering, somewhat interested, or very interested in the field as a career (5) the participant was very confident or somewhat confident in their ability to be successful in a physics career, and (6) the participant was glad to have picked BYU for their REU experience.

**Mini-classes.** Participant reactions to the mini-classes were somewhat mixed. While the majority that responded to the REU survey (i.e., eight students) listed that they were useful and informative for helping them to consider sub-fields of physics. Four stated that the classes were interesting, but not useful for their area of research. Of those listed as helpful mini-classes, 15 of the 17 classes were what might be considered “skill classes” (see Table 4). The other two were graduate school and interferometry. Participants also provided suggestions and other class topics the program administrators might want to consider. The topics listed were machine shop, scientific writing and presenting, Labview, microscopy, and spectroscopy.

One participant felt she, “got a little lost because [she] did not have enough background information.” This and the mention of other skill building opportunities suggest that the participants may need additional understanding before being able to comprehend the content of some of the other mini-classes.

Because of these findings, it is recommended that learners be informed of class content beforehand so that preparation may be made by those who may feel underprepared. Perhaps a list could be distributed prior to the class of terms and/or concepts that will need to be reviewed prior to upcoming classes along with suggested reading material. Every effort should be made to help each participant feel able to ask questions and interact with the presenter.

Table 4

*Summary of Helpful Mini-class Responses*

Class Topic	Number of Times Listed
Skill Classes	
Lyx	6
Mathematica	3
Vacuum Class	6
Non-skill Classes	
Graduate School	1
Interferometry	1

Participants tended to like classes that focused on the teaching of skills. They suggested the classes should be interactive, meaning that ideas can be shared between participants and instructors. Classes are more enjoyable if they have sufficient background knowledge to understand the content.

**Mentoring.** Each of the participants had something positive to say about the mentor experience they had. Mentors were easy to talk to and work with. They provided support and insight into their research and talked with participants about graduate school. Two students mentioned that their experience with their mentor could have been better. One said that although the experience could have been better, some valuable experience was gained. No explanation was provided describing how the relation could have been improved. The other said, “My advisor left during the summer for a few weeks, so I didn’t have as much interaction as I would have wanted, but I feel we have a good relationship and I’ve had a positive experience.” This was further clarified by the interview with this participant where it was mentioned that the least

favorite part of the program was that, “my actual advisor went out of town for like a month.” While others stepped in to help, it appears to have had a negative impact on the participant. There was another student who provided a suggestion about the mentoring program even though the participant felt it was a positive experience. This student suggested, “Maybe have a few professors who are more dedicated to the REU students and aren’t quite so busy [with] their own research.”

Because of these findings and the strong influence that faculty mentors have on the experience of the participant found in the literature, mentors should be chosen who will be around for the duration of the program. These mentors should be willing to take time away from other projects to guide the research experience of each mentee and provide the time and supervision needed.

Overall, the mentor experience was positive for the participants. They developed beneficial relationships with the professors and had appropriate supervision from them. The long-term absence of a faculty mentor, even if arrangements are made for others to fill in, has a negative effect on participant perception of this aspect of the program.

**Graduate school.** Most of the participants (i.e., 10 of the 12 respondents) indicated they are planning to attend graduate school, two of the 10 however plan to pursue graduate degrees in areas other than physics (see table 5). The remaining two were undecided. Nine indicated that the program did influence their decision about graduate school. For all of them, the experience helped them solidify their decision and/or area of interest for graduate studies. Of the remaining three who said the REU experience had no influence on them regarding graduate school, two said they were already planning on graduate school, and one who was also undecided said the program had no influence. It is interesting to note that this student reported in an interview that

they will probably follow the path of the spouse. If the spouse goes to graduate school, most likely in Counseling and Psychology, this participant will probably attend graduate school in that same field.

Table 5

*Summary of REU survey graduate school data*

Response	n	Explanation
Planning to attend		
Yes	10	
No	0	
Undecided	2	
REU influenced decision		
Yes	9	
No	3	2 already planning to attend graduate school 1 undecided, but will probably attend with husband

Most were positively influenced by their experience to continue on to graduate school. Those who reported no influence from the experience either had previous plans to go, or are waiting on the decision of a spouse.

**The Research Experience.** When asked in an open ended question what the most beneficial part of the program was for them, 11 out of the 12 respondents pointed to the different aspects of the research they were doing as the best part (e.g., hands on experience, utilizing

research equipment, learning and applying practical skills, literature reviews, publishing, and collaboration ). Participants liked their research experience at this site because they felt that BYU faculty were accustomed to doing research with undergraduates and it is a “high quality institution.”

Interviews indicated that the majority of the participants felt the research experience was helpful to them in making decisions to continue with research or not. They liked the hands-on experience that they were exposed to, especially the ability to work directly with equipment. A participant stated that this opportunity provided a research experience that would have otherwise been unavailable to them. All the participants but one felt the research experience was significant to them. The dissenter felt like the experience was not authentic and did not represent what research was really like. This participant enjoyed the experience and liked having freedom to explore interests but that in an authentic research setting he, “wouldn’t be able to control it as much, it will be a lot more of doing somebody else’s project, working on really mundane detail for hours every day”. All participants indicated that they were glad that they chose this site to have their REU experience.

Because of the varying expectations described in the REU survey by the participants, it is hard to measure if a significant research experience was had. It is evident that all but one interviewed felt that they had had such an experience. For the most part, final presentations showed enthusiasm for their research.

**Physics as a Career.** Most participants reported positive interest in physics as a career and high confidence in their ability to be successful in a career in physics. Students who tend to have high interest in a career in physics tend to have high confidence in their ability to be successful ( $r=.817$ ). Figures 1 and 2 summarize participant responses.

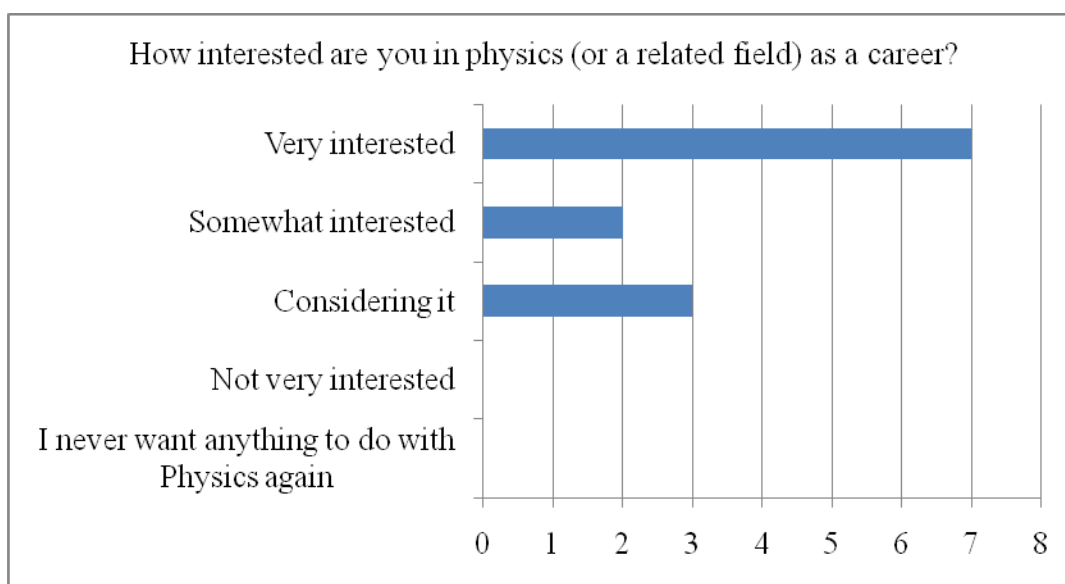


Figure 1. Summary of participant interest in physics as a career.

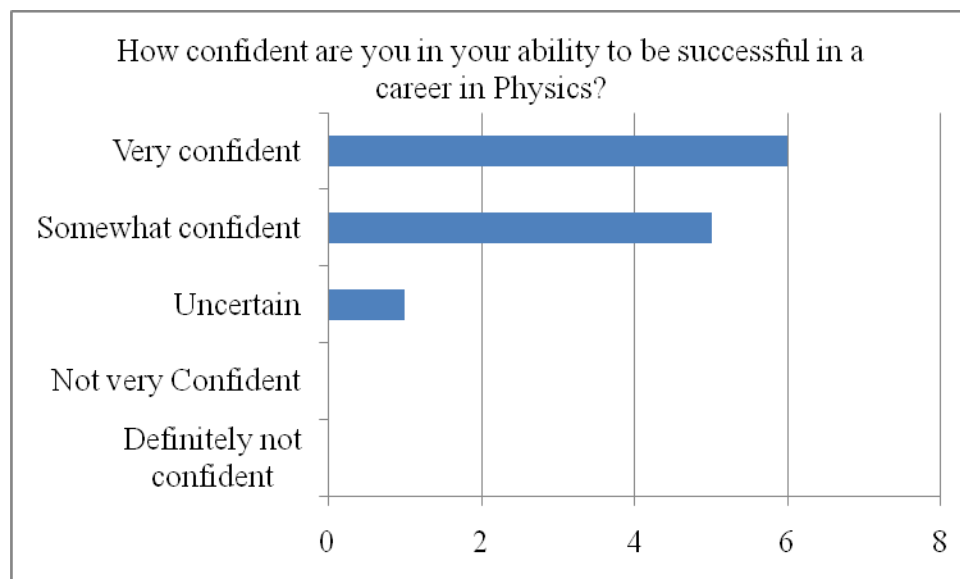


Figure 2. Summary of participant confidence in being successful in a career in physics.

When asked how participation in the REU program influenced participant attitudes towards physics as a career, two respondents indicated that the program strongly influenced their

attitude. One was very interested in Physics and the other indicating they were considering Physics. The individual who is considering physics as a career said that, "Prior to this program my answer would have been [I never want anything to do with physics again]." All others reported that the program did not have a significant influence their attitude towards Physics, or that it just confirmed what they already planned.

During interviews, almost all participants indicated that they knew they wanted to do something in the field of physics from a very young age. This could explain why, with high interest in physics as a career and confidence they can be successful, participants do not feel the program had a large effect on them in this aspect.

Those who participated in this REU program were interested in physics as a career and feel confident that they can be successful. As a result they did not believe that the REU program had a significant impact on their attitude about going into the field of physics.

**Suggestions for Improvement.** Participants made a wide variety of suggestions for program administrators to consider. With regards to faculty mentoring, it was suggested that faculty who have more time to dedicate to the REU students and are not quite so busy with their own research be selected as mentors. Students also suggested that scheduled meeting times with the mentors could be established where participants could meet and discuss needs and provide progress reports. They also thought establishing a specific schedule with deadlines would be beneficial. Some wanted outside trips to other research facilities off campus. Another suggestion was that participants be able to start using the equipment sooner and be exposed to more types of equipment.

The final suggestion was that more could be done to help participants learn to write and present physics research. They suggested that more opportunities to share information with other

participants through reporting be made available earlier in the process so that all could be aware of other research taking place. Considering the objective of this program to help all participants have a significant research experience, these suggestions are particularly important. Writing, conducting experiments, reporting and presenting are all essential parts of research. It is recommended that participants be given several opportunities to write about their research and allow others, possibly mentors and peers, to provide feedback. When preparing for project presentations, participants should have the opportunity to receive instruction and guidance that will improve their presentations.

It is also recommended that some medium should be made available for participants to share their progress, interesting experiences, difficulties, etc. with other participants. Perhaps something like a blog could be implemented where participants could write regularly and allow for others to comment. This not only allows others to be aware of what other research is taking place, but could provide support, new ideas, or insights into problems that might be solved by a more collaborative effort.

The culmination of this research experience comes at the end of the summer when all participants present their research and findings. It is recommended that a more formal presentation opportunity be made available that would resemble more of a professional conference where research is likely to be presented. Inviting a broader population to participate would help create a more authentic environment. This might provide a more accurate representation of other research presentations that might be made available to the participant later on, adding to the authentic research experience.

**Summary.** The program did meet an acceptable standard established for this evaluation question. Though student experiences varied, the program seems to be meeting its primary aim to



help participants have a significant research experience by the end of the summer. Participants found value in the mini-classes they experienced and provided additional topics for the REU administrators to consider. Mentor-participant interaction was generally positive but long term absences from the program by one faculty member negatively impact participant perceptions of that relationship. Participants felt the program had a positive influence when it came to decisions about graduate school. Those who did not feel it had a positive influence had either already firmly decided to attend graduate school, or their plans depended more on the plans of a spouse. All but one participant felt they had a significant research experience, with only one student feeling that the experience did not match what they felt research was really like.

### **Aspects of the Participant Attitudes Question**

This question was answered through the administration of three instruments that have been determined to be reliable and valid for determining attitudes of students in the sciences. Each survey measured a different area of participant attitude and was compared with interview data and some REU survey data to clarify understanding. Significance for these data were determined at an  $\alpha=.05$  level.

**Attitude towards Physics.** The *Colorado Learning Attitudes about Science Survey (version 3)* (see Appendix B) was used to collect data that addressed participant attitudes towards physics. This survey was used to measure university student attitudes about physics and physics learning. It was administered near the beginning and at the end of the program. Differences in the pre and post response data was used to determine if there was a change in participant attitude.

Paired-samples t tests comparing participant pre and post scores were conducted on the group as a whole, and then broken out by gender. In general there was a statistical difference ( $p =$

.010) found when comparing the pre and post responses for all students in the Sense Making/Effort category. The change in scores shifted positively by 10 points out of 100. The positive shift in this category is interpreted as a shift towards responses an expert would choose when asked the same set of questions. This category means participant attitudes towards exerting the effort needed towards sense-making is worthwhile. Comparisons by gender yielded no significant difference.

When considering that all participants sought out this opportunity to have an intensive physics research opportunity it is no surprise that their answers, both pre and post, are overwhelmingly aligned with responses an expert would give if asked the same questions. Still, there was an increase in attitudes even though most subjects already had a positive attitude towards physics. The interview data and observational data lead one to the same conclusion. These are subjects who have grown up always fascinated by physics principles. Most were surrounded and influenced by family or teachers in the field of physics from a very young age. Though not much change can be measured in the attitudes of the participants towards physics, likely due to a ceiling effect, we can conclude that these participants' attitudes were not negatively affected by the REU program.

**Attitude towards Research.** Participant attitudes toward research were measured using the *Attitudes and Factors Affecting Research Utilization* survey tool (see Appendix C). These results should not be confused with findings from the previous evaluation question regarding significance of the research experience in Physics. This section is only analyzing the change in attitude towards research in general.

There was no significance change found in attitudes from pre to post data based on a paired-samples t test; nor was any significant difference in results found based on gender. A

closer look at these data revealed that of the 10 participants who responded to both surveys, five had attitudes that became more favorable towards research while the other five became less favorable. On average the directional changes were canceled out.

Within these groups, the difference in attitude was significant,  $p = .019$  for those with an improved attitude, and  $p = .013$  for those whose attitude declined. Table 6 shows the ranges of responses from each group. Both groups had near identical ranges at the beginning of the REU program, but by the end had a shift in attitude.

Table 6

*Summary information for research attitudes between groups*

Period of Program	Range (min = 1 – max = 10)
Improved Attitude Group (n = 5, p = .019)	
Beginning	2.17-----5.00
End	3.00-----6.17
Worse Attitude Group (n = 5, p = .013)	
Beginning	2.17-----4.67
End	1.33-----4.17

This result implies that the experience the participants had over the summer had a polarizing effect. Either it helped students see that they liked research or helped them see that it was not what they wanted to do, or at least it was not what they thought it would be.

Participation in this program appears to have changed the attitude of the participants one way or another.

**Attitude towards Graduate School.** Graduate school attitude was measured using the *Attitudes toward Graduate Studies Survey* (Carpinelli et al., 2007). This survey is intended to measure different aspects of the participant's attitude towards graduate school. This survey was also administered pre and post to see if there was a change in attitude over the course of the program. Paired-samples t tests were performed on the group as a whole, and then broken out by gender to look for differences.

The paired-samples t tests results yielded no significant change in attitude for all students or by gender. Insight gained from the REU Survey mentioned earlier indicated that there were three participants who were unsure if they wanted to go on to graduate school. The REU Survey was administered at the end of the program, but interviews conducted toward the beginning and middle of the program confirmed these attitudes. They were consistently unsure about graduate school. When those three participants were removed from the dataset and the t test reapplied, the "no interest in grad school" category became significant ( $p=.047$ ). The scores for this category dropped, indicating they were more likely to feel positively about graduate school. Overall, the program did appear to have a positive effect on individual participant attitudes towards graduate school to some degree.

**Summary.** The standard established for this evaluation question was not met. It was expected that a positive shift in participants' attitude toward graduate school attendance would be observed over the summer. No significant change was noted overall, however, it was found that the program did help individual students in other ways. Though some attitudes towards research increased and others decreased, participants reported that the experience helped them

decide one way or another whether research was what they really wanted to do. Although attitudes towards physics did not seem to be significantly affected, more in-depth research may need to be done to determine if, given this population's positive attitude toward Physics, much can be done to significantly improve their attitude.

The small sample size in this study likely affected the results. With a larger dataset from future programs, perhaps more definitive results from attitudinal data could be obtained. Identify specific areas of the program that will benefit most from evaluation, and implement a strategy to achieve it.

### **Other Findings**

After reviewing all of the data available, there was one student who appeared to stand out from the others. Participant 10 had responses seemingly opposite those of the others when looking at the attitudes towards physics; thus a negative case analysis is warranted. This individual's responses were interpreted as having a more negative attitude towards physics than the rest. The interview data provides insight here. This participant indicated that astronomy was the major he was most interested in, but that a double major in physics and astronomy was being sought. The following explanation was provided:

Originally I was majoring exclusively in astronomy but then I had a conversation with my advisor and he told me that it actually would be better if I did a dual major in physics and astronomy because apparently that dual major looks better on a resume.

It appears that the only interest in physics is to improve the resume. This participant's attitude towards graduate studies does not stand out from the rest, but he was one that indicated that he was unsure about graduate school. This was also confirmed in the interview. Responses

of attitude towards research identify this participant as one whose attitude became more favorable. In fact he had the most positive values for this survey with 5.00 at the beginning and 6.17 at the end. When asked in the interview if the REU program affected their attitude towards research, the participant replied, "It's actually kind of discouraged my view of research." This does not seem to be consistent with the survey answers.

Throughout the interview, there was a sense of apathy towards everything related to the REU experience. This site was chosen by the participant because it was the only one of the six he applied to that accepted him. Graduate school may be an option, but it will depend on what GPA is achieved. Upon being asked how the participant liked the program, the monetary aspects were referenced and ended with, "I'm just sort of going along with it right now." The final presentation reflects this same type of apathy towards the whole experience.

This participant is mentioned specifically because of the inconsistencies in the data. Data from other participants on surveys and observations clarified and/or supported each other. The different sources of data for this participant seem to conflict. The other participants seemed to have had a stronger purpose for participating in the program while this student cited mainly extrinsic reasons. Ultimately, the program did not seem to have as great an impact as it might have had on someone else with stronger reasons for participating. Perhaps the administrators of this site might be able to find some anomalies in the application of this participant when contrasted with the others. If participants like this one can be identified before acceptance, then the student could either be denied or given extra resources to help them make the most of the experience provided.

Considering the experience of this participant, it is recommended that site administrators should look closely at the reasons given by prospective student for participating. Consider

admitting those with multiple reasons to participate. If someone is chosen who might not have several reasons for participating, plan what might be done to support the participant so that a positive experience can be had.

## **Chapter 5: Recommendations and Conclusions**

The evaluation recommendations stated earlier and the conclusions presented hereafter are based on the evaluator's observations and interpretation of data from the participants. The recommendations are intended for the improvement of the Physics REU program at BYU and determine whether it is being implemented as intended with good results.

The seven recommendations made early are summarized here. They are (1) select faculty mentors that can dedicate sufficient time and attention to the program (see p. 25), (2) address participant preparations for mini-classes (see p. 24), (3) provide deeper instruction on physics writing and presenting (see p. 30), (4) allow formal final presentations (see p. 30), (5) provide a method for more frequent sharing of project statuses (see p. 30), (6) consider prospective participant reasons for participating before acceptance to better understand how to help the students (see p. 37), and (7) to continue evaluation efforts (see p. 35).

### **Evaluation Limitations**

There were four things in particular that limited this evaluation. These were (1) the small population size, (2) the participants not all contributing contributed equally to the collected data, (3) attitudinal instruments may not have been sensitive enough to this population, and (4) missed communication with program administrators resulted in missing data sources.

The small population size probably affected the statistical significance of the results. A larger group would have provided better comparisons, but there were simply only 13 participants accepted for this summer. Perhaps over time, the same data can be collected on future participants to provide a better data pool.



Because not all were available and/or willing to complete surveys or participate in interviews, there are some holes in the data that might have shed greater light and understanding on the evaluation. This limitation also exacerbates the previously mentioned limitation of sample size.

Because the lack of significance found in the change of participant attitudes does not seem to match up with other data collected, we might conclude that the attitudinal surveys might not be sensitive enough to measure any change in attitudes. Additional evaluation in the future may help derive a more definitive answer of how the REU at this site affects student attitudes in specific areas.

There were several occasions when communication with the program administrators did not occur as desired. The evaluator asked for information regarding mid-semester presentations, but was not notified until after they had taken place. This resulted in a missed opportunity for observation. Towards the end of the summer, it became evident that the site administrator became occupied with other activities and was unable to dedicate sufficient time to the evaluation and respond adequately to evaluation needs at two specific occasions. First, faculty data that was to be requested by the site administrator was not collected resulting in missing data from an important stakeholder group. Second, the lack of response from requested insight and interpretation of interim report findings that may have benefited the evaluation with an expert's opinion.

### **Overall Conclusions**

Participants in the Physics Research Experiences for Undergraduates at Brigham Young University overwhelmingly indicated they were glad they picked this site to have their REU

experience. They are generally happy with the mini-classes, had a positive relationship and experience with their faculty mentor, felt a positive influence to go on to graduate school, and felt confident in their ability to be successful in the field of physics.

Although there was some evidence of minor improvements, attitudes towards physics were largely unchanged. This result most likely comes from the type of students that are selected for this program. Through the application and selection process to participate, mainly those with very positive attitudes towards physics apply and were accepted. This program did seem to have a polarizing effect on participants. It seemed to help students decide one way or another whether research is a path they would like to pursue. Participants seemed to leave this program with a better attitude towards graduate school than when they started.

Overall, the program was judged to be successful in helping students have a significant research experience by the end of the summer and helps them solidify their future plans, whatever they may be.

## Chapter 6: Meta-evaluation

Through the course of this evaluation, many experiences provided learning opportunities for the evaluator. There were two specific lessons that were particularly insightful that are discussed below. They were (1) trying to address the correct audiences appropriately and (2) the importance for the evaluator to be involved with data collection as much as possible. The remainder of this report contains a meta-evaluation applying Stufflebeam's (1999) 10-point evaluation checklist.

The process of report writing and presenting of results made it clear that each audiences needs must be addressed sufficiently for a general report to be successful. Without sufficient foundational knowledge, one might find it difficult to understand why the evaluation was conducted the way it was. This report was originally written more with the client in mind. By so doing, those with little or no explanation of what a REU program would be like would make it difficult to comprehend certain components of the evaluand. More background information of the evaluand was added to help an audience with little exposure to REUs better understand what was being evaluated.

Throughout the evaluation, the evaluator was central to every data collection procedure but one. Data was collected and maintained directly by a member of the evaluation team, the only exception being the observational data from the faculty mentors. The client felt that the data would be better obtained or that the faculty would respond better to the program administrator rather than the evaluation team. It was a mistake for the evaluator to concede this responsibility. As a result, no data was collected from this important stakeholder group that could have provided significant insight into participant experiences.

The following is the resulting application of the 10-point evaluation checklist from Stufflebeam (1999). Explanations of failed standards and rationale for non-applicable standards are discussed where appropriate. The following ratings were applied, poor, fair, good, very good, and excellent.

### **Utility Standards**

The utility standards are intended to ensure that an evaluation will serve the information needs of intended users. After applying the standards for the utility section, this evaluation was judged to have earned an overall rating of very good.

**U1 Stakeholder Identification.** This was rated excellent overall. The evaluation had planned to involve stakeholders throughout the evaluation but some factors impeded the anticipated implementation. The client was to be involved constantly. This was successful during the first half of the program, but the client became less and less responsive to inquiries and requests towards the end. Faculty mentors were to be engaged through the site administrator, as it was decided that better response would be had through this approach. It appears that this interaction never took place.

One area that was not implemented very well was the consulting with stakeholders to identify their information needs. This was done very well with the client through multiple face to face meetings and email, but not very successfully with the other stakeholders mentioned. To some degree, the information needs for NSF were discussed through the client since the evaluation was being conducted in part to meet the sites reporting needs to NSF. Faculty were never contacted to discuss what information needs they would have.

**U2 Evaluator Credibility.** The overall rating for this area was very good. The evaluator was prepared to address stakeholder criticisms and suggestions, but unfortunately, none have been presented to date.

Very little effort was made to help the stakeholders understand the evaluation plan, technical quality, and practicality. Besides the initial in-person conversations with the client to discuss what the evaluation plan was, no other effort was made.

**U3 Information Scope and Selection.** A ranking of very good was achieved here. Besides the client, no other stakeholders were interviewed to determine their different perspectives. However, efforts were made to obtain this information from the faculty but results were never acquired.

The evaluator did not feel that, because of the nature of this project, adding additional evaluation questions during the evaluation would be permissible. Because of the IRB permissions obtained, only evaluation questions that could be answered with existing data being collected could possibly be introduced. Though none were considered, additional evaluation questions utilizing existing data collection plans could have been introduced.

**U4 Values Identification.** The evaluator felt that this area was achieved and addressed in all respects resulting in an excellent rating. It is believed that there were no pertinent laws that needed to be referenced, nor were there any pertinent societal needs to be identified.

**U5 Report Clarity.** This area was ranked very good. Though an executive summary has not yet been provided to the stakeholders, it will be included with the final report presented to the client when additional non-evaluation research has been completed. A technical report has not been provided and there are no plans to do so.

There were some issues with the clarity of the interim report. A colleague identified some minor errors and organizational issues with the report that has been addressed for the final report.

**U6 Report Timeliness and Dissemination.** This area is excellent for all applicable standards. There are plans to issue a final report in the near future. Exchanges with the program staff and policy board are one in the same for this case. Except for conditions mentioned earlier with less frequent interaction towards the end of the program, exchanges were timely. There was no perceived need to have any exchanges with the public media.

This evaluation fails to implement specific examples that might help audiences other than the client, to relate findings to practical situation. It is hoped that audiences will be able to find application of the findings presented herein to their specific situation.

**U7 Evaluation Impact.** Evaluation impact was judged to be very good from the perspective of the evaluation. Though efforts were made to involve stakeholders throughout the duration of the evaluation, effectiveness tapered off near the end. Written reports were supplemented with one way communication from the evaluator. The evaluator plans on meeting with the client in person to review findings with them. It is anticipated that the client will participate.

Because of the above issues, it is expected that the impact of the evaluation will be less than it could have been with more stakeholder interaction.

### **Feasibility Standards**

The feasibility standards are intended to ensure that an evaluation will be realistic, prudent, diplomatic, and frugal. After applying the standards for the feasibility section, this evaluation was judged to have earned an overall rating of excellent.

**F1 Practical Procedures.** This area was excellent. All practical procedures standards were met except for engaging locals to help conduct the evaluation. It was possible to involve the client, participants, and others in the physics area (students and faculty) to conduct the evaluation. However, the evaluator determined that involving the participants would impact the evaluand and therefore corrupt the data. Inclusion of any of the others listed might introduce bias that could affect evaluation findings.

**F2 Political Viability.** Political viability was judged to be very good. Though no diverging views were reported, they would have been welcomed as they would have provided additional insight. Efforts to involve stakeholders to the extent to which they wanted to participate were made. The standard of terminating any corrupt evaluation was found to be non-applicable to this evaluation.

This evaluation failed to employ a firm public contract. Nothing was formally signed by the parties involved. The only agreement made came from an oral understanding between the evaluator, the client, and a representative of the Center for Teaching and Learning.

**F3 Cost Effectiveness.** This was also an excellently achieved area. The standard to make use of in-kind services was found to have been non-applicable. Because the evaluator was conducting this evaluation to fulfill requirements for a Master's degree and the CTL needed funding to pay the students that would be employed to participate on the evaluation team, no in-kind services were proposed.

This evaluation did not provide accountability information. Ultimately, the program is accountable to NSF who provided grant monies to sustain the program. Accountability for stewardship of that grant will be provided by NSF. The evaluator did not feel it proper to impose

any accountability on the REU program due to the nature of the evaluator's status as a graduate student.

### **Propriety Standards**

The propriety standards are intended to ensure that an evaluation will be conducted legally, ethically, and with due regard for the welfare of those involved in the evaluation, as well as those affected by its results. It was determined that this evaluation earned a very good rating in this area.

**P1 Service Orientation.** This area was found to be excellent. The only aspect that has not yet been done is informing all right-to-know audiences of the program's positive and negative outcomes. It is anticipated that the client will publish these evaluation findings on its website for all audiences to reference.

**P2 Formal Agreements.** This area is ranked either excellent or poor depending on the interpretation. All agreements were documented in written form which became the project proposal. If the proposal is sufficient to meet the requirement of a "written agreement" then it is excellent. If a signature was to be obtained, then this evaluation would rate poor. For purposes of this evaluation, it is interpreted that a non-signed agreement is acceptable.

The only area not agreed upon was editing. The evaluation staff was established at the time IRB approval was sought, identifying those who would be involved directly with the evaluation and reporting. But no specific agreement was made concerning individuals who would be involved in the editing.

**P3 Rights of Human Subjects.** This evaluation was excellent in this area as all standards were met.



**P4 Human Interactions.** This area was very good. The weak areas were effective communication with stakeholders, honoring time commitments, and being even-handed in addressing different stakeholders.

Most of the communication with the stakeholders was effective and successful. However, near the end of the program communication became poor, most likely due to the medium used, email. Phone calls and more personal visits would probably have been more effective.

The interim report was not turned in at the originally scheduled time. Data from the faculty members had been requested by the evaluator through the site administrator. These data were to be used to clarify evaluation findings. The report was put on hold by the evaluator to wait for the data to become available. Ultimately, the report was completed and sent without these data.

The evaluation was much more heavily weighted toward the client than any other stakeholder. While this might have been appropriate considering those who have the most input and stand to benefit most. However, more effort should have been made to address the faculty group who support this program.

**P5 Complete and Fair Assessment.** This standard also received an excellent score. The one item that was not addressed was to show how the program's strengths could overcome its weaknesses. Recommendations were made that could improve the many strengths of the program, but there is nothing specific that shows how a strength could overcome a weakness.

**P6 Disclosure of Findings.** A ranking of very good was achieved here. The right-to-know audiences were never specifically defined at any time during the evaluation. There are participants, prospective participants, and other REU programs that should have a right to know about these evaluation findings.

As stated earlier, no formal contracts were established at any point. There was no contract established to assure compliance with right-to-know requirements.

**P7 Conflict of Interest.** This standard was also rated very good. The evaluator did not feel that contracting with the funding authority instead of the funded program was applicable in this case. Though NSF is the funding authority, it has left the burden of evaluation on each. It was also determined that having internal evaluators report to the chief executive officer was also not applicable in this case since the evaluators were considered external. No contractual safeguards against conflicts of interest were established.

The evaluation could have benefitted more from engaging uniquely qualified persons (other than the evaluator) to participate in the evaluation. REU site administrators from other location could have been contacted to provide insight and interpretation that may have been beneficial to the evaluation.

**P8 Fiscal Responsibility.** Fiscal Responsibility was judged to be very good for this evaluation. Since there were no budgetary modifications needed, requesting appropriate approval for a budget modification was not applicable.

This evaluation did not employ comparison contract bidding.

### **Accuracy Standards**

The accuracy standards are intended to ensure that an evaluation will reveal and convey technically adequate information about the features that determine worth or merit of the program being evaluated. The overall ranking for these standards is very good.

**A1 Program Documentation.** This was the lowest ranked standard of all with a ranking of good. Little was done to maintain records from various sources of how the program operated.

The only information came from the grant proposal and from limited observation from the evaluation team.

Because of the fault explained above, nothing was done to analyze the discrepancies between the descriptions of how the program functions and how it was intended to function. Also, discrepancies between how the program was intended to operate and how it actually operated were not analyzed.

Since the above records were not maintained, this evaluation could not ask the stakeholders to review the information to determine the accuracy of the records.

A technical report was not created to document the program's operation.

**A2 Context Analysis.** This standard received a rating of excellent. No effort was made to try and analyze how the program's context is similar to or different from that of other programs where it might be adopted.

The item that focused on identifying and describing critical competitors to this program that functioned at the same time in the programs environment was deemed not applicable. Though there were other summer REU programs taking place across the nation, none operated in the environment of this REU. Other similar summer programs may have taken place in other fields than physics at the same time on the BYU campus, but they remained separate.

**A3 Described Purposes and Procedures.** This standard was also excellent. Because the evaluation's purposes stayed the same throughout the evaluation, it was not deemed necessary to describe that it did remain the same. This being true, there was no need to update the evaluation procedures to accommodate any changes.

**A4 Defensible Information Sources.** This standard was also seen to be excellent. Because the entire population was used in every data collection situation, no sampling was

implemented. All data collection instruments were included in an appendix except for the Attitudes toward Graduate Studies Survey that was used by permission of the authors for implementation only.

**A5 Valid Information.** This standard received an excellent rating as well. The only weak area was the lack of documentation on how each procedure was scored, analyzed, and interpreted.

**A6 Reliable Information.** All areas in this standard were met giving a rating of excellent. It was determined that pilot testing of new instruments in order to identify and control sources of error was not needed in this evaluation. All instruments used had previously been found to be reliable and valid for the purposes they were used for.

It was also determined that the need to check consistency between multiple observers was not needed since the evaluators observations were the only ones used. If the requested interpretations from the client had been provided to the evaluator, this element would have needed to be addressed.

**A7 Systematic Information.** The Systematic Information standard was also determined to be excellent. The only area lacking here was to have data providers verify their data. Participants interviewed and surveyed should have been asked to verify the information they provided.

**A8 Analysis of Quantitative Information.** This standard was also excellent. Since the qualitative measures used in this evaluation came from published literature and had been validated, no preliminary exploratory analysis to assure the data's correctness or to gain greater understanding of the data was conducted. There was also very limited time to have done such.

No effort was given to employ multiple analytic procedures to check consistency and replicability of findings.

**A9 Analysis of Qualitative Information.** This standard was rated very good. The evaluation did not test the derived categories from qualitative analysis for reliability and validity. It also did not classify the obtained information into any validated analysis categories, because of the previous statement. However items were classified into categories for analysis.

**A10 Justified Conclusions.** This area was found to be excellent. The one lacking element was to cite information that supported each conclusion. The evaluator felt that the chapter outlining the findings provided sufficient explanation as to not warrant restatement for each conclusion for which they applied.

**A11 Impartial Reporting.** This standard was very good. No appropriate editorial authority was established nor was the right-to-know audience explicitly determined. Little effort was made in this report to describe the steps taken to control bias. Though they may be implied, they were not made explicit.

**A12 Metaevaluation.** This final standard was excellent. Since this chapter is a requirement of the Masters project, it was determined that contracting for an independent metaevaluation was not needed. It is anticipated that the Masters Committee members will conduct their own metaevaluation.

## **Schedule**

Almost all components of the evaluation were late to some degree for differing reasons. Some items took longer than expected to prepare while others were delayed while waiting for information from the client. A summary of the schedule can be observed in Figure 3.

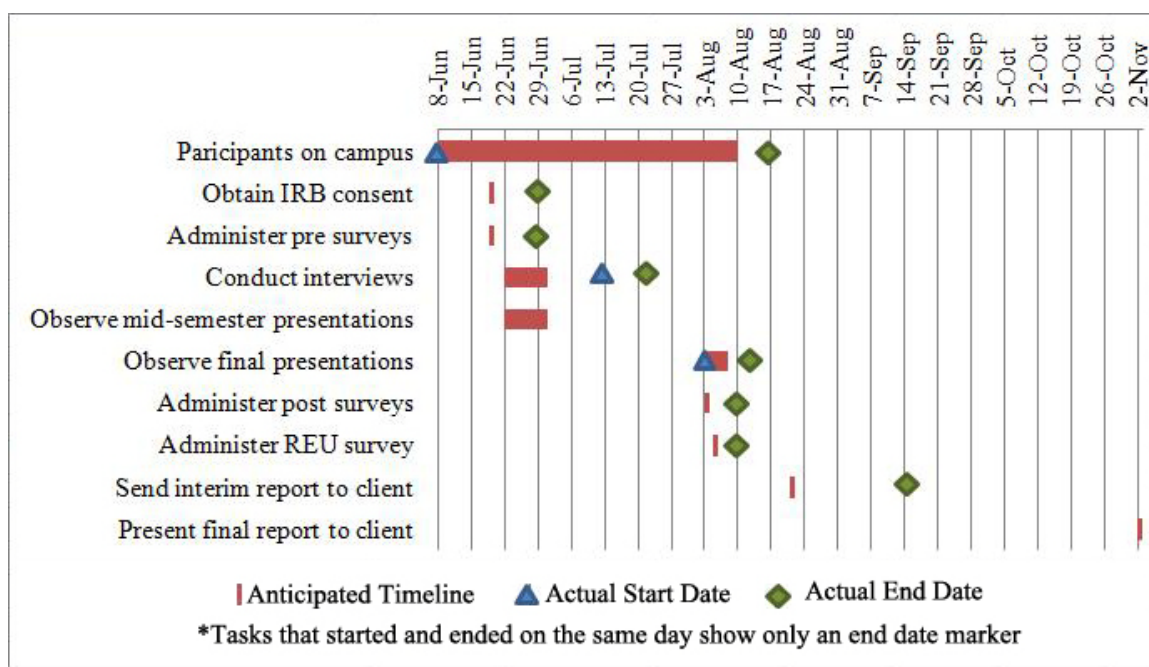


Figure 3. Evaluation Timeline, Anticipated vs. Actual.

The obtaining of IRB consent from the participants and the administration of the initial round of attitudinal surveys (pre surveys) were delayed due to a longer than expected wait for approval. These events took place 10 days after the anticipated date.

It was intended that the interviews be administered midway between the pre and post survey collections to minimize the impact of evaluation needs on the participants. Because of the delay in the administration of the pre surveys, interviews began three weeks later than anticipated, but lasted just as long as planned.

Because of reasons described earlier in the report, the mid-semester presentations were not observed. Observations of final presentations began as planned, but took longer than expected as the participants remained on campus a week longer than originally specified by the REU administration. Presentations occurred at the end of the program.

The final administration of surveys (post surveys) was to be administered at the end of the program. Since the participants were on campus longer than anticipated, the administration of these surveys was delayed. Post surveys were delayed five to seven days.

The interim report was delayed 24 days. This delay was in anticipation of receiving data from faculty mentors so that they could be included in the report. When the evaluator decided the interim report could no longer await these data, it was completed without the data and sent to the client.

The final report has not yet been presented to the client since there are research data being collected in conjunction with this evaluation that does not have any bearing on the evaluation itself. A final report will be written and presented to the client. It is anticipated that the report will be presented in mid-November 2009.

### **Budget**

The cost of this evaluation fell well within the estimated budget (see Table 7). Supplies were close to what was estimated. Paper survey costs were below the estimates because they were printed double sided and were not as long in length as anticipated. The online survey did not cost anything for the use of the software, but costs to create the surveys are reflected in the team member hours. The personnel costs were significantly lower than anticipated. This can be attributed to the efficiency and competency of the team members. Also, much work was done by the evaluator who is not charging for his time.

### **Overall Critique**

The following is a summary of the strengths and weaknesses the evaluator sees in this evaluation.

Table 7

*Evaluation Budget Comparison*

Item	Estimated Cost	Actual Cost
Supplies	\$30	\$23.21
Paper Survey	\$25	\$7.50
Online Surveys	\$300	\$0
Team Member 1	100 hours at \$10/hour = \$1000	13.67 hours at \$11.75/hour = \$160.58
Team Member 2	100 hours at \$10/hour = \$1000	14 hours at \$9:50/hour = \$133
	Total Estimated Cost: \$2355	Total Actual Cost: \$324.29

**Strengths.** Much was done to implement different data collection procedures to better understand the data collected. Overall, the evaluation was as unobtrusive as possible to minimize its effects on the program participants. A competent evaluation team was assembled that met the needs of the evaluation, making it successful.

The Evaluation also ended on the specified budget and provides answers to the critical evaluation questions outlined by the client at the onset of the evaluation.

**Weaknesses.** The evaluation would have been significantly strengthened if two areas had been better addressed, stakeholder interactions and agreements.

Because the evaluator followed the recommendation of the REU site administrator to not have direct contact with the faculty mentors, no data was obtained from this important stakeholder group. It is impossible to know how this group would have responded to requests by the evaluator, but direct access would have allowed insight into this stakeholder's view of the



program, its operation, and observational data as members of the program in closest contact with the participants.

More should have been done to obtain better agreements with the client. Better discussions on the right-to-know group and understanding of how the report would be distributed would have made the evaluation stronger. Signatures should have been sought to ensure that all parties provided the support that was needed and expected.

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## Appendix A

# Consent to be a Research Subject

### **Introduction**

This research study is being conducted by Brian Chantry, an Instructional Psychology and Technology masters student, at Brigham Young University to evaluate the Physics Research Experiences for Undergraduates at Brigham Young University.

### **Procedures**

You will be asked to participate in surveys at the beginning and end of the program as well as two months after. You may also be asked to participate in a brief interview. With your permission, interviews will be taped and transcribed. Surveys will last about 15-20 minutes, interviews may last about 15-30 minutes.

### **Risks/Discomforts**

There are minimal risks for participation in this study. However, you may feel emotional discomfort when answering questions about personal opinions. The interviewer will be sensitive to those who may become uncomfortable.

### **Benefits**

There are no direct benefits to subjects. However, it is hoped that through your participation researchers will learn more about the effectiveness of the Physics REU program at Brigham Young University.

### **Confidentiality**

Unless you request otherwise in writing, all information provided will remain confidential and will only be reported without identifying information. All data, including surveys and tapes/transcriptions from interviews, will be kept in a locked cabinet and only those directly involved with the research will have access to them. After the research is completed, the digital audio recordings will be deleted.

### **Compensation**

There is no compensation for participation.

### **Participation**

Participation in this research study is voluntary. You have the right to withdraw at anytime or refuse to participate entirely without jeopardy to your class status, grade or standing with the university.

**Questions about the Research**

If you have questions regarding this study, you may contact Brian Chantry at 422-5336, [brian\\_chantry@byu.edu](mailto:brian_chantry@byu.edu).

**Questions about your Rights as Research Participants**

If you have questions you do not feel comfortable asking the researcher, you may contact Dr. Christopher Dromey, IRB Chair, 422-6461, 133 TLRB, [dromey@byu.edu](mailto:dromey@byu.edu).

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_



## Appendix B

### Colorado Learning Attitudes about Science Survey (version 3)

1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree

1. A significant problem in learning physics is being able to memorize all the information I need to know.
2. When I am solving a physics problem, I try to decide what would be a reasonable value for the answer.
3. I think about the physics I experience in everyday life.
4. It is useful for me to do lots and lots of problems when learning physics.
5. After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.
6. Knowledge in physics consists of many disconnected topics.
7. As physicists learn more, most physics ideas we use today are likely to be proven wrong.
8. When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values.
9. I find that reading the text in detail is a good way for me to learn physics.
10. There is usually only one correct approach to solving a physics problem.
11. I am not satisfied until I understand why something works the way it does.
12. I cannot learn physics if the teacher does not explain things well in class.
13. I do not expect physics equations to help my understanding of the ideas; they are just for doing calculations.
14. I study physics to learn knowledge that will be useful in my life outside of school.

15. If I get stuck on a physics problem on my first try, I usually try to figure out a different way that works.
16. Nearly everyone is capable of understanding physics if they work at it.
17. Understanding physics basically means being able to recall something you've read or been shown.
18. There could be two different correct values to a physics problem if I use two different approaches.
19. To understand physics I discuss it with friends and other students.
20. I do not spend more than five minutes stuck on a physics problem before giving up or seeking help from someone else.
21. If I don't remember a particular equation needed to solve a problem on an exam, there's nothing much I can do (legally!) to come up with it.
22. If I want to apply a method used for solving one physics problem to another problem, the problems must involve very similar situations.
23. In doing a physics problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem.
24. In physics, it is important for me to make sense out of formulas before I can use them correctly.
25. I enjoy solving physics problems.
26. In physics, mathematical formulas express meaningful relationships among measurable quantities.
27. It is important for the government to approve new scientific ideas before they can be widely accepted.

28. Learning physics changes my ideas about how the world works.
29. To learn physics, I only need to memorize solutions to sample problems.
30. Reasoning skills used to understand physics can be helpful to me in my everyday life.
31. We use this question to discard the survey of people who are not reading the statements.  
Please select agree—option 4 (not strongly agree) to preserve your answers.
32. Spending a lot of time understanding where formulas come from is a waste of time.
33. I find carefully analyzing only a few problems in detail is a good way for me to learn physics.
34. I can usually figure out a way to solve physics problems.
35. The subject of physics has little relation to what I experience in the real world.
36. There are times I solve a physics problem more than one way to help my understanding.
37. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.
38. It is possible to explain physics ideas without mathematical formulas.
39. When I solve a physics problem, I explicitly think about which physics ideas apply to the problem.
40. If I get stuck on a physics problem, there is no chance I'll figure it out on my own.
41. It is possible for physicists to carefully perform the same experiment and get two very different results that are both correct.
42. When studying physics, I relate the important information to what I already know rather than just memorizing it the way it is presented.

Categories Statements comprising category:

Real World Connection 28, 30, 35, 37

Personal Interest 3, 11, 14, 25, 28, 30

Sense Making/Effort 11, 23, 24, 32, 36, 39, 42

Conceptual Connections 1, 5, 6, 13, 21, 32

Applied Conceptual Understanding 1, 5, 6, 8, 21, 22, 40

Problem Solving General 13, 15, 16, 25, 26, 34, 40, 42

Problem Solving Confidence 15, 16, 34, 40

Problem Solving Sophistication 5, 21, 22, 25, 34, 40

Not Scored 4, 7, 9, 31, 33, 41 (Adams et al., 2006).

## Appendix C

### Attitudes and Factors Affecting Research Utilization

How I feel about physics\* research

(please circle the appropriate number)

Comfortable	1 2 3 4 5 6 7 8 9 10	Uncomfortable
Cold	1 2 3 4 5 6 7 8 9 10	Warm
Interested	1 2 3 4 5 6 7 8 9 10	Bored
Afraid	1 2 3 4 5 6 7 8 9 10	Confident
Good	1 2 3 4 5 6 7 8 9 10	Bad
Tired	1 2 3 4 5 6 7 8 9 10	Invigorated
Pleasant	1 2 3 4 5 6 7 8 9 10	Unpleasant
Disinterested	1 2 3 4 5 6 7 8 9 10	Curious
Adequate	1 2 3 4 5 6 7 8 9 10	Inadequate
Turned off	1 2 3 4 5 6 7 8 9 10	Inspired

\*the word “physics” was substituted here in place of the original word “Nursing” (Olade, 2003).

## Appendix D

### REU Survey

1. How helpful were the mini-classes in developing new skills important for your research this summer and the future? Which min-classes were the most useful?
2. What suggestions do you have to strengthen the mini-classes? Are there any mini-classes that you wish we would offer?
3. How do you feel about the mentor relationship that you developed with your faculty advisor while participating in the program? Please consider learning about Physics, career opportunities and expectations, and making decisions about graduate school.
4. Are you planning on going to graduate school?
5. Did the REU experience influence your decision to undertake graduate study in physics or a related field? How?
6. How interested are you in physics (or a related field) as a career?
  - a. Very interested
  - b. Somewhat interested
  - c. Considering it
  - d. Not very interested
  - e. I never want anything to do with Physics again
7. How did your participation in the REU program influence your attitude about your answer to question six?
8. How confident are you about your ability to be successful in a career in Physics?
  - a. Very Confident

- b. Somewhat confident
  - c. Uncertain
  - d. Not very confident
  - e. Definitely not confident
9. Are you glad that you picked BYU for your REU experience? Why or why not?
  10. What aspect of your REU experience were most beneficial to you this summer?
  11. What opportunities do you wish you would have had this summer that weren't offered?
  12. How and in what ways did your BYU REU experience meet your expectations you had in coming here?
  13. If you had to pick the best thing about the whole program what would it be?
  14. If you had to pick one thing you would want to change about the program what would it be?
  15. Other comments about your experience at BYU this summer.

## Appendix E

### Guiding Questions for Participant Interview

1. What are your feelings towards the field of physics?
  - a. Share an experience that helped you become interested in the field of physics.
  - b. Who else do you know in the field of physics, and how did they influence your current feelings towards physics?
  - c. How does working in the field of physics make you feel?
2. What are your feelings towards research, as you have been experiencing it, in the field of physics?
  - a. Tell me about your research experiences in physics.
  - b. Do you enjoy conducting physics research? Why or why not?
  - c. What aspects of research do you like most / least?
3. What are your feelings towards graduate school?
  - a. Tell me what you expect graduate school to be like.
  - b. How would you see yourself fitting into graduate school?