University of Twente
Enschede - The Netherlands

SURFing toward a doctoral degree

Master thesis for the Communication Studies program, University of Twente, Enschede, The Netherlands

25 September 2007

A.M. Kamphuis, B.Sc.

Graduation committee:

Drs. J.J. van Hoof
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Abstract

The efficacy of the SURF NIST Boulder program is investigated by means of a questionnaire based on the Theory of planned behavior. The target group for this investigation consists of the students that have participated in the SURF NIST Boulder program in 2004, 2005 and 2006. The results of this investigation show that the SURF NIST Boulder program has a medium positive effect on students' perceived behavioral control regarding the pursuit of a doctoral program; as well as on their social norm, which has a medium positive effect on students' attitude toward pursuing a doctoral program. Because of the causal relation between this particular perceived behavioral control and attitude and intention; and the causal relation between intention and behavior, the SURF NIST Boulder program exerts a positive influence on students' future behavior. The results of this investigation should – because of the very limited number of respondents – be interpreted as an indication of facts and not as settled facts. Generalizations to more general populations of students are difficult to make due to the number and composition of respondents. Additional and periodically repeated research is recommended to improve both the validity and reliability of the results of this investigation.

Summary

Motivation

The SURF NIST Boulder program has been established to address the nation's worsening shortage of career researchers through its outreach activities aimed at recruitment of outstanding students that are either underrepresented in science or engineering or from regional colleges that may have limited research opportunities for undergraduates (Magee, 2005; and Magee, 2006). This investigation will provide information that will enable program administrators to adapt the program to better meet its objectives.

Research questions

The main research question for this investigation is:

To what extent is the SURF NIST Boulder program effective in reaching its principal goal, namely motivating students to pursue doctoral programs in preparation for careers in research and development?

This research question will be answered by use of the following sub questions:

1. *What are the underlying determinants for the choice whether or not to pursue a doctoral program?*
2. *Is the SURF NIST Boulder program of influence on one or more of the determinants for choosing to pursue a doctoral program?*
3. *Is there a connection between the choice that is made regarding pursuing a doctoral program and demographic variables like gender, student ability, and socio-economic status?*

Research design

The target group for this investigation consists of the students that have participated in the SURF NIST Boulder program in 2004, 2005 and 2006. All former students have been invited to participate in this investigation. This investigation has been conducted by means of a questionnaire that was distributed among the respondents. The questionnaire used consists of multiple summated rating scales and has been developed based on the Theory of planned behavior. The questionnaire included questions asking about students' subjective norm, attitude, perceived behavioral control, intention, and behavior regarding the pursuit of a doctoral program.

Results

The data analysis shows that there is a positive causal relation between respondents' attitude toward pursuing a doctoral program and their perceived behavioral control toward the pursuit of a doctoral program, and their intention to pursue a doctoral program. The data analysis also shows that there is a positive causal relation between respondents' intention and their behavior.

Conclusions and recommendations

The SURF NIST Boulder program has a medium positive effect on students' perceived behavioral control regarding the pursuit of a doctoral program; as well as on their subjective norm, which has a medium positive effect on students' attitude toward pursuing a doctoral program. Because of the causal relation between this particular perceived behavioral control and attitude and intention; and the causal relation between intention and behavior, the SURF NIST Boulder program exerts a positive influence on students' future behavior.

It is recommended to make use of the contacts between SURF their coworkers; and to add a seminar to the summer seminar series; to influence students' perceived behavioral control regarding the pursuit of a doctoral program, as well as their attitude toward the pursuit of a doctoral program and their perceived behavioral control regarding the requirements for pursuing a doctoral program. The forming of new friendships and peer networks among SURF students can be encouraged by developing an online meeting place. This will enable students to initiate contacts before the program starts, and to maintain contacts after the program has ended. The SURF mentors should be well advised about supervising the SURF students to ensure an experience in the SURF NIST Boulder program that is as positive as possible; thus influencing students' attitudes toward a career in science.

It is also recommended to ask SURF NIST Boulder alumni to act as "ambassadors" for the program. Looking at which students to admit to the program, and giving priority to "disadvantaged" applicants should be considered for an optimal effect on the population of students in exact sciences because of the limited number of available fellowships. It is recommended to continue the program into the future, so that future students can also benefit from participating.

Discussion and reflection

The choice for the Theory of planned behavior as the theoretical framework, and the choice for a questionnaire as the medium, was suitable for the research that was performed in this investigation. The most serious concern regards the number of respondents that were available for this investigation. The results of this investigation should – because of the very limited number of respondents – be interpreted as an indication of facts and not as settled facts.

Generalizations to more general populations of students are difficult to make due to the number and composition of respondents. The construct validity of the questionnaire used in this investigation meets the expectations. Because it was only possible to administer the questionnaire once it is not possible to assess the reliability as would be possible by repeated use of the survey.

Additional and periodically repeated research is recommended to improve both the validity and reliability of the results of this investigation.

Contents

1. Introduction

This thesis describes the research project that has been performed at the National Institute of Standards and Technology in Boulder, Colorado from July 2006 through August 2007, with the goal to gain insight into impacts upon students that participated in the Summer Undergraduate Research Fellowship program.

1.1 Motivation

The National Institute of Standards and Technology (or NIST) in Boulder hosts a Summer Undergraduate Research Fellowship program which is also known as SURF NIST Boulder.

The SURF NIST Boulder program is sponsored by the National Science Foundation since 2006. In the grant proposal is stated that "for long-term feedback, the [SURF NIST Boulder] Directors will implement a formal program of tracking student alumni after they leave the SURF program. A questionnaire to poll SURF alumni will be developed and responses will be collected annually" (Magee, 2005).

Developing and implementing this questionnaire is aimed at gaining insight into the long-term outcomes of the SURF program concerning alumni's education, profession, and other related impacts.

1.2 Research context

During the last years there have been serious concerns about the decreasing number of students who go on to pursue a career in science, especially among women and minorities. This phenomenon is known as the so-called "swing from science" (Osborne, Simon & Collins, 2003). The reason for concerns about this swing from science is that scientists are needed in today's society for maintaining a nation's achievements and competitiveness in science and technology as well as for maintaining economic prosperity (Dick & Rallis, 1991; Etkina, Matilsky & Lawrence, 2003; Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Summers & Hrabowski, 2006; Ware & Lee, 1998; Wieman & Perkins, 2005; Woolnough & Guo, 1997).

The SURF NIST Boulder program has been established to "address the nation's worsening shortage of career researchers through its outreach activities aimed at recruitment of outstanding students that are either underrepresented in science or engineering or from regional colleges that may have limited research opportunities for undergraduates" (Magee, 2005; Magee, 2006). This investigation will provide information that will enable program administrators to adapt the program to better meet its objectives.

1.3 Definition of research problem and research questions

The purpose of this investigation is to research whether or not the SURF program plays a role in students' decision-making process regarding the pursuit of a doctoral program. The main research question for this investigation will therefore be:

To what extent is the SURF NIST Boulder program effective in reaching its principal goal, namely motivating students to pursue doctoral programs in preparation for careers in research and development?

This research question will be answered by use of the following sub questions:

1. *What are the underlying determinants for the choice whether or not to pursue a doctoral program?*
2. *Is the SURF NIST Boulder program of influence on one or more of the determinants for choosing to pursue a doctoral program?*
3. *Is there a connection between the choice that is made regarding pursuing a doctoral program and demographic variables like gender, student ability, and socio-economic status?*

The following expectations for the outcomes of this investigation have been formulated based on the literature that is discussed in Chapter 2:

- Expectation 1: A) It is expected that the underlying determinants for the choice whether or not to pursue a doctoral program are a student's attitude, subjective norm, perceived behavioral control and intention (Ajzen, 1991; Ajzen, 2006; Armitage & Conner, 2001).
  B) More specifically, it is expected that attitude is the most important determinant for deciding to pursue a doctoral program, although the importance of each determinant varies for each student making this decision (Freedman, 1997; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Mares, 2005; Ware & Lee, 1998; Weinburgh, 1995; Wieman & Perkins, 2005).

- Expectation 2: A) It is expected that the SURF NIST Boulder program will influence one or more of the determinants for choosing to pursue a doctoral program (Stake & Mares, 2001).
  B) More specifically, it is expected that participating in the SURF NIST Boulder program will increase students' motivation and confidence, which are part of the factor perceived behavioral control (Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005).
  It is further expected that participating in the SURF NIST Boulder program will help students develop a more realistic view of how it would be to have a career in science. A more realistic view would influence students' perceived behavioral control (Chu, 2004; Osborne, Simon & Collins, 2003; Plucker

& Gorman, 1999; Richmond & Kurth, 1999; Stake & Mares, 2001).
It is also expected that participating in the SURF NIST Boulder program will increase students' social support through new friendships, which will change the subjective norm toward a more positive take on pursuing a doctoral degree (Stake & Mares, 2001; Stake & Nickens, 2005).

- Expectation 3: A) It is expected that there is a connection between demographic variables and the choice that is made regarding the pursuit of a doctoral program (Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Ware & Lee, 1998; Weinburgh, 1995; Werts, 1967; Woolnough, 1994; Woolnough & Guo, 1997).
  B) More specifically, it is expected that there will be a connection between gender and pursuing a doctoral program, with boys pursuing or planning to pursue these programs more often than girls (Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Woolnough, 1994).
  It is further expected that there will be a connection between socio-economic class and pursuing a doctoral program, with students from a higher socio-economic class pursuing or planning to pursue these program more often than students from a lower socio-economic class (Hodkinson & Sparkes, 1997; Stake & Mares, 2001; Ware & Lee, 1998; Woolnough, 1994; Woolnough & Guo, 1997).
  It is also expected that there will be a connection between students' aptitude and pursuing a doctoral program, with high-ability students pursuing or planning to pursue these programs more often than lower-ability students (Hodkinson & Sparkes, 1997; Werts, 1967; Woolnough, 1994; Woolnough & Guo, 1997).

1.4 Research objective

Researching the long-term outcomes of the SURF program is of importance to the program, because it makes it possible to adapt the SURF program to better meet its principal goal of the program, namely "to motivate students to pursue doctoral programs in preparation for careers in research and development" (Magee, 2005).

It is unknown if the SURF program plays a role in students' decision-making regarding the pursuit of a doctoral program. It is therefore that the determinants of deciding whether or not to pursue such a program are investigated.

1.5 Thesis preview

This thesis consists of the following chapters:

Chapter ***1*** gives an introduction, including a research motivation, the research context and the research questions. Chapter ***2*** outlines the theoretical framework used to develop the questionnaire and for interpreting the results of the data analysis. Chapter ***3*** describes the research design and chapter ***4*** contains the results of the data analysis. Chapter ***5*** gives conclusions and recommendations and chapter ***6*** concludes with a discussion and reflection regarding this research project.

2 Theoretical framework

The theoretical framework for researching the questions posed in Chapter 1 is discussed in this chapter. Relevant theories and models are discussed, as well as literature describing previous research and literature on the subject of science enrichment programs, and research experience programs for undergraduate students.

2.1 Introduction

Multiple theories explain and predict human behavior. Theories often used to predict a wide range of behaviors are the Theory of reasoned action and the Theory of planned behavior. Both say that human behavior, such as the choice to pursue a doctoral degree in preparation for a career in science, can be predicted and explained on the basis of a limited number of determinants. Lesser-known approaches involve reasons theory and expectancy-value theory, both of which take a different approach to predicting and explaining human behavior. These theories are explained in section 2.2.

2.2 Behavioral theories and models

2.2.1 Theories of Reasoned Action and Planned Behavior

The Theory of reasoned action states that a person's behavior can be derived from his or her intention to perform this particular behavior, as illustrated in Figure 2.1. The intention can be derived from a person's subjective norm and attitude toward the behavior.

Subjective norm refers to perceived social pressure from important others to perform or not perform the behavior in question, attitude refers to a person's favorable or unfavorable evaluation of a certain behavior (Ajzen, 1991). Intention indicates a person's readiness to perform a behavior (Ajzen, 2006); it is an expression of all the motivational factors that influence the performance of a certain behavior. Intentions indicate how much effort a person is willing to put into performing a behavior (Armitage & Conner, 2001). The stronger this intention, the more likely it is that the specific behavior will be performed (Ajzen, 1991).

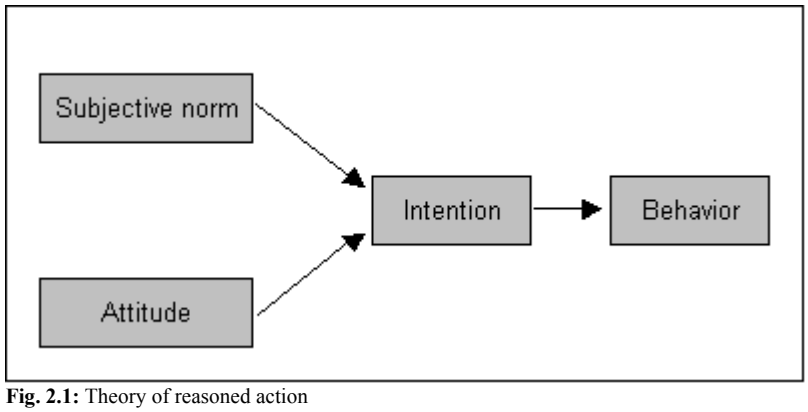

Fig. 2.1: Theory of reasoned action

The Theory of planned behavior, which is illustrated in Figure 2.2, is an expansion of the Theory of reasoned action (Armitage & Conner, 2001). This theory not only uses subjective norm and attitude to predict a person's intention to perform a certain behavior, but also includes perceived behavioral control to predict this intention (Ajzen, 1991). Perceived behavioral control has been added to the Theory of reasoned action to allow the theory to predict behaviors that are not completely under a person's control as is assumed by the Theory of reasoned action (Armitage & Conner, 2001).

Perceived behavioral control refers to the perceived ease or difficulty of performing a certain behavior and can vary across situations and behaviors. It is assumed that it also reflects anticipated hindrances that could affect the performance of a certain behavior (Ajzen, 1991), and that it moderates the effect of intention on behavior (Ajzen, 2006). Perceived behavioral control thus influences behavior both indirectly (through its contribution to the forming of intentions) and directly (Ajzen, 1991; Armitage & Conner, 2001). This is because the decision to convert intention to behavior is partly influenced by a person's belief that the behavior can be performed successfully. Individuals are more likely to (try to) perform behaviors that they believe can be performed successfully (Armitage & Conner, 2001).

The three components together can predict a person's intention to perform a certain behavior with high accuracy (Ajzen, 1991). The contribution of the factors to an intention can vary across situations and populations (Ajzen & Fishbein, 2004; Armitage & Conner, 2001). For example: attitude and perceived behavioral control will be less important for forming an intention in cases where the social pressure is high.

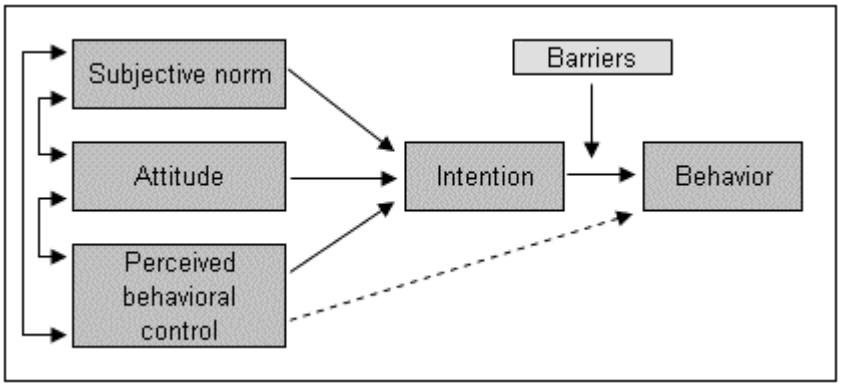

Fig. 2.2: Theory of planned behavior

Perceived behavioral control can, in combination with a person's intention, be used to predict this person's behavioral achievement (Ajzen, 1991; Armitage & Conner, 2001). Whether or not to perform a certain behavior is partly dependent on personal and environmental barriers that are not under a person's influence (Armitage & Conner, 2001). The effort that is put in to perform a behavior successfully is likely to increase when the intention remains the same and perceived behavioral control increases. A person's perceived behavioral control can be used as a replacement for the estimate of the actual control, which refers to a person's actual ability to perform a behavior. Actual behavioral control can be a good predictor of a successfully performed behavior. It is important however, that the intention and the perceived behavioral control are compatible with the behavior that is to be predicted. Another condition for an accurate prediction is that the intention and the perceived behavioral

control must remain the same over the period that elapses between the measuring of the components and the performance of the behavior.

Central component: intention

The central component in both theories is a person's intention to perform a certain behavior. It is important to note that a behavioral intention can only be translated into a performance of the behavior if the individual is able to decide whether or not to perform the behavior. This is because performance of a behavior depends partly on non-motivational factors like availability of resources and opportunities. A person should succeed in performing a behavior when he or she has both the intention to perform a behavior as well as the opportunities and resources, or complete control over the performance of a certain behavior. The component perceived behavioral control becomes more useful when the amount of control over a behavior diminishes. Behaviors can be predicted from intention only when there are no control problems in performing a certain behavior.

Expectancy-value model

The Theory of planned behavior presumes that subjective norm, attitude, and perceived behavioral control are determined by a person's beliefs that are relevant to the behavior, as seen in Figure 2.3. Normative beliefs thus influence the subjective norm; behavioral beliefs influence attitude; and control beliefs influence a person's perceived behavioral control.

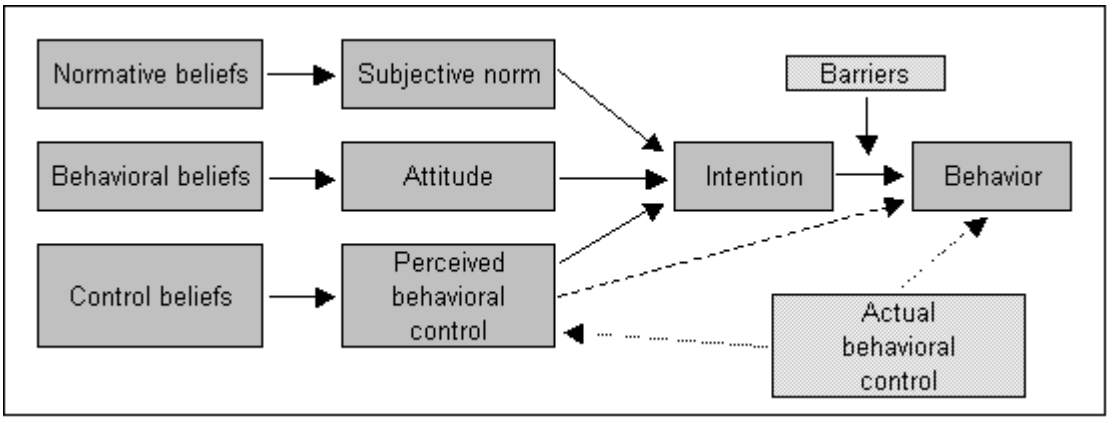

Fig. 2.3: Theory of planned behavior

The expectancy-value model describes how attitudes are developed (Ajzen, 1991). Subjective norms and perceived behavioral control follow a similar process of development (Armitage & Conner, 2001).

Attitudes are a person's evaluation of a certain behavior (Ajzen, 1991; Armitage & Conner, 2001). The expectancy-value model states that attitudes are developed from behavioral beliefs that individuals hold about a certain object. Each belief links a certain outcome or other attribute, like a consequence or a value, to a certain behavior. Each of the attributes is positively or negatively valued. All attributes that are linked to an object together constitute a person's attitude toward an object. The values associated with the attributes influence the attitude proportionally to the strength of the belief (Ajzen, 2006; Armitage & Conner, 2001).

The subjective norm is the socially expected behavior, and is made up of normative beliefs. These beliefs refer of the likelihood that important others (like

family members and friends) will approve or disapprove of performing a certain behavior. The subjective norm consists of each of these beliefs multiplied by a person's motivation to comply with these beliefs (Ajzen, 1991; Ajzen, 2006; Armitage & Conner, 2001).

Perceived behavioral control is a person's estimate of his or her ability to perform a certain behavior. The perceived behavioral control factor is made up of control beliefs that deal with the perceived power of factors that can facilitate or inhibit the performance of a behavior, like the availability of resources and opportunities. These beliefs can be partly based on past experience, but are usually based on second-hand information about the behavior. Perceived behavioral control over a certain behavior grows when more resources and opportunities are available. The strength of each control belief depends on the power of the control factor the enable or inhibit performing a certain behavior (Ajzen, 2006).

2.2.2 Reasons theory

An approach similar to, but not as elaborated as, the Theory of planned behavior for predicting behavior is Reasons theory. This theory uses three concepts to understand behavior: a person's behavioral frequency-intention (indicating how often an individual is intending to perform a certain behavior), a person's reasons to perform a certain behavior, and a person's reasons not to perform a certain behavior. Reasons theory is based on the assumption that behavior can better be predicted if reasons are formally conditioned (Westaby, Fishbein & Aherin, 1997).

Reasons theory is based on three assumptions: the nonperformance postulate, the combination postulate and the performance postulate. The nonperformance postulate states that only reasons for not performing a behavior are activated when a person does not or will not perform a certain behavior. The combination postulate states that both reasons for and reasons against performing a behavior are activated when a person sometimes does (or will) and sometimes does not (or will not) perform a certain behavior. The performance postulate states that only reasons for performing a behavior are activated when a person does or will perform a certain behavior (Westaby, Fishbein & Aherin, 1997).

The reasons that are spoken of in this theory are the same beliefs that are used in the Theory of planned behavior, namely behavioral beliefs that refer to advantages and disadvantages; normative beliefs that refer to the opinions of important others; and control beliefs that refer to possible obstacles or barriers (Westaby, Fishbein & Aherin, 1997).

2.2.3 Expectancy-value theory

Expectancy-value theory, which is illustrated in Figure 2.4, describes the manner in which people make behavioral decisions based on their expectancies of the outcome of a certain behavior and the value they attribute to the outcomes of the specific behaviors (Borders, Earleywine & Huey, 2004). These are the most important determinants of choice (Eccles & Wigfield, 2002). A person's choice for a certain behavior can be explained by beliefs about how well he or she will do (ability beliefs thus form an expectancy of success (Eccles & Wigfield, 2002)) and by the extent to which the behavior is valued (Wigfield & Eccles, 2000). Expectancies refer to beliefs about one's competences (Eccles & Wigfield, 2002) and to the fact that performance is dependent on effort (Shepperd & Taylor, 1999); values refer to reasons for performing a certain behavior (Eccles & Wigfield, 2002) and to the perceived

importance of achieving a certain outcome (Shepperd & Taylor, 1999). Expectancy-value models link achievement performance, persistence, and behavioral choice directly to expectancies for success and beliefs about the value of a certain behavior. Positive and negative features of a behavior influence choices. All choices are associated with costs, because choosing one behavior often eliminates other options (Eccles & Wigfield, 2002).

Ability beliefs refer to a person's perception of his or her competence at a certain behavior (Wigfield & Eccles, 2000). The valuing of a behavior consists of four types of values. Attainment value refers to the importance of doing well when performing a certain behavior. The intrinsic value refers to the fact that performing a certain behavior can be gratifying for a person. Utility value refers to the usefulness of performing a certain behavior. Cost finally, refers to how much effort performing a certain behavior will require, to negative features of a task, and to limited access to alternative behaviors (DeBacker & Nelson, 1999; Eccles & Wigfield, 2002; Shepperd & Taylor, 1999; Wigfield & Eccles, 2000). Goals are seen as a distal influence on behavior through values and expectancies (DeBacker & Nelson, 1999).

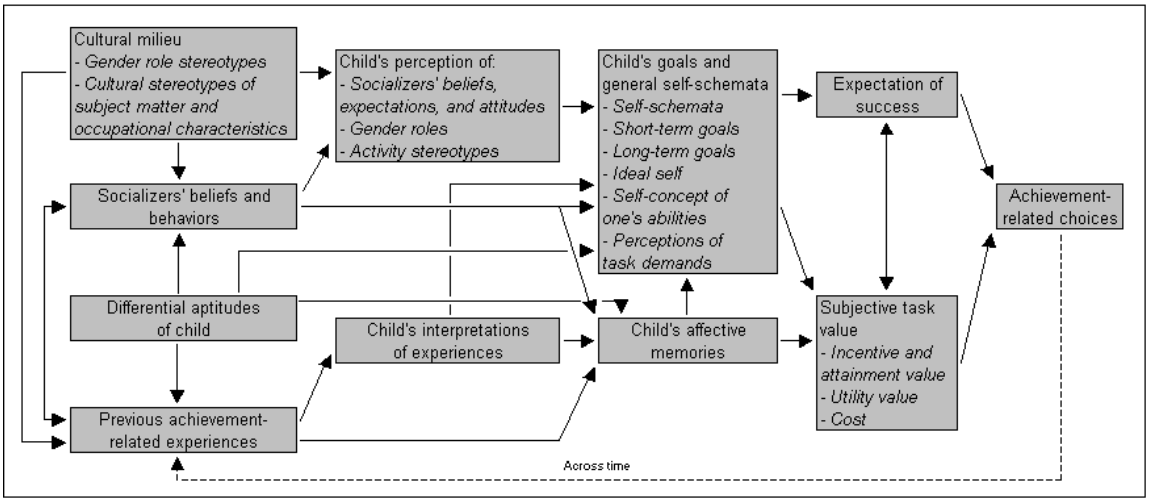

Fig. 2.4: Expectancy-value theory (Eccles & Wigfield, 2002)

2.3 Choice of theoretical framework

The choice for a scientific career depends on several determinants, and could be explained using several different theoretical frameworks. This study is based on the Theory of planned behavior, for the following reasons.

The Theory of planned behavior provides the most solid theoretical framework of the above-discussed theories. This theory has been used to predict a wide variety of behaviors and has been proved in many studies (Ajzen, 1991; Ajzen & Fishbein, 2004; Armitage & Conner, 2001). The theory is relatively simple, with a limited number of variables. This smaller number of variables however, does include all determinants that are thought of as being important in decision-making processes. The limited number of variables is an advantage over the Expectancy-value theory because of the small number of respondents available for this study.

Reasons theory and Expectancy-value theory, on the other hand, are more problematic to use. Reasons theory is too simplistic to predict the complicated

decision to pursue a doctorate degree. There will be more determinants that exert influence on such a decision than just reasons for and reasons against it.

In contrast to this, the Expectancy-value theory is too complicated for this investigation. The definitions of the various variables differ between publications (Borders, Earleywine & Huey, 2004; DeBacker & Nelson, 1999; Eccles & Wigfield, 2002; Shepperd & Taylor, 1999 and Wigfield & Eccles, 2000), the theory is often adapted to fit investigations, and relations between variables are not clear (DeBacker & Nelson; Eccles & Wigfield, 2002). Another problem is caused by how the Expectancy-value theory has been tested. Although the theory speaks of choices between multiple alternative behaviors, practically all the research has been focused on a single behavioral choice to be made by grade school students.

Finally, a lot of the variables and reasoning of Reasons theory and the Expectancy-value theory are present in the Theory of planned behavior. This makes the Theory of planned behavior the most suitable theoretical framework for this investigation.

The reason for describing these two theories is that they explain behavior in a way that is different from the Theory of planned behavior. Reasons theory gives a very simple account of how people make decisions, which can clarify the somewhat more complicated approach of the Theory of planned behavior. The Expectancy-value theory on the other hand, shows a more complicated picture that gives more credit to the complicated process that the making of a decision really is.

2.4 Theoretical approach of this investigation

An overview of the literature on the subject of behavioral choices of students who participated in summer programs is given in this paragraph. A description of successful (summer research) programs for college students is also included. The overview starts with a literature review concerning the components of the Theory of planned behavior, namely attitude, subjective norm, perceived behavioral control and intention. Literature on demographics and research experience programs, as well as descriptions of successful programs forms the second half of this paragraph.

2.4.1 Justification of discussed literature

A lot of research has been done to further the understanding of the behavioral choices made by students regarding their education. Unfortunately, most of the research done in this field, and described in this overview, focuses on whether or not grade school students will choose science courses like physics, mathematics, biology and general science classes. The science enrichment programs that have been the subject of research are mostly of a general nature.

Although it is clear that grade school students and college students are not in the same target group, the literature that is presented below can still indicate an explanation for the behavioral choices made by college students regarding their continued education (that is, their choice of whether or not to pursue a doctoral degree in science). This is because the behavioral model for predicting behavior in both grade school students and college students focuses on the impact of attitude toward a subject on the choice for a certain behavior.

A distinction between literature that focuses on high school students and literature that focuses on college students has not been made. This is because there is no literature that applies only to high school students that is not in accordance with literature that focuses on college students. This is also true for the literature that applies to college students.

2.4.2 Subjective norm

Social support is a determinant of a person's choice to perform a certain behavior. There are several groups that can be distinguished as being important factors of social support, namely parents and family, friends, and teachers, mentors, and counselors.

The effect of important others on students' behavior should not be underestimated because it can be very influential (Dick & Rallis, 1991). Interaction with significant others has an effect on career decisions (Hodkinson & Sparkes, 1997). Science-related encouragement from family, friends, and teachers has been strongly related to science confidence and motivation among high school science students. Social encouragement is important for the development and maintenance of positive attitudes toward science (Stake & Mares, 2005). Environmental factors such as family, culture, and community, have been found to influence the career decisions of some ethnic minorities in the United States (Hodkinson & Sparkes, 1997; Singaravelu, White & Bringaze, 2005). The availability of a strong support person has a positive influence on Asian-American students (Singaravelu, White & Bringaze, 2005).

Parents and family

Positive family attitudes toward science and toward careers in science exert influence on students' career decisions (Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Singaravelu, White & Bringaze, 2005; Stake & Mares, 2001; Stake & Mares, 2005). Parents are perceived to be an influence on career choice more often for students (both boys and girls) choosing careers in engineering and science, than for those not choosing such careers (Dick & Rallis, 1991). Girls that chose science careers indicated that they were drawn to them because of strong affective experiences with a loved one, such as a parent or grandparent (Jones, Howes & Rua, 2000).

Fathers play the most significant role in the students' level of career certainty, compared to that of other family members (Singaravelu, White & Bringaze, 2005). There is a relation between social support from the father and a student's participation in extra-curricular activities (Osborne, Simon & Collins, 2003). Social support from a students' family is also positively related to a change in students' motivation, confidence, science knowledge, and new friendships after participating in a science enrichment program (Stake & Mares, 2001). There is also a strong influence of family on a student's attitude toward science (Stake & Mares, 2001 and Stake & Mares, 2005).

Investigations on minority populations in the United States show parental influence as being a major factor in career decision-making. Family has a significant influence in the degree of career certainty. Parental acceptance or pressure, not necessarily interest, is a major component in career choices. For some, academic excellence brings honor to the family, and failure brings dishonor (Singaravelu, White & Bringaze, 2005).

Domestic American students have a lower family influence compared tot international students. Their career interest precedes familial expectations (Singaravelu, White & Bringaze, 2005).

Friends

Friends are the most important form of social support for mid-adolescents. Having social support from friends is a strong determinant of a person's choice to perform a certain behavior (Osborne, Simon & Collins, 2003 and Stake & Nickens, 2005). Friends also exert influence on a person's achievement attitudes and science attitudes (Stake & Mares, 2005; Stake & Nickens, 2005). Friends are a factor that influences career decisions and the degree of career certainty (Hodkinson & Sparkes, 1997; Singaravelu, White & Bringaze, 2005). Friends who are not supportive of academic success are a factor that keep underrepresented minorities from persisting in science (Summers & Hrabowski, 2006).

In general, boys tend to have more social support from friends for their interest in science than girls (Stake & Mares, 2001; Stake & Nickens, 2005). This difference in social support may contribute to differences in science motivation between boys and girls. Having friends who have a positive attitude toward science and careers in science, causes girls to change their view toward science and careers in science into a more positive one (Stake & Nickens, 2005).

Participating in a science enrichment program can change the difference in social support for girls. They reported to have stronger science peer relationships after participating in a science enrichment program, than the boys that participated in the same program. Social support is of importance for girls, because science is generally viewed as being a male domain and therefore not as supportive for women in science (Stake & Nickens, 2005).

Domestic American students scored a little lower in the influence of friends, compared to Asian and non-Asian international students that are studying in the United States. Asian international students had the highest mean score for the influence of friends (Singaravelu, White & Bringaze, 2005).

Teachers and mentors/counselors

Teachers are more influential than the curriculum they teach. Students need to be inspired by their teachers and be challenged and stimulated by the science they do, if they are going to want to continue with science into higher education and careers (Wieman & Perkins, 2005; Woolnough & Guo, 1997). Personal encouragement given by science teachers encourages students to study science or engineering (Woolnough, 1994), but boys tend to receive more support from their science teachers than girls (Stake & Mares, 2001). Teachers also have a strong influence on students' attitudes toward science (Stake & Mares, 2005), as well as on their involvement in science in general (Stake & Mares, 2001). Teachers influence career decisions, and have a significant influence in the degree of career certainty (Singaravelu, White & Bringaze, 2005). Teachers were perceived to be an influence on career choice more often for students (both boys and girls) choosing careers in engineering and science, than for those not choosing such careers. Teachers may play a particularly important role in influencing the career choice of some of the girls that plan a career in engineering or science (Dick & Rallis, 1991; Ware & Lee, 1998).

It has been shown that teachers' influences are positively related to changes in students' attitudes toward science after participating in a science enrichment program. Students who are encouraged more by their science teachers gained more confidence

during their participation in a science enrichment program. Students with teachers who were positive role models gained more in motivation, confidence and science knowledge (Stake & Mares, 2001).

Asian international and domestic American students placed a higher importance on the role of school counselors in their choice of an academic major and career. Non-Asian international students did not place importance on school counselors. The role of school counselors might not be as important as the role of family and friends in non-Asian international students' career choices (Singaravelu, White & Bringaze, 2005).

2.4.3 Students' attitude toward science

Attitudes toward science are the feelings, beliefs and values students hold about science. A distinction can be made between attitudes toward an object and attitudes toward actions that can be performed toward this object. An attitude toward a certain action is better at predicting this behavior than the attitude toward the object. There is, for example, a difference between students' attitude toward science in general and their attitude toward science in school. The specific attitude toward science in school is better at predicting choices for pursuing a doctoral degree than the attitude toward science in general (Osborne, Simon & Collins, 2003).

The task value of a certain subject or behavior is an important factor in explaining students' attitudes toward science. It consists of interest, importance and utility. Interest as the enjoyment of performing a certain task; importance as how important it is to perform well on a certain task; and utility as how useful a certain task is for reaching a certain goal. A positive attitude toward a certain behavior or activity is a strong determinant of a person's choice to perform the behavior (Osborne, Simon & Collins, 2003). Students who reported a positive attitude toward mathematics (and negative attitudes toward verbal areas) in high school, were more likely than other students to major in a scientific field in college (Ware & Lee, 1998).

An example of the effect of attitude on behavior can be found in the number of students who have studied nuclear and radiochemistry in the 1970s and 1980s (Peterson, 1997; Robertson & Kleppinger, 2005). In the 1970s concerns were expressed concerning the number of students in these fields. A survey done in 1987 showed a sixty percent decrease in radiochemical faculty between 1978 and 1987; it also showed a 57% decrease in nuclear and radiochemical courses offered in doctoral programs.

Two events occurred between the two surveys: the nuclear reactor accidents at Three Mile Island in Pennsylvania (1979) and at Chernobyl in Ukraine (1986). These events, and the public perception of them, played a role in the decreases noted in the number of faculty and graduate students pursuing nuclear and radiochemical research (Peterson, 1997). Negative public perception had led to student reluctance to enter the field (Robertson & Kleppinger, 2005). This can be explained by the fact that the anxiety, often connected with nuclear research, increased in the period that the accidents happened. This had a negative influence on the public's and aspiring students' attitudes towards working in nuclear research. Without a more positive attitude, a lot of students abandoned the possibility of studying nuclear and radiochemistry (Peterson, 1997).

Attitude and achievement

There is a moderate to strong connection between attitude toward science and achievement in science (Freedman, 1997; Stake & Mares, 2001; Wieman & Perkins, 2005; Weinburgh, 1995). A positive attitude toward science is not necessary for achievement in science (Osborne, Simon & Collins, 2003). Achievement tends to increase when attitude becomes more positive, and these changes in achievement cause changes in interest (Freedman, 1997). This connection is stronger for girls than for boys (Weinburgh, 1995). The promotion of positive attitudes toward science is therefore very important (Stake & Mares, 2001). Students who are interested in science and enjoy science, and who are successful in science in school, are likely to have a lasting positive attitude toward science (Freedman, 1997; Osborne, Simon & Collins, 2003). Among junior-high-school students, achievement in science depends more on their attitude toward science than on talent (Stake & Mares, 2005).

Cultural influences on students' attitudes toward science

Different groups hold different opinions about the value of science and the value of careers in science. Students' attitudes can be influenced significantly by cultural factors. It has been shown that ethnic origin has a more significant influence than gender on students' attitudes toward (a career in) science (Osborne, Simon & Collins, 2003). The most positive attitudes toward science are found in European-Americans, while Asian-Americans have the most positive attitude toward a career in science. Asian parents are an important factor in their children's career choices. Asian students make career decisions that are more based on long-term advantages whereas European-American students tend to base their career decisions on their personal enjoyment and ability. These choices tend to be more individualistic and are more aimed at immediate attraction (Osborne, Simon & Collins, 2003). As long as a culture maintains the traditional view of what is appropriate for girls and for boys and communicates the idea that science is more appropriate for boys than for girls, it is likely that students will bring these attitudes and opinions to school (Jones, Howe & Rua, 2000).

2.4.4 Perceived behavioral control

The same information that a person would use for their perceived behavioral control is used to form the concept of the possible self as a scientist. This concept consists of self-images that a person associates with future career goals, based on a person's context, self-knowledge, and direct experience (Hodkinson & Sparkes, 1997; Jones, Howe & Rua, 2000; Richmond & Kurth, 1999; Woolnough, 1994). The possible self as a scientist has been associated with a person's performance and occupational and educational decisions. Gender does not predict a person's view of their possible self as a scientist. Friendships with persons who have a positive attitude toward science on the other hand, do predict a person's view of his or her possible self as a scientist, independent of gender. Students with more "science friendships" have a more positive view of their possible self as a scientist (Stake & Nickens, 2005).

Confidence is highly predictive of students' persistence in science and of their achievement in science (Hodkinson & Sparkes, 1997; Stake & Mares, 2005). Students' estimate of their ability in science was positively correlated with achievement. A positive relationship exists between students' perception of their ability to achieve in science and their achievement in science (Freedman, 1997).

As girls grow up they lose confidence in their academic abilities and lower their career aspirations (Weinburgh, 1995). Girls tend to be less positive than boys in their view of themselves having a career in science (Stake & Nickens, 2005). They believe having a career in science, in combination with having a personal life and/or having a family, is more problematic than do boys (Stake & Mares, 2001; Stake & Nickens, 2005; Ware & Lee, 1998). Young women are more likely than young men to make a career decision in relation to domestic circumstances (Hodkinson & Sparkes, 1997). Women who think that a career in science is incompatible with having a family are less likely to choose a career in science. Men's science and family choices are generally not related (Stake & Nickens, 2005).

Confidence in one's abilities is significantly related to changes in a student's view of his or her possible self, and to an increase in expectations for a successful career in science, after participating in a science enrichment program. It is also positively related to an increase in science motivation, confidence, and knowledge, after participating in a science enrichment program (Stake & Mares, 2001).

Science role models are important for the promotion of interest in science and achievement in science (Stake & Mares, 2001). Girls' less positive attitudes change when they have contact with someone who is involved in science, in that it causes girls to change their view toward science and careers in science into a more positive one. Having contact with somebody involved in science has the same effect on boys as on girls (Stake & Nickens, 2005). Attitude toward science is mainly affective (Freedman, 1997). Affective experiences with people who students love or admire, influences their acceptance of science as a possible career (Jones, Howe & Rua, 2000). Having friends who have a positive attitude toward science and careers in science causes the same change in girls' views and attitudes (Stake & Nickens, 2005).

2.4.5 Intentions and behavior

Students who are most certain about their career are more likely to persist in their educational efforts. Clear career goals, certainty in degree expectation, and selection of a major, have a positive influence on students' persistence in college (Singaravelu, White & Bringaze, 2005).

Career decisions can be forced by external events or actions of other people, although students can be certain about their career goal (Hodkinson & Sparkes, 1997). An example is not being admitted to graduate school, which causes students to re-evaluate their career goals and the way to reach these goals.

2.4.6 Influence of demographic factors

Gender

Gender is one of the factors that have an influence on a person's attitude toward science and perceptions of science as a career (Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Stake & Nickens, 2005; Woolnough, 1994). Of all the variables that may influence attitudes toward science, gender has generally been shown to be significant (Osborne, Simon & Collins, 2003; Stake & Nickens, 2005) and to have a consistent influence (Weinburgh, 1995). The characteristics of gender differences that were measured in 2001 are highly similar to those identified in students of the 1980s (Jones, Howe & Rua, 2000).

Boys have more positive attitudes toward science than girls in all types of science. High-performing girls however, have a more positive attitude than boys (Weinburgh, 1995). Girls' less positive attitudes exist even though they perform as well or better than boys (Jones, Howe & Rua, 2000).

The difference between boys and girls in their attitudes toward science is visible as early as in grade school, with girls having a less positive attitude toward and less motivation for science, than boys (Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Weinburgh, 1995). For both boys and girls there is a strong, positive relationship between attitude toward science and achievement in science. The relationship is stronger for girls than for boys (Weinburgh, 1995). Even those girls who perform well in science classes are more likely than boys to drop out of science at every academic level (Stake & Mares, 2001; Stake & Nickens, 2005). Girls' attitude toward science tends to decline by middle school, and this decline persists through high school. The differences between boys' and girls' attitudes toward science widens as students move from elementary to secondary school (Jones, Howe & Rua, 2000). The interest of different genders in science can be seen as an explanation for segmentation of the labor market, in that no one considers the whole range of possible opportunities in education or careers (Hodkinson & Sparkes, 1997).

It has been argued that the difference in attitudes between boys and girls is caused by the fact that girls have less opportunity to play with or use technological devices and instruments, which leads to a lack of experience and to negative attitudes toward science (Osborne, Simon & Collins, 2003). Boys continue to have more extracurricular activities that are related to physical sciences than girls (Jones, Howe & Rua, 2000; Weinburgh, 1995; Woolnough & Guo, 1997). If females had more frequent and early experiences, then their achievement and interest in the physical sciences may be greater as they continue in their education. Early use of science-related tools and toys influences girls' development of attitude toward science. Playing with gadgets at home has a very strong positive influence on the career choice of future scientists and technologists (Woolnough & Guo, 1997). Girls with positive attitudes toward science attribute their attitudes in part to extracurricular activities (Jones, Howe & Rua, 2000). Involvement in extracurricular activities, such as science competitions, projects, and school-industry links, does much to stimulate the imagination of the students, and thus makes them more inclined toward and/or keeps them motivated for a scientific career (Woolnough & Guo, 1997).

Girls are highly intrinsically motivated, while boys are more often extrinsically motivated[1] (Osborne, Simon & Collins, 2003). In general, hard working students turn out to be more intrinsically motivated than students who do not work as hard (Lens & Decruyenaere, 1991). Extrinsic values, such as money, status and prestige influence career decisions. These values are important for Asian-American's occupational decisions (Singaravelu, White & Bringaze, 2005). Pay was a more important factor in career choice for men in general. Genuine interest was a more important factor for women not choosing careers in engineering or science. These gender differences do not appear among students with extremely strong mathematics and science coursework backgrounds. A student's career goal directly shapes the student's perception of both the intrinsic and extrinsic value of academic tasks. This

[1] Being intrinsically motivated means making career choices based on important values, such as caring for other people. The career choices are thus made for their own sake. Being extrinsically motivated means making career choices based on external characteristics, like job status and salary.

perception of task value has, in turn, an effect on the student's academic choices, performance, and persistence (Dick & Rallis, 1991).

Personality traits
It is not clear whether or not personality traits have influence on or determine a students' career choice (Woolnough, 1994).

Socio-economic class
Patterns of career progression are dependent on, among others, social class (Hodkinson & Sparkes, 1997; Woolnough & Guo, 1997). Students' attitudes toward science and technology, both as subjects and as careers, are affected by their home background (Woolnough, 1994). Both academic ability and socio-economic background are relevant to career choice (Hodkinson & Sparkes, 1997). Most students aiming to continue education in science come from a scientific home background, with one or both of their parents having a scientific degree and working in a science-based industry. High socio-economic status predicted science majoring for men in the 1980s (Ware & Lee, 1998).

Scientists have parents who studied science or engineering more often than average. Students who go on studying science or engineering have been influenced by a scientific home background, both in their attitudes toward science, and their technical hobbies and skills (Woolnough, 1994). Social status (measured by parents' education) is not related to the effects on students of participating in a science enrichment program (Stake & Mares, 2001).

Ethnicity
Career patterns are dependent on, among others, ethnicity (Hodkinson & Sparkes, 1997). Ethnic background plays an indirect, if not a direct, role in science major choice. Specifically, race is negatively associated with grade point average for black and Hispanic boys and girls (Ware & Lee, 1998).

Talent
Talent is a very strong predictor of – but not a guarantee for – achievement in science. Talented students have the most potential for a successful career in science. Intelligence and student motivation are correlated because of reciprocal influence, as are motivation and school results (Stake & Mares, 2001). Academic ability is relevant to career choice (Hodkinson & Sparkes, 1997; Werts, 1967). Patterns of career progression are dependent on, among others, academic achievement (Hodkinson & Sparkes, 1997). Students who are studying science generally have higher ability than students who are studying a subject that is not science related (Werts, 1967; Woolnough, 1994; Woolnough & Guo, 1997).

Talent is not related to a change in motivation, confidence, science knowledge and friendships after participating in a science enrichment program (Stake & Mares, 2001).

2.4.7 Influence of school-related factors

Curriculum
It is unclear whether or not the curriculum has any influence on students' attitudes toward science. What can be said is that a science curriculum that matches with

students' interests and experiences brings about a more positive attitude toward school science (Osborne, Simon & Collins, 2003).

Perceived difficulty of science
Students' perception that science is a difficult subject is a determinant of subject choice (Woolnough & Guo, 1997). It is the major reason for students not to take science in school. The difficulty of the subject and the amount of work involved is by some students seen as a positive aspect. Future physicists and chemists find the subject easy (Woolnough, 1994). Boys indicated that science was easy rather than difficult to learn, whereas girls were less positive about the ease of learning of science (Jones, Howe & Rua, 2000).

Classroom environment
School and classroom variables are a strong influence on students' attitudes toward science. Variety is a key factor in creating interest in a science education. Students with a positive attitude toward science have a high level of involvement, a very high level of personal support, and strong positive relationships with their classmates (Osborne, Simon & Collins, 2003).

The quality of teaching of school science is also an important determinant of a student's attitude toward school science. The most common reasons for liking or disliking a subject are teacher-related. The most important variable affecting students' attitudes was the kind of science teaching they experienced (Osborne, Simon & Collins, 2003; Wieman & Perkins, 2005). Instruction that makes science more exciting and that encourages students has a positive influence on students' attitude toward science and their achievement in science (Freedman, 1997; Robertson & Kleppinger, 2005; Wieman & Perkins, 2005). The nature of science instruction strongly affects students' attitude toward science, which is a strong predictor of achievement in science, science learning, and the amount of science a student will choose to experience. Instruction that promotes a positive attitude toward science will improve achievement (Freedman, 1997). Hands-on, activity-based laboratory instruction enhances students' attitude toward science (Freedman, 1997; Robertson & Kleppinger, 2005). Laboratory instruction has a positive effect on students' perception of their ability to achieve in science (Freedman, 1997).

Students believe that school science should be more about learning to do science through scientific investigations, than about learning scientific facts and theories. Extended practical projects show them what science is like and get them more interested in it (Woolnough, 1994). Future scientists prefer student-centered science activities in which they are given responsibility to plan their own work (Woolnough, 1994; Woolnough & Guo, 1997).

2.4.8 Career choice

There is not one single factor that is universally influential on students' career choice (Ware & Lee, 1998; Woolnough, 1994; Woolnough & Guo, 1997). Many of the influences on the choice of a science major in college are indirect (Ware & Lee, 1998). Several factors can be identified to influence a student's choice for science (Osborne, Simon & Collins, 2003).

The most important factors are a student's participation in, and positive experience with, extra-curricular activities and the quality of the teaching of science (Osborne, Simon & Collins, 2003; Ware & Lee, 1998; Woolnough, 1994; Woolnough

& Guo, 1997). The quality of teachers and their teaching is an important determinant of a student's attitude toward science, as well as subject choice (Osborne, Simon & Collins, 2003; Wieman & Perkins, 2005; Woolnough, 1994). Teachers who lack specialist knowledge and who have little enthusiasm for the subject have a negative effect on students' attitudes toward science. Teacher variables are of more importance for determining students' attitudes toward science than curriculum variables (Osborne, Simon & Collins, 2003). Good teaching is characterized by teachers being enthusiastic about their subject, setting it in everyday contexts, and running well-ordered and stimulating science lessons.

Other important factors are personal encouragement given by science teachers, practical nature of the science lessons, the intellectual satisfaction of doing science, the level of difficulty in school science, the likely job satisfaction, status, and salary in science and engineering, scientific hobbies, playing with gadgets at home, and links with local industry through speakers, visits, and work experience (Woolnough, 1994; Woolnough & Guo, 1997). Technology, scientific hobbies, and fiddling with gadgets at home was important for males, but not for males. The involvement with human issues was important for females and not females (Woolnough, 1994).

The most discriminating factors that encouraged the potential scientists were (differently for different students) the quality of the science teaching and the intellectual stimulation of the science curriculum, the attractiveness of careers in science and engineering, and the home background in which the students are encouraged in scientific hobbies (Woolnough & Guo, 1997).

Students were encouraged toward careers in science by what the teachers did, by the nature of the subject itself, by the attractiveness of careers in science, by involvement with extra-curricular activities in science, by home factors, and by the attractiveness of higher education courses in science (Woolnough & Guo, 1997).

2.4.9 Effects of science enrichment programs and research experience programs[2]

Determining which students benefit most from science programs can have important policy implications (Stake & Mares, 2001). This is because it would be in the interest of program administrators to select those students who will benefit the most from participating.

Students, who enter a program with science advantages over other students, appear to profit more from a program. These science advantages are: a previous science enrichment experience, strong support from family and teachers, a positive teacher model, and confidence in their abilities. Returning students may show more increase in motivation and confidence than first-time students. This is because the experience students gain during a first science enrichment program helps them prepare to take advantage of opportunities in a second program. It is also an advantage to have parents with a more than average education, friends who are interested in science, and science teachers who are positive role models (Stake & Mares, 2001).

Social support variables contribute to predicting a change in motivation and confidence for a career in science, as well as to the formation of new friendships for

[2] Science enrichment programs are aimed at high school students, while research experience programs are aimed at undergraduate students.

students that participate in a science enrichment program (Stake & Mares, 2001; Stake & Mares, 2005).

Demographic variables like gender, parents' education, and talent do not predict a change in students' attitudes toward science after participating in a science enrichment program. These demographic variables are, on the other hand, positively related to a change in students' motivation, as well as to forming new friendships for social support. Gender was the only significant variable of the three mentioned above. Student ethnicity does not predict how much a student will change after participating in a science enrichment program (Stake & Mares, 2001).

As described above, friends who have a positive attitude toward science and careers in science are an important factor in person's attitude. Friends also play a role in a person's educational and occupational decisions. Science enrichment programs can contribute to the social support a person needs for these decisions. This is because students who participate in science enrichment programs will be among a group of students who hold positive attitudes, which will add to the social support for their career decisions, and which can help students with forming a more positive view of science and careers in science (Stake & Nickens, 2005). Science enrichment programs that encourage a high level of interaction between students can be effective in helping girls to establish friendships among the participating students (Stake & Mares, 2001; Stake & Nickens, 2005).

Girls tend to profit more from participating in science enrichment programs, as well as students with supportive families and teachers, and students who had great confidence in their abilities upon entering a program. These students gained more in motivation for a career in science, in expectations for a successful career in science, in confidence, and in science knowledge (Stake & Mares, 2001).

It is not certain to what extent science enrichment programs are effective in promoting positive attitudes toward science and in increasing students' aspiration for a career in science (Stake & Mares, 2001). Science enrichment programs have a positive effect on students' motivation for science, as well as on their confidence that they could achieve a successful career in science (Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005). It has been shown that science enrichment programs are able to improve science achievement (Stake & Mares, 2001; Stake & Mares, 2005).

Young people make decisions that are based on partial information (Hodkinson & Sparkes, 1997). A student's perception of science, and specifically of pursuing a doctoral degree, is an important determinant of this person's choice whether or not to pursue such a degree (Osborne, Simon & Collins, 2003). The experience students get with research and scientists through a science enrichment program or a research experience program will help them to develop a better understanding of how it would be to work as a scientist in a certain field (Osborne, Simon & Collins, 2003; Plucker & Gorman, 1999; Richmond & Kurth, 1999; Stake & Mares, 2001; Wieman & Perkins, 2005). This more accurate picture can then help students in deciding about their future careers (Chu, 2004; Osborne, Simon & Collins, 2003; Stake & Mares, 2001). Science enrichment programs and research experience programs thus play an important role in enabling participating students to make a better-underpinned decision than students who did not participate in a research experience program.

2.4.10 Successful research experience programs

The Meyerhoff Scholars Program

The Meyerhoff Scholars Program (MSP) at the University of Maryland, Baltimore County, improves the participation of underrepresented minorities in science. The program involves mentorship, summer and other workshops, and targets high-achieving high school students. Students are offered a four-year scholarship. The program was developed to address factors that keep these minority students from succeeding in science: "academic and cultural isolation, motivation and performance vulnerability in the face of low expectations, peers who are not supportive of academic success, and discrimination, whether perceived or actual". The program is aimed at undergraduate students, who go on to doctoral programs in science and engineering, and encourages students to pursue academic goals and prepare for graduate school. Candidates for the program are nominated by their high school teachers and counselors (Summers & Hrabowski, 2006).

The Meyerhoff Scholars Program has four objectives: academic and social integration, knowledge and skill development, support and motivation, and monitoring and advising. Five elements have been identified as being the most important for reaching them: recruiting high achieving minority students with interest in science who are the most likely to be retained in the scientific pipeline; offering financial support; providing an orientation program for incoming freshmen; recruiting the most active research faculty to work with the students; and involving the students in scientific research as early as possible (Summers & Hrabowski, 2006).

Of the students that participate in the Meyerhoff Scholars Program, 86% earn a bachelor's degree in science or engineering and 41% continue their education in doctoral or medical-doctoral programs. MSP students are twice as likely to earn a Bachelor's degree in science or engineering than students who are invited to the program but choose not to participate. MSP students are 5.3 times more likely to continue with graduate study than students with similar preparation and interest who did not participate in the program (Summers & Hrabowski, 2006).

Rutgers Astrophysics Institute

Gifted high school students get an opportunity to learn about science and conduct their own research through participating in the Rutgers Astrophysics Institute (RAI) at Rutgers University. RAI is a yearlong research program in X-ray astrophysics for high school students and their teachers. Students are selected based on transcripts and teacher recommendations. The program starts with the four week Astrophysics Summer Institute to learn students the physics and astronomy they need to understand the models and methods of data collection and analysis they need to complete the program. During the following academic year, students conduct research in their schools on an X-ray source for which no model has yet been build. The program ends with a conference where students present their results to astrophysicists from Rutgers University, RAI administration, students' parents, and teachers (Etkina, Matilsky & Lawrence, 2003).

RAI focuses on several recommendations about how to conduct and assess science programs for gifted students: emphasis on inquiry processes; real laboratory work; challenging content; interactions with practicing scientists; and use of technology. The program affects students' approaches to learning and their approach to problem solving. An analysis of student journals, their questions, questionnaire responses, and presentations showed that their perceptions about science processes and learning approaches changed owing to their experience, and that these changes

persisted after the instructional part of the program was over. Owing to their combined experiences in the program, students changed their approach to problem solving and knowledge acquisition (Etkina, Matilsky & Lawrence, 2003).

Nuclear Science Program at San José State University

The Nuclear Science Program at San José State University (SJSU) is aimed at undergraduate students. The program was developed in the early 1980s to address a concern about the number of graduate students studying nuclear and radiochemistry (Kinard & Silber, 2005; Peterson, 1997; Robertson & Kleppinger, 2005). The college level summer school is sponsored by the U.S. Department of Energy. The fundamentals from the four major SJSU nuclear science undergraduate courses are combined with seminars and field trips to form an intensive six-week lecture and laboratory program. Participating students earn eight semester-hours of undergraduate credit (Ling, Englert & Stone, 1993).

The intent of the program is to introduce outstanding college students to the field of nuclear and radiochemistry, with the goal that some of these students will consider careers in nuclear science. The lodging arrangements and field trips help the students bond and give them a cohesiveness that is one of the great strengths of the program. Throughout the lifetime of the program, the students have continued to interact and support each other after they return to home institutions and on into their graduate careers (Robertson & Kleppinger, 2005). A highlight of the program is that all invited speakers have lunch or dinner with the students so that there is an ample opportunity for the speakers to interact with the students outside the classroom (Kinard & Silber, 2005). Direct interaction with scientists is valuable for gifted students (Stake & Mares, 2001).

One measure of the success of the program is the number of students who have gone on to careers in the nuclear and radiochemistry field. Many of the students continue on into careers in medicine, law and industry. Nearly 20% of the students get their doctoral degrees in nuclear or radiochemistry and a major portion of these students become nuclear science professionals. The program makes a point of bringing graduates of the program back to lecture after they have received their doctoral degree. The students enjoy meeting these speakers and learning first hand about possible careers in nuclear science from people who were in their position just a few years earlier (Kinard & Silber, 2005).

In 1987 a second summer school in nuclear and radiochemistry was founded at Brookhaven National Laboratory. Graduates of this program were surveyed from 1989 through 1994. It was found that 65% were in graduate school, 24% were in medical school, 7% were in doctoral or medical degree programs, 41% were in nuclear science and 80% felt that their summer school experience was helpful in getting a research job the following summer (Peterson, 1997).

3. Research design

The design process of the instrument used in this investigation is described in this chapter. A description of the target group is given, followed by a reasoned choice for a questionnaire as the means of research. Questionnaire format is discussed, followed by a description of the development of the questionnaire. The last part of this chapter focuses on the implementation of the questionnaire.

3.1 Target group

The target group for this investigation consists of the students that have participated in the SURF NIST Boulder program in 2004, 2005 and 2006. A total of 45 students have participated in the SURF NIST Boulder program, which is a relatively small group for research into behavioral determinants. All of the students that participated have therefore been invited to participate in the survey, because of sample size requirements. Even small differences between groups can become statistically significant when a small dataset is used for statistic analysis. Also, one person with an opinion that differs from other respondents will have a big influence on mean responses in a small dataset. The more respondents, the more accurate the dataset will reflect the total population of former SURF students.

3.2 Choice of research instrument

This investigation has been conducted by means of a questionnaire that was distributed among the respondents. The development of a questionnaire as the means of research is one of the terms of the grant proposal for the National Science Foundation (Magee, 2005). This proposal states that "a questionnaire to poll SURF alumni will be developed and responses will be collected annually". Using the same format each year also makes comparisons easier to make.

3.3 Questionnaire format

This investigation has been done by means of a questionnaire with questions in a Likert scale format. The scales used in the questionnaire have five possible answering options, varying from agree to disagree (agree, slightly agree, undecided, slightly disagree, and disagree). This answering format has been chosen because of the following reasons. Respondents should not be forced to give either a positive or negative answer, but should have the possibility to indicate they are undecided. This excludes answer formats that have an even number of answer possibilities. The five point scale has been chosen because three options for answering cannot capture the difference between strong and moderate opinions; seven answering option on the other side provides respondents with too many nuances for answering that can be difficult to distinguish.

The questionnaire used in this investigation consists of multiple summated rating scales. This means that a separate rating scale, which consists of multiple items to measure the construct, addresses each construct in the Theory of planned behavior. This is because these constructs result from totaling up several multiplications of beliefs and belief strengths (as is explained in Chapter 2).

Each item consists of a statement with five answer options. A score is attached to each answer option: from five points for answering "agree" to one point for answering "disagree" for beliefs items. These item scores multiplied by the score for the question that asks for belief strength if such a question is present. Scores for belief strength range from minus two points for answering "disagree" to two points for answering "agree". Both scores are then multiplied to arrive at the final score. All final scores for a construct are added up and divided by the number of questions in a scale to arrive at the total score, which is used for data analysis.

3.4 Scale construction

3.4.1 Scale development

A method for constructing summated rating scales has been used for developing the questionnaire that was used in this investigation (Spector, 1992). This method implies (1) defining the constructs that are to be measured; (2) designing the questionnaire, including scale format, response choices and instructions; (3) pre-testing the first version of the questionnaire and adjusting possible faults; (4) first administration of the scale and calculating internal-consistency reliability; and (5) validating the questionnaire when the calculations show a internally consistent scale.

The fourth and fifth parts of this method have not been performed in developing the questionnaire for this investigation. This is because there were no respondents available who were similar to the target group and who could participate in a first administration of the questionnaire. This is due to the Paperwork Reduction Act (Government of the United States of America, n.d.), which states that government agencies are not allowed to survey the general public without approval from the Office of Management and Budget[3].

The data gathered with the implementation of the questionnaire has been used to calculate internal-consistency reliability and to validate to questionnaire for future use.

3.4.2 Construct definitions

The questionnaire that was used in this investigation has been developed based on the Theory of planned behavior (shown in Figure 2.3). Items have been formulated for each part of the theory that is to be measured. Together these items should reflect the constructs accurately. The constructs have been defined based on the theoretical framework presented in Chapter 2.

[3] A normal clearance from the Office of Management and Budget (OMB) for a collection of information from the public takes five to six months and involves Federal Register Notices and discussions with OMB.

Subjective norm

Subjective norm is a person's perceived social pressure whether or not to pursue a doctoral program in preparation for a career in science. This perceived social pressure is made up of opinions of important others towards pursuing a doctoral program and the person's motivation to comply with the opinions of the important others.

Items that are used for measuring students' subjective norm ask about the opinion of parents and family, friends, and teachers, mentors and counselors (Dick & Rallis, 1991; Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Singaravelu, White & Bringaze, 2005; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005; Ware & Lee, 1998; Wieman & Perkins, 2005; Woolnough, 1994; Woolnough & Guo, 1997). Possible partners have also been included in the list of important others. An example of an item measuring the opinion of important others is "My friends think that I should pursue a doctoral program". An example of an item measuring a student's motivation to comply is "I find it important to meet my friends' expectations".

A question about the effect of the SURF NIST Boulder program on students' subjective norm has also been included. The item measuring this effect is "I formed lasting friendships with other SURF students while participating in the SURF NIST Boulder program".

The items measuring students' subjective norm have been formatted as a list to prevent a large section of very similar questions.

Attitude

Attitude is a person's favorable or unfavorable evaluation of pursuing a doctoral program in preparation for a career in science. This evaluation is made up of beliefs that are linked to science and to pursuing a doctoral program and the person's evaluation of these beliefs.

Items that are used for measuring a person's attitude ask about the attributes and outcomes that are linked to pursuing a doctoral degree in preparation for a career in science. Examples of attributes are the levels to which a person thinks pursuing a doctorate program is enjoyable, interesting, important for getting a career in science, useful for getting a career in science (Freedman, 1997; Osborne, Simon & Collins, 2003), intellectually satisfying, difficult, and attractive (Woolnough, 1994; Woolnough & Guo, 1997). Examples of outcomes are long-term advantages (Osborne, Simon & Collins, 2003) from pursuing a doctoral program, like the likely job satisfaction, status, and salary (Woolnough, 1994; Woolnough & Guo, 1997), and the attractiveness of jobs in science and engineering (Woolnough & Guo, 1997). An example of an item measuring an attitude attribute is "Science is interesting". An example of an item measuring a possible outcome of pursuing science is "Having a career in science is attractive".

A question about the effect of the SURF NIST Boulder program on students' attitudes has also been included. The item measuring this effect is "Participating in the SURF NIST Boulder program heightened my appreciation of science".

Perceived behavioral control

Perceived behavioral control is a person's evaluation of his or her ability to successfully pursue a doctoral program in preparation for a career in science. This evaluation is made up of the person's beliefs about factors that can inhibit or facilitate pursuing a doctoral program and the person's perceived power of these factors.

Items that are used for measuring a person's perceived behavioral control ask about inhibiting and facilitating factors like a persons confidence in his or her own abilities, a person's context, self-knowledge, and experience (Hodkinson & Sparkes, 1997; Jones, Howe & Rua, 2000; Richmond & Kurth, 1999; Singaravelu, White & Bringaze, 2005; Stake & Mares, 2005; Woolnough, 1994). An example of a question that focused on facilitating factors is "I am confident that I am able to successfully pursue a doctoral program". An example of a question that measures an inhibiting factor is "Combining a career in science with a personal and/or family life outside of work is not possible".

Some items with questions about the effect of the SURF NIST Boulder program on students' perceived behavioral control have also been included. An example of an item measuring this effect is "Participating in the SURF NIST Boulder program made me more confident in my ability to pursue a doctoral program".

Intention

Intention is a person's readiness to pursue a doctoral program in preparation for a career in science. Intention is predicted by a person's attitude, subjective norm and perceived behavioral control.

Although intention can be derived from a respondent's attitude, subjective norm and perceived behavioral control, this will also be assessed directly. The item used to measure intention is "I intend to pursue a doctoral program".

A question about the effect of the SURF NIST Boulder program on students' intention to pursue science has also been included. The item measuring this effect is "How did your participation in the SURF NIST Boulder program affect your intention to go to graduate school?".

Behavior

Behavior is pursuing or not pursuing a doctoral program in preparation for a career in science. The item 'I am currently pursuing a doctorate degree or have received a doctorate degree in the past' will determine this.

A question about the effect of the SURF NIST Boulder program on students' behavior has also been included. The item measuring this effect is "How did your participation in the SURF NIST Boulder program affect your decision to go to graduate school?".

Barriers

Barriers are factors that can inhibit pursuing a doctoral program in preparation for a career in science. Barriers are included in a person's perceived behavioral control and will therefore not be addressed separately.

Actual behavioral control

Actual behavioral control is a person's actual ability to pursue a doctoral program in preparation for a career in science. This will not be measured in investigation, the construct of perceived behavioral control will be used to assess the actual behavioral control.

Personal information section

The personal information section consists of questions that probe for information that can be used to predict whether or not students will go on to pursue a doctoral program. This will include demographic variables like gender, socio-economic status,

and ability (Hodkinson & Sparkes, 1997; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Ware & Lee, 1998; Woolnough, 1994; Woolnough & Guo, 1997). Socio-economic status will be assessed by the average level of education of students' parents (Stake & Mares, 2001; Ware & Lee, 1998; Woolnough, 1994). Ability will be determined by students' grade point average (GPA) (Werts, 1967; Woolnough, 1994; Woolnough & Guo, 1997).

The personal information section will also include variables like students' former participation in research experience programs (Stake & Mares, 2001) and students' participation in science oriented extra-curricular activities (Osborne, Simon & Collins, 2003; Ware & Lee, 1998; Woolnough, 1994; Woolnough & Guo 1997).

The quality of science teaching in students' schools, (Osborne, Simon & Collins, 2003; Ware & Lee, 1998; Wieman & Perkins, 2005; Woolnough, 1994; Woolnough & Guo, 1997) contacts with local industry through speakers, visits, and work experience, as well as students' scientific hobbies (Woolnough 1994; Woolnough & Guo, 1997), have not been included in the personal information section.

Questions asking about the quality of the science teaching in students' schools are not included in the questionnaire because this is too broad of a concept to cover with just one or two questions. A bigger section to cover this subject adequately would not fit the purpose of this questionnaire. The "contacts with (local) industry" are left out because students will get these contacts through their participation in the SURF NIST Boulder program. "Scientific hobbies" and "playing with gadgets" are not included because it is not specified what is meant by these terms, questions asking about these factors (for example "Do you have scientific hobbies") will be ambiguous and open for interpretation, what makes them unsuitable for use in a questionnaire.

3.5 Pretest

The questionnaire used in this investigation has been pretested by use of the reader-focused, non-specific plus-minus method, meaning that the questionnaire is assessed by a group of respondents that is similar to the document's target group and meaning that the respondents were to decide where to comment on, thus generating a broad spectrum of feedback (De Jong & Schellens, 1997; De Jong & Schellens, 1998; Lentz & De Jong, 1997; Schellens & Maes, 2000). The respondents are asked to put plusses or minuses in the margin for each positive or negative experience and to explain their experiences afterwards (De Jong & Schellens, 1997; De Jong & Schellens, 1998; De Jong & Schellens, 2000; Schellens & Maes, 2000).

The questionnaire has been revised based on the pretest results. The final version of the questionnaire as it has been used in this investigation is included in Appendix A.

A total of 14 NIST employees have been invited to participate in the pretest, of whom 6 responded. This group consists of 6 men, in the ages between 31 and 51. Their educational level varies from a Bachelor's degree (one person) to a doctoral degree (three persons) in science or engineering. Two of the pretest respondents have a Master's degree in science or engineering.
As mentioned in section 3.4.1, the pretest respondents are not part of the questionnaire target group. Although this is the case, it may be assumed that the comprehension problems that were mentioned in the pretest are also valid for the target group. This is

because the education levels and professional background of the pretest group and the target group are similar.

3.6 Questionnaire implementation

An online version of the questionnaire has been used for the implementation of the survey. SURF alumni have been tracked down and have received an invitation by email to take part in this investigation. Invitation reminders were sent to increase response rates.

There are several reasons for using an online questionnaire. Respondents cannot skip questions or give multiple or unclear answers to questions when using an online questionnaire, because questions can be marked as mandatory. Filling out the questionnaire and sending it in are combined in one act. This eliminates the possibility of respondents forgetting to send in their filled out questionnaires. Filling out an online questionnaire by checking answer options is also less effort than filling out a questionnaire in a text-editing program or on paper. This increases the probability that SURF alumni will actually respond. Another advantage of using an online questionnaire is that it will not be necessary to import survey data manually. This eliminates the chance of errors while importing data.
An online questionnaire also allows for anonymity of respondents, which is more difficult to achieve when using electronically or postal mailed questionnaires. Respondents are asked for permission to link the information given in the personal information section of the questionnaire to their person. This information will be used to construct an alumni database for the SURF NIST Boulder program.

A question asking for a password has been added to the online version of the questionnaire. This is because the questionnaire will be on a website that is also accessible for people other than SURF alumni. The password will be used to distinguish possible unwanted data from the survey data.

It was not possible to include a “not applicable” option to the answer options for the question asking about respondents’ motivation to comply with their partner’s opinion only. This option could either be added to all questions or to none of the questions. The choice has been made not to add this answer option. This decision could cause unreliable data for the subjective norm of the partner. This was preferred to the option of giving the respondents a “not applicable” option for all questions, thus risking incomplete datasets. A comment box was added at the end of the questionnaire to enable respondents to explain given answers and to write down comments about the questionnaire.

The final version of the questionnaire starts with instructions for the respondents. The purpose of these instructions is to prevent misunderstanding of the questionnaire by explaining that the survey does not focus on factual knowledge, but that respondents’ opinion about the propositions is of importance. The instructions also assure respondents that it will not be possible to link responses or results to a specific person, and that the data gathered with the questionnaire will be handled carefully and confidentially.

4. Results

The process of data analysis and the results originating from the data analysis are described in this chapter. First a description of the respondents is given, based on the demographic variables measured in the questionnaire. This is followed by a factor analysis done to extract constructs from the dataset. The factor scores for the different constructs have been used in a correlations analysis and a regression analysis to determine the behavioral determinants of pursuing a doctoral program.

4.1 Description of respondents

A total of 33 respondents participated in the online survey. Three of the respondents did not complete the questionnaire, resulting in incomplete datasets for these respondents that have not been used in the analysis. The thirty complete sets of data have been used for the analysis described in this chapter.

The population of former SURF students is a homogeneous group caused by the enrollment requirements for participating in the SURF NIST Boulder program. Two thirds of the population of former SURF students participated in the survey. It is reasonable to assume that this group is a representative sample of the total population of former SURF students.

The group of respondents consists of 23 men and 7 women. The average age is 22, with the youngest respondent being 19 years old and the oldest respondent being 28 years of age.

The highest completed education of almost all respondents is a Bachelor program (93%); two respondents completed a Master program (7%). Respondents' grade point averages (GPAs) range from 3.00 to 4.00, with an average of 3.75. Of the respondents, some attend a school that is not very selective (16.7%), half of the respondents attend a school that is somewhat selective, and a third of the respondents attend a very selective school. Most respondents (76.7%) participated in extra-curricular activities while they were in school. A large group (73.3%) of the respondents received one or more scholarships and/or fellowships[4], more than half of the respondents (53.3%) of the respondents received one or more awards and/or recognitions.

The highest completed education of respondents' mothers is most often a Bachelor degree (50%); respondents' fathers most often have a Master degree (40%). The average education of students' parents has been used to form three groups, indicating a low (13.3%), average (73.3%) or high (13.3%) socio-economic status[5].

Eight respondents participated in the SURF NIST Boulder program in 2004 (26.7%); eleven of the respondents participated in 2005 (36.7%) and sixteen of the respondents were part of the 2006 program (53.3%). Two students of the class of 2004 also

[4] The received scholarships and/or fellowships do not include the SURF fellowship.

[5] An average parental education less than completion of a Bachelor program is categorized as having a low socio-economic status. An average parental education constituting of a completed Bachelor or Master program is categorized as having an average socio-economic status. An average parental education of more than completion of a Master program is categorized as having a high socio-economic status.

participated in 2005; three students that participated in 2005 also took part in the program in 2006. Half of the respondents participated in another research experience program for undergraduate students (REU) before participating in the SURF NIST Boulder program.

Participating in the SURF NIST Boulder program made some students (26.7%) change their course selections in college; almost half of the respondents (46.7%) reinforced their decision after participating in the program; some of the respondents (26.7%) indicated that participating in the SURF NIST Boulder program had no impact on their course selections.

Some students (26.7%) changed their choice of graduate program after participating in the SURF NIST Boulder program, more than half of the students (60%) saw their choice being reinforced, and a few respondents (13.3%) indicated that the SURF NIST Boulder program did not impact their choice of graduate program.

After the SURF NIST Boulder program more than half of the participants (56.7%) gave one or more seminars and or talks, a third of the students were an author on one or more papers based on their work in the SURF NIST Boulder program. Some students (26.7%) also were an author on other papers.
Percentages for these demographic variables are shown in Table 4.1.

Table 4.1: Description of respondents

Gender	Male (76.6%)	Female (23.3%)	
Age	Average age: 22	Youngest student: 19	Oldest student: 28
Highest completed education	Bachelor program (93%)	Master program (7%)	
GPA	Average GPA: 3.75	Lowest GPA: 3.00	Highest GPA: 4.00
School selectivity	Not very selective (16.7%)	Somewhat selective (50%)	Very selective (33.3%)
Extra-curricular activities	No participation (23.3%)	Participation (76.7)	
Scholarships/Fellowships	No reception (26.7%)	Recipient (73.3%)	
Awards/Recognitions	No reception (46.7%)	Recipient (53.3%)	
Socio-economic status	Low status (13.3%)	Average status (73.3%)	High status (13.3%)
SURF particpation[a]	2004 (36.7%)	2005 (36.7%)	2006 (53.3%)
REU participation	No prior participation (50%)	Prior participation (50%)	
Course selections	No impact (26.7%)	Reinforcement of decision (46.7%)	Changed decision (26.7%)

Table 4.1 (continued): Description of respondents

Choice of graduate program	No impact (13.3%)	Reinforcement of decision (60%)	Changed decision (26.7%)
Talks and/or seminars based on work done in the SURF NIST Boulder program		Yes (56.7%)	No (43.3%)
Author on one or more papers based on work done in the SURF NIST Boulder program		Yes (33.3%)	No (67.7%)
Author on one of more other papers		Yes 26.7%)	No (73.3%)

[a] Two students participated in 2004 and in 2005; three students participated in 2005 and 2006.

The questionnaire contained seven questions aimed at measuring effects of participating in the SURF NIST Boulder program on participating students (questions 11, 14, 20-22, 24 and 26 in Appendix A).

Most students indicate that participating in the SURF NIST Boulder program heightened their appreciation of science (76.7% agreed; 20% agreed slightly). A majority of the respondents indicate that participating in the SURF NIST Boulder program made them more confident in their ability to pursue a doctoral program (26.7% agreed; 36.7% agreed slightly). Participating in the SURF NIST Boulder program gave almost all students a deeper understanding of what it is like to be a research scientist (80% agreed; 13.3% agreed slightly), and improved students' chances of getting admitted into graduate school (46.7% agreed; 50% agreed slightly).

Most students formed lasting friendships with other SURF students while they were participating in the SURF NIST Boulder program (23.3% agreed; 33.3% agreed slightly).

Students' intentions to go to graduate school were affected by their participation in the SURF NIST Boulder program, most students (80%) said that it reinforced their intention, a few respondents (6.6%) indicated they changed their intention from either not wanting to start graduate school into wanting to start graduate school or vice versa.

Students' decisions to go to graduate school were affected by their participation in the SURF NIST Boulder program, most students (80%) said that it reinforced their decision, a few (3.3%) of the students indicated they changed their decision toward not starting graduate school.

The effects of the SURF NIST Boulder program are shown in Table 4.2.

Table 4.2: Effects of the SURF NIST Boulder program

Appreciation of science		
Lowered appreciation (0%)	No impact (3.3%)	Heightened appreciation (96.7%)
Friendships		
No lasting friendships (33.3%)	No impact (10%)	Lasting friendships (56.6%)
Confidence in abilities		
Lowered confidence (13.3%)	No impact (23.3%)	Heightened confidence (63.4%)
Understanding of work as a research scientist		
Less understanding (3.3%)	No impact (3.3%)	Deeper understanding (93.3%)
Chances of admission into graduate school		
Lowered chances (0%)	No impact (3.3%)	Improved chances (96.7%)
Intention to pursue a doctoral program		
Negative effect (3.3%)	No impact (13.3%)	Positive effect (83.3%)
Decision to pursue a doctoral program		
Negative effect (3.3%)	No impact (16.7%)	Positive effect (80%)

4.2 Questionnaire validity and reliability

4.2.1 Factor analysis

Exploratory factor analysis has been performed to identify underlying constructs, or factors, which explain the data gathered with the questionnaire. Both a calculated version of the construct "subjective norm", and a version only consisting of opinions of important others have been used initially. The calculated construct of subjective norm did not fit with the rest of the data in the results it produced; it has thus not been included in the analysis that is discussed in this chapter.

The factor analysis identified several groups of questions, or items, that correspond with the Theory of planned behavior. The items measuring intention and behavior were not included in the factor analysis because these are separate parts of the Theory of planned behavior. Appendix B contains a list with minimum, maximum, and mean items scores and the belonging standard deviations.

Some of the items do not belong to any factor, which indicates that these items are ambiguous and not suitable for being included in the factor analysis. A lower limit of .500 for factor loading was used as a guideline to exclude items from the factor structure. Items with a factor loading below .500 do not correlate well enough to a specific factor and can therefore not be a part of that factor.
Appendix C contains a list of items that have been excluded from the factor analysis.
A reliability analysis has been performed for each factor that emerged from the factor analysis by means of computing Cronbach's Alpha, a measure for the internal

consistency of a scale. Items that did not correlate well with other items in a scale have been excluded from the factors, thus improving the internal consistencies.

An Alpha value of .500 for a scale has been used as a lower limit for excluding factors from the factor structure.

A second exploratory factor analysis has been performed without the ambiguous and excluded items to verify the factor structure found in the first factor analysis. The factor structure is shown in Table 4.3. Appendix D contains the complete results of the factor analysis.

Every factor in the factor structure has an Alpha value over .500, indicating that the factors are reliable, and can be used as separate scales in the further data analysis. The reliability scores for each factor are included in Table 4.3.

Table 4.3: Factor structure

Factor	Cronbach's Alpha
Subjective norm	α = .8791
My family thinks I should pursue a doctoral degree.	
My parents think I should pursue a doctoral degree.	
My friends think I should pursue a doctoral degree.	
My teachers think I should pursue a doctoral degree.	
My mentors/counselors think I should pursue a doctoral degree.	
Deleted items	
-	
Attitude – Pursuit of a doctoral program	α = .8543
Pursuing a doctoral program is important for getting a career in science.	
Pursuing a doctoral program is useful for getting a career in science.	
Pursuing a doctoral program is intellectually satisfying.	
Deleted items	
Science is interesting.	
Effect of SURF	α = .7218
Participating in the SURF NIST Boulder program made me more confident in my ability to pursue a doctoral program.	
Participating in the SURF NIST Boulder program gave me a deeper understanding of what it is like to be a research scientist.	
Deleted items	
My parents think I should pursue a doctoral degree.	
Perceived behavioral control – Pursuit of a doctoral program	α = .6823
I am confident that I am able to successfully pursue a doctoral program.	
I am willing to commit to spend another three years in school after receiving my Master's degree (without taking financial aspects into account).	
Deleted items	
Pursuing a doctoral program is intellectually satisfying.	
How did your participation in the SURF NIST Boulder program affect your intention to go to graduate school?	
How did your participation in the SURF NIST Boulder program affect your decision to go to graduate school?	

Table 4.3 (continued): Factor structure

Factor	Cronbach's Alpha
Attitude – Career in science	α = .6839
Having a career in science is attractive.	
Having a doctoral degree will allow for a higher salary.	
Having a doctoral degree will allow for more job status.	
Deleted items	
Science is enjoyable.	
Perceived behavioral control – Requirements for pursuing a doctoral program	α = .5881
I am able to finance the pursuit of a doctoral program.	
I am able to do my own original research.	
Deleted items	
-	

4.2.2 Factor scores

Factor scores have been calculated for all factors found in the factor analysis. Factor scores that are outliers have not been included in further data analysis. This is because outliers exert too big of an influence on means and standard deviations in small datasets like the one used in this investigation.

Table 4.4 contains the lowest and highest achieved scores for each factor as well as the mean score and the standard deviations. Scores are based on a 5-point Likert scale, ranging from 1 for a factor's negative influence to 5 for a factor's positive influence on respondents' behavior.
Appendix E contains histograms for the factor scores shown in Table 4.4, Figures E1 through E6.

Table 4.4: Factor scores.

Factor	*Minimum score*	*Maximum score*	*Mean score*[a]	*Std. Deviation*
Subjective norm	2.40	5.00	3.91	0.78
Attitude – Pursuit of a doctoral program	2.67	5.00	4.35	0.74
Effect of SURF	3.00	5.00	4.31	0.62
PBC[b] – Pursuit of a doctoral program	2.00	5.00	4.22	0.92
Attitude – Career in science	3.67	5.00	4.48	0.47
PBC[b] – Requirements for pursuing a doctoral program	1.50	5.00	3.76	1.08

[a] Mean score based on a 5-point Likert scale, ranging from 1 for negative influence to 5 for positive influence.
[b] Perceived behavioral control.

4.3 Descriptive results

Different groups have been compared based on the demographic variables described in section 4.1. Appendix F contains tables with the factor scores belonging to these comparisons, Table F1 through F7.

Subjective norm
Students from families with a high socio-economic status are more influenced by the subjective norm than students from families with a low socio-economic status (F = 3.070, DF = 26, p = 0.65). There are no significant differences for subjective norm between students from families with an average socio-economic status and students from families with a high or low socio-economic status.

Attitude – Pursuit of a doctoral program
Students that did not participate in extra-curricular activities while they were in school have a more positive attitude toward the pursuit of a doctoral program than students who did participate in extra-curricular activities (t = 2.523, DF = 19.708, p = .020).

Effect of SURF
Participating in the SURF NIST Boulder program had more effect on students who gave talks and/or seminars based on their work in the program than on students who did not give talks and/or seminars (t = -1.862, DF = 12.316, p =.087).

Perceived behavioral control – Pursuit of a doctoral program
Students that participated in extra-curricular activities while they were in school have a higher perceived behavioral control regarding the pursuit of a doctoral program than students who did not participate in extra-curricular activities (t = -1.734, DF = 25, p = .095).
Students that are an author on papers that are not based on their work in the SURF NIST Boulder program have a higher perceived behavioral control regarding the pursuit of a doctoral program than students who are not a author on other papers. (t = -2.115, DF = 24.748, p = .045).

Attitude – Career in science
Students that are an author on papers that are not based on their work in the SURF NIST Boulder program have a more positive attitude toward having a career in science than students who are not a author on other papers. (t = 1.892, DF = 7.478, p = .098).

Perceived behavioral control – Requirements for pursuing a doctoral program
Boys have a higher perceived behavioral control regarding the requirements for pursuing a doctoral program than girls (t = 2.924, DF = 25, p = .007).

Students with an average GPA[6] have a higher perceived behavioral control regarding the requirements for a doctoral program than students with a low GPA (F = 2.981, DF = 26, p = .070). There are no significant differences for perceived behavioral control regarding the requirements for pursuing a doctoral program between students with a high GPA and student with an average or low GPA.

[6] High, average and low grade point averages based on the population of former SURF students that participated in this investigation. Low GPAs are lower than or equal to 3.60. Average GPAs are between 3.60 and 3.80. High GPAs are above 3.80.

Intention to pursue a doctoral degree
Students that received scholarships and/or fellowships have a higher intention to pursue a doctoral program in the future than students who did not receive scholarships and/or fellowships (t = -1.724, DF = 25, p = .097).

There are no significant differences between groups regarding their behavior. There are also no significant differences between groups that are based on age, highest completed educational level, school selectivity, students that changed their course selections and/or their choice of graduate program after participating in the SURF NIST Boulder program, year of participation, being on author on any papers based on work in the SURF NIST Boulder program, or receiving awards and/or recognitions.

4.4 Determination of behavioral determinants

4.4.1 Correlations between constructs

Positive connections between the various constructs found during the factor analysis are expected based on the Theory of planned behavior (see Figure 2.2). These connections are expected among the attitude constructs, the perceived behavioral control constructs, and the subjective norm construct; between the attitude, perceived behavioral control and subjective norm constructs and respondents' intention to pursue a doctoral degree; as well as between respondents' intentions and their behavior. A correlations analysis has been performed to see if these positive connections are present. Table 4.5 contains the results of the correlations analysis. Figure 4.1 visualizes the results of the correlations analysis.

Table 4.5: Correlations matrix.

Subscale	1	2	3	4	5	6	7	8
1. Subjective norm	--	.430**	.408**	.311	.136	.193	.405**	.371*
2. Attitude - Pursuit of a doctoral program		--	.131	.335*	.593***	.230	.716***	.592***
3. Effect of SURF			--	.476**	.098	.318	.368	.282
4. PBC[a] - Pursuit of a doctoral program				--	.159	.375*	.607***	.542***
5. Attitude - Career in science					--	.074	.425**	.207
6. PBC[a] - Requirements for pursuing a doctoral program						--	.245	.102
7. Intention							--	.868***
8. Behavior								--

[a] Perceived behavioral control.
*p < .10 , **p < .05 , *** p < .01

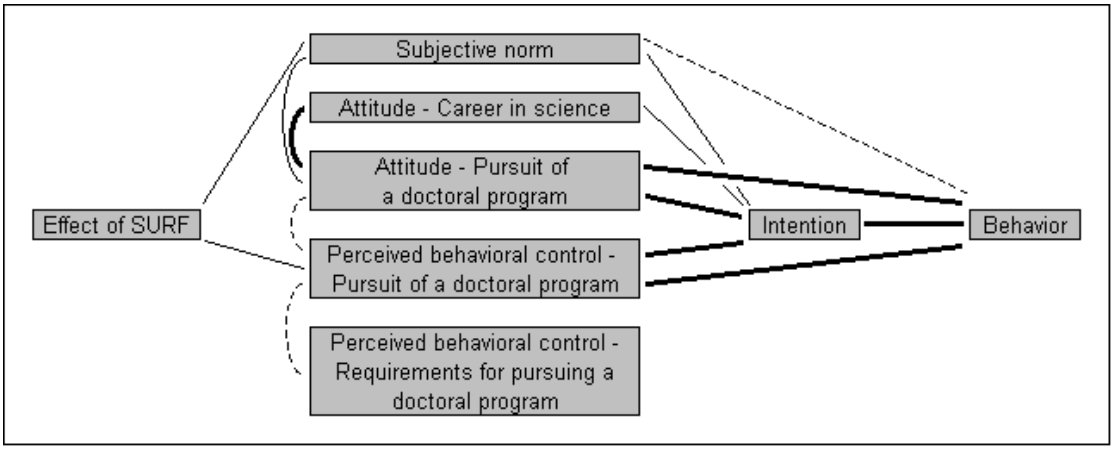

Fig. 4.1: Correlations between constructs.
Note. Dashed lines represent a correlation with $p < .10$. Thin lines represent a correlation with $p < .05$. Thick lines represent a correlation with $p < .01$.

The results of the correlations analysis correspond to the Theory of planned behavior. The correlations between intention and behavior; between the perceived behavioral control, attitude, and subjective norm constructs and intention; and among the perceived behavioral control, attitude and subjective norm constructs match the connections described by this theory.

Additionally, the perceived behavioral control, attitude, and subjective norm constructs lead to intention, which leads to behavior. These correlations are also as described by the Theory of planned behavior.

The SURF NIST Boulder program correlates to the perceived behavioral control and subjective norm constructs.

4.4.2 Regression analysis

The Theory of planned behavior states that causal relations are present between the constructs perceived behavioral control, attitude, and subjective norm and respondents' intention to pursue a doctoral degree. The theory also states that a causal relation is present between respondents' intention to perform a specific behavior and their actual behavior. Regression analyses have been performed to determine if these causal relations are present. The stepwise method for regression analysis has been used because the purpose of this analysis is to find a causal model for the data gathered in this investigation.

Determinants of respondents' intention to pursue a doctoral degree
A regression analysis has been performed for respondents' intention to pursue a doctoral degree. The factors subjective norm, attitude toward pursuing of a doctoral program, perceived behavioral control toward pursuing of a doctoral program, attitude toward a career in science, perceived behavioral control toward requirements for pursuing a doctoral program, and effects of SURF NIST Boulder were used as independent variables.

The model that emerged from this analysis states that there is a positive causal relation between respondents' attitude toward pursuing a doctoral program and their perceived behavioral control toward the pursuit of a doctoral program, and their intention to pursue a doctoral program. The total variance explained with this model is 64%. Table 4.6 contains the results of the regression analysis for intention.

Table 4.6: Results of the regression analysis for factors predicting respondents' intention to pursue a doctoral degree.

Factor	*B*	*SE B*	β
Step 1	1.203	0.235	.716
Attitude – Pursuit of a doctoral program			
Step 2			
Attitude – Pursuit of a doctoral program	0.970	0.211	.577
PBC[a] – Pursuit of a doctoral program	0.555	0.168	.414

Note. R^2 = .493 for Step 1; R^2 = .637 for Step 2 (p = .000).
[a] Perceived behavioral control.

Determinants of respondents' behavior.

A regression analysis has also been performed for respondents' behavior. The factors subjective norm, attitude toward pursuing of a doctoral program, perceived behavioral control toward pursuing of a doctoral program, attitude toward a career in science, perceived behavioral control toward requirements for pursuing a doctoral program, and effects of SURF NIST Boulder, and intention were used as independent variables.

The model that emerged from this analysis states that there is a positive causal relation between respondents' intention and their behavior. The total variance explained with this model is 74%. Table 4.7 contains the results of the regression analysis for behavior.

Table 4.7: Results of the regression analysis for factors predicting respondents' behavior

Factor	*B*	*SE B*	β
Step 1			
Attitude – Pursuit of a doctoral program	0.782	0.213	.592
Step 2			
Attitude – Pursuit of a doctoral program	0.611	0.206	.462
PBC[a] – Pursuit of a doctoral program	0.408	0.164	.387
Step 3			
Attitude – Pursuit of a doctoral program	-0.078	0.198	-.059
PBC[a] – Pursuit of a doctoral program	0.014	0.139	.013
Intention	0.710	0.140	.902
Step 4			
Attitude – Pursuit of a doctoral program	-0.081	0.191	-.061
Intention	0.718	0.114	.912
Step 5			
Intention	0.683	0.078	.868

Note. R^2 = .324 for Step 1; R^2 = .440 for Step 2; R^2 = .724 for Step 3; R^2 = .735 for Step 4; R^2 = .744 for Step 5 (p = .000).
[a] Perceived behavioral control.

These two regression analyses show that there are causal relations between behavior and intention, and between intention and attitude toward pursuing a doctoral program and perceived behavioral control toward pursuing a doctoral program. This corresponds to the Theory of planned behavior.

5. Conclusions and recommendations

The results presented in Chapter 4 are interpreted in this chapter and are used to answer the research questions posed in this investigation. This is followed by recommendations that can help the SURF NIST Boulder program to better reach its goal of motivating students to pursue doctoral programs in preparation for careers in research and development.

5.1 Conclusions

The answers for the different research questions are based on the results that are presented in Chapter 4. The answers to the different sub-questions are used to come to an answer for the main research question that considers the effectiveness of the SURF NIST Boulder program in motivating students to pursue doctoral programs in preparation for a career in research and development.

1. *What are the underlying determinants for the choice whether or not to pursue a doctoral program?*
Students' attitude toward pursuing a doctoral program and their perceived behavioral control regarding the pursuit of a doctoral program are determinants of the intention to pursue a doctoral program. Students' intention to pursue a doctoral degree is the determinant for their behavior of actually pursuing a doctoral program. This is in accordance with Expectation 1A and the literature (Ajzen, 1991; Ajzen, 2006; Armitage & Conner, 2001).

It was expected (Expectation 1B) that attitude would be the most influential among the determinants for pursuing a doctoral program. This influence was proven to be correct by the data analysis (Freedman, 1997; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Mares, 2005; Ware & Lee, 1998; Weinburgh, 1995; Wieman & Perkins, (2005).

2. *Is the SURF NIST Boulder program of influence on one or more of the determinants for choosing to pursue a doctoral program?*
The SURF NIST Boulder program is of influence on some of the determinants for choosing to pursue a doctoral program, which is in accordance with Expectation 2A and the literature (Stake & Mares, 2001).

The program exerts influence on one of the two of the determinants for intention, namely students' perceived behavioral control regarding the pursuit of a doctoral program. The SURF NIST Boulder program also exerts influence on one of the factors that is correlated to intention, namely students' subjective norm. This is in accordance with the literature and Expectation 2B, which state that participating in the SURF NIST Boulder program will improve students' perceived behavioral control, as well as their subjective norm (Chu, 2004; Osborne, Simon & Collins, 2003; Plucker & Gorman, 1999; Richmond & Kurth, 1999; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005).

3. *Is there a connection between the choice that is made regarding pursuing a doctoral program and demographic variables like gender, student ability, and socio-economic status?*
Demographic variables don't exert a direct influence on students' behavior, but do influence the determinants for students' intention to pursue a doctoral program. This is in accordance with Expectation 3A and the literature (Osborne, Simon & Collins, 2003; Stake & Nickens, 2005; Ware & Lee, 1998; Weinburgh, 1995; Werts, 1967; Woolnough, 1994; Woolnough & Guo, 1997).
The results of this research show that it is advantageous to be a boy from a family with a high socio-economic status; with a high GPA; who received scholarships and/or fellowships; who is an author on papers prior to work done in the SURF NIST Boulder program; and who gave talks and/or seminars based on work in the SURF NIST Boulder program. This is in concordance with the literature (Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Nickens, 2005; Ware & Lee, 1998; Werts, 1967; Woolnough 1994; Woolnough & Guo, 1997) and Expectation 3B.

The main research question *"To what extent is the SURF NIST Boulder program effective in reaching its principal goal, namely motivating students to pursue doctoral programs in preparation for careers in research and development?"* can be answered based on the answers to the sub-questions.

The vast majority of SURF students that have the intention to pursue a doctoral program in the future will indeed do so. It has been shown that students' attitude towards the pursuit of a doctoral program and students perceived behavioral control regarding the pursuit of a doctoral program contribute toward students' intention.

The SURF NIST Boulder program has a medium positive effect on students' perceived behavioral control regarding the pursuit of a doctoral program, as well as on their subjective norm, which has a medium positive effect on students' attitude toward pursuing a doctoral program. In other words, students have a higher perceived behavioral control and attitude regarding the pursuit of a doctoral program after participating in the SURF NIST Boulder program. Because of the causal relation between this particular perceived behavioral control and attitude and intention, and the causal relation between intention and behavior, the SURF NIST Boulder program exerts a positive influence on students' future behavior.

5.2 Recommendations

The opportunity to influence participants of the SURF NIST Boulder program by means of communications should be seized although the participation in the SURF NIST Boulder program already has a positive effect on participating students.

The recommendations are presented in two sections. Recommendations for improving the behavioral determinants of students' intentions and decisions to pursue a doctoral program are presented in section 5.2.1. Recommendations for the SURF NIST Boulder program as a whole are presented in section 5.2.2.

5.2.1 Recommendations for improving behavioral determinants

Perceived behavioral control regarding the pursuit of a doctoral program

Participating in the SURF NIST Boulder program exerts influence on students' perceived behavioral control regarding the pursuit of a doctoral program through students' own experiences as well as the former experiences of the doctoral students, postdocs and scientists who are students' coworkers during the program (Ajzen, 1991; Stake & Mares, 2001; Stake & Mares, 2005).

It is recommended to make use of the contacts between SURF their coworkers to influence this perceived behavioral control. Coworkers form a source of information regarding the pursuit of a doctorate. Their experiences can help students form a more realistic view of the pursuit of a doctoral program, and thus a more realistic perceived behavioral control. The more realistic this perceived behavioral control, the better students can make an informed intention or make an informed decision about pursuing a doctoral program. Students should be encouraged to discuss this topic and to ask questions about their coworkers' experiences as doctoral students (Ajzen, 1991; Stake & Mares, 2001 and Stake & Mares, 2005).

Adding a seminar to the summer seminar series, followed by a discussion about this topic, would also serve the purpose of influencing students perceived behavioral control regarding the pursuit of a doctoral program and getting students to contemplate their own reasons whether or not to pursue a doctoral degree in the future.

Subjective norm

Having a network of science-oriented peers and friends is important for students who want to continue their education and career in science (Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Singaravelu, White & Bringaze, 2005; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005; Summers & Hrabowski, 2006).

It is recommended that the forming of new friendships and peer networks among SURF students be encouraged, not only during the program but also before and after. Developing an online meeting place where new and former SURF students can interact can accomplish this. It will enable students to initiate contacts before the program starts, and to maintain contacts after the program has ended. Enabling interaction among new students, alumni and mentors will also provide an opportunity for a growing network of peers.

Attitude toward a career in science

Role models can contribute toward students' attitudes (Freedman, 1997; Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005). Participants in the SURF NIST Boulder program are immersed in the everyday reality of working in research and development in a national laboratory. This experience alone will influence students' attitudes (Jones, Howe & Rua, 2000; Stake & Mares, 2001; Stake & Mares, 2005; Richmond & Kurth, 1999; Robertson & Kleppinger, 2005; Woolnough, 1994; Woolnough & Guo, 1997).

It is recommended to advise the scientists who will acts as SURF mentors well about supervising the SURF students to ensure an experience that is as positive as possible. Misunderstandings between mentors and students could lead to a less than ideal experience in the SURF NIST Boulder program, leading to a less than ideal effect on a students' attitude toward having a career in science (Osborne, Simon & Collins, 2003; Ware & Lee, 1998; Woolnough, 1994; Woolnough & Guo, 1997).

It is also recommended to use the summer seminar series to allow students a look into the varied career options for someone with a doctoral degree. It should be considered to invite guest speakers from all directions of science, as these speakers can inspire students to pursue a doctoral degree for different reasons (Woolnough, 1994; Woolnough & Guo, 1997).

Attitude toward the pursuit of a doctoral program
As said, role models can contribute toward students' attitudes (Freedman, 1997; Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens; 2005).

It is recommended to encourage conversations about positive and negative experiences that can be encountered while pursuing a doctoral program between participants in the SURF NIST Boulder program and their aforementioned coworkers. Learning about these experiences can cause students to change their beliefs about pursuing a doctoral program, thus changing their attitude about the subject (Ajzen, 2006; Armitage & Conner, 2001).

Efforts to influence students' attitudes toward the pursuit of a doctoral program should be combined with the efforts to influence students' perceived behavioral control regarding the pursuit of a doctoral program.

Perceived behavioral control regarding the requirements for pursuing a doctoral program.
Students' intentions and decisions to pursue a doctoral program are dependent on possible barriers that can inhibit the performance of a behavior (Armitage & Conner, 2001). The perceived behavioral control regarding the requirements for pursuing a doctoral program can be interpreted as a representation of such barriers.

It is recommended to address the subject of possible inhibiting barriers with the participating students. Having knowledge of how other and former doctoral students handled barriers will enable students to better cope with possible hindrances (Ajzen, 1991; Stake & Mares, 2001; Stake & Mares, 2005).

This topic should be combined with the recommendations made for influencing students' perceived behavioral control regarding the pursuit of a doctoral program, and the recommendations made for influencing students' attitude toward the pursuit of a doctoral program.

5.2.2 General recommendations

External communications
Recommendations have been made concerning communications with, and between students during and after their participation in the SURF NIST Boulder program. The communication regarding the publication of the program is also of importance.

Although the SURF NIST Boulder program is already very well publicized[7], it is recommended to ask SURF NIST Boulder alumni to act as "ambassadors" for the

[7] The promotional activities for the SURF NIST Boulder program are aimed at college counselors, professors and students. These activities are an ongoing, year-round process of presentations at professional conferences; talks by NIST technical staff at universities; general mailings to institutions; postings with student information services; giving research seminars and talking to prospective students about NIST research programs; information at a NIST Web site; and professional networking.

A number of professional organizations serving the needs of underrepresented minorities are regularly visited by NIST staff, as are many women and minority-serving institutions. The program

program. Hearing about the possibilities offered in the SURF NIST Boulder program from an enthusiastic SURF alumnus will add another dimension to the publicity package, namely the experiences of a former program participant (Freedman, 1997; Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; Stake & Mares, 2001; Stake & Mares, 2005; Stake & Nickens, 2005).

Student admission to the SURF NIST Boulder program

The results of the data analysis show that it is advantageous for students who want to continue their education and career in science to have certain demographic characteristics[8]. In combination with the goals of the SURF NIST Boulder program[9], it could be considered to look at which students to admit to the program for an optimal effect on the population of students in exact sciences because of the limited number of available fellowships.

It can be postulated that participating in the SURF NIST Boulder program will have less influence on students that can be described as "advantaged" than on students who are "disadvantaged". This is because of the fact that advantaged students are more likely to choose a career in science independently of their participation in the SURF NIST Boulder program. Thus, there is more to gain for disadvantaged students by participating in the SURF NIST Boulder program than there is for advantaged students. The SURF NIST Boulder program aims at promoting careers in research and development among groups that are underrepresented in science; the characteristics of the advantaged student are more applicable to groups that are well represented in science than to groups that are underrepresented (Stake & Mares, 2001; Werts, 1967; Woolnough & Guo, 1997).

Based on these arguments it could be considered to give priority to program applicants who are disadvantaged.

Program continuation

The SURF NIST Boulder program has a positive effect on participating students' future behavior. The design of the program, with its focus on research, education, and social interaction among participants, makes the program effective in encouraging students to pursue a doctoral program in preparation for careers in science.

It is recommended to continue the program into the future, so that future students can also benefit from participating.

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staff personally contacts and arranges for visits to colleges and universities on a contact list, speak with their faculty representatives; and pass materials to school representatives at national conferences.

A mailing list is used to send information packets. New inquiries also receive a packet and are added to the mailing list. The information packet contains an introductory letter; a poster describing the SURF NIST Boulder program; SURF business cards; web links to federal grant forms; a copy of the Federal Register announcement; and information on the previous participating schools (Magee, 2005).

[8] See section 5.2.1.

[9] The goal of the SURF NIST Boulder program is to motivate students to pursue doctoral programs in preparation for careers in research and development, aiming at the recruitment of students that are either underrepresented in science or engineering, or from regional colleges that may have limited research opportunities for undergraduate students (Magee, 2005).

6. Discussion and reflection

This chapter contains a critical retrospect on the investigation described in this thesis. Included are a discussion of the execution of the investigation, a reflection on the qualities and limitations of the investigation, and suggestions for further research.

6.1 Discussion

Choice of theoretical framework

The choice for the Theory of planned behavior as the theoretical framework was suitable for the research that was performed in this investigation. The model that emerged from the data analysis is very similar to the model of the Theory of planned behavior, although not all connections are the same. This difference is also explained by the literature, in that different behaviors across different situations can be caused by a different configuration of the various elements in the theory (Ajzen & Fishbein, 2004; Armitage & Conner, 2001).

Choice of research design

The various variables of the Theory of planned behavior have been measured by means of self-reports. This way of measuring includes a risk of yielding unreliable data due for example to socially desirable answers by respondents. It can be assumed that respondents answered the questions truthfully because of the facts that the questionnaire was confidential and that results could not be linked to a specific person.

Using an online questionnaire as the medium for implementing the survey was satisfactory. The decision to mark questions as mandatory lead to the desired effect of no incomplete data sets because of skipped questions.

A disadvantage of using particular software for developing and implementing the questionnaire was the fact that it was not possible to include a "not applicable" option to the answer options for the question about respondents' motivation to comply with their partner's opinion only. As anticipated, this lead to unreliable data for the subjective norm of the partner, as a result this variable was excluded from the data analysis.

The most serious concern regards the number of respondents that were available for this investigation. The amount of data is in fact too for performing statistical analysis. It was, unfortunately, not possible to solve this problem by inviting additional respondents to participate in the survey because of the Paperwork Reduction Act, which does not allow government agencies to survey the general public without permission from the Office of Management and Budget (Government of the United States of America, n.d.).

The results of this investigation should – because of the very limited number of respondents – be interpreted as an indication of facts and not as settled facts.

6.2 Reflection

Validity and reliability

The external validity of this investigation is affected by both the number and composition of the group of respondents.

Due to the limited number of respondents, the data gathered in this investigation and the results based there upon can be greatly influenced by a small number of respondents with visions that differ from the general perception in the entire target group. Generalizations to the greater population of students that participate in research programs for undergraduate students are therefore difficult to make.

Applicants for the SURF NIST Boulder program differ from both the population of science students and the population of students in general due to the selection process for admission to the program. Only excellent students qualify for the fellowship grants. This makes it difficult to generalize the results of this investigation to the population or science students or to the population of students as a whole.

The construct validity of the questionnaire used in this investigation meets the expectations. The factors that emerged from the data analysis consist of items addressing similar variables, and correspond to the different variables and connections described by the Theory of planned behavior.

The reliability of the data gathered by this questionnaire can not be accounted for based on this investigation. Because it was only possible to administer the questionnaire once it is not possible to assess this reliability as would be possible by repeated use of the survey.

Relevance of research

The scientific relevance of this investigation is twofold.

The Theory of planned behavior has not previously been used to assess the effect of a research experience program for undergraduates on students' future behavior regarding their continued education. This investigation shows that this theory can indeed be used to predict this kind of behavior and thus contributes to the scientific literature on the application of the Theory of planned behavior in research of behavioral determinants.

The effect of student participation in research experience programs on determinants of students' future behavior has not been previously investigated by the method used in this investigation. This investigation thus contributes to the literature on the effects of such programs.

The social relevance of this investigation is situated in showing which variables are determinants for students' intentions and decisions whether or not to pursue careers in science and development, and thus contributing knowledge on how to oppose the "swing from science" and increase the number of students interested in careers in science and development.

6.3 Suggestions for further research

It is recommended to repeat the research performed in this investigation periodically; not only to increase the knowledge of students' achievements and the effects there upon of the SURF NIST Boulder program, but also to gradually expand the number of respondents and thus come to a higher validity and reliability of produced results.

It is also recommended to perform preliminary research to further develop the questionnaire before administering it. This research would consist of asking respondents to verbalize the beliefs they associate with each construct from the Theory of planned behavior. The result of this would be questionnaire constructs consisting of more items, and thus a better representation of the constructs described by the theory. Constructs consisting of more items would also improve questionnaire validity and reliability.

It would be an enrichment if future investigations could include a control group. For instance consisting of students that applied for the SURF NIST Boulder program, but did not participate; consisting of students that participated in other research experience programs; or consisting of students that did not participate in any research experience program. It would also be interesting to implement a pretest-posttest design for participants of the SURF NIST Boulder program, possibly in combination with a control group.

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Korte samenvatting (Abstract in Dutch)

De effectiviteit van het SURF NIST Boulder programma is onderzocht met behulp van een vragenlijst gebaseerd op de Theorie van het geplande gedrag. De doelgroep voor dit onderzoek bestaat uit de studenten die in 2004, 2005 en 2006 hebben deelgenomen aan het SURF NIST Boulder programma. Uit de resultaten blijkt dat het SURF NIST Boulder programma een gemiddeld positief effect heeft op de zelfeffectiviteit wat betreft het doen van promotieonderzoek, en op de subjectieve norm. De subjectieve norm heeft een gemiddeld positief effect op de attitude ten opzichte van het doen van promotieonderzoek. Het SURF NIST Boulder programma oefent een positieve invloed uit op het gedrag van studenten, gezien de causale relatie tussen de zelfeffectiviteit wat betreft het doen van promotieonderzoek en intentie, en de causale relatie tussen intentie en gedrag. De resultaten van dit onderzoek moeten – vanwege het zeer kleine aantal respondenten – geïnterpreteerd worden als een indicatie, en niet als vaststaande feiten. Het is lastig om de resultaten van dit onderzoek te generaliseren naar meer algemene studentenpopulaties vanwege het aantal, en de samenstelling van, de respondenten. Aanvullend en periodiek herhaald onderzoek is aanbevolen om zowel de validiteit als de betrouwbaarheid van de onderzoeksresultaten te verbeteren.

Samenvatting (Summary in Dutch)

Motivatie

Het SURF NIST Boulder programma is ontwikkeld om het stijgende tekort aan wetenschappers in de Verenigde Staten aan te pakken door middel van activiteiten die gericht zijn op het beïnvloeden van voortreffelijke studenten die of behoren tot een minderheidsgroep in de wetenschap of die onderwijs volgen aan regionale onderwijsinstellingen die een beperkt aanbod hebben in onderzoeks-mogelijkheden voor Bachelorstudenten (Magee, 2005 and Magee, 2006). Het doel van dit onderzoek is informatie te verkrijgen die de leidinggevenden van het SURF NIST Boulder programma in staat stelt het programma zo aan te passen dat het beter beantwoordt aan de gestelde doelen.

Onderzoeksvragen

De hoofdvraag in dit onderzoek is:

In hoeverre is het SURF NIST Boulder programma effectief in het bereiken van het hoofddoel, namelijk het motiveren van studenten om te gaan promoveren in voorbereiding op een carrière in de wetenschap?

Deze onderzoeksvraag zal beantwoord worden met behulp van de volgende subvragen:

1. *Wat zijn de determinanten voor de keuze om wel of niet te gaan promoveren?*
2. *Is het SURF NIST Boulder programma van invloed op één of meer van de determinanten voor de keuze om wel of niet te gaan promoveren?*
3. *Is er een verband tussen de keuze die gemaakt wordt wat betreft wel of niet promoveren en demografische variabelen zoals geslacht, talent en socio-economische status?*

Onderzoeksopzet

De doelgroep voor dit onderzoek bestaat uit de studenten die in 2004, 2005 en 2006 hebben deelgenomen aan het SURF NIST Boulder programma. Alle voormalige deelnemers zijn uitgenodigd om deel te nemen aan het onderzoek. Het onderzoek is uitgevoerd met behulp van een vragenlijst die verspreid is onder de respondenten. De vragenlijst bestaat uit meerdere summated rating scales, en is ontwikkeld gebaseerd op de Theorie van het geplande gedrag (Armitage & Conner, 2001). De vragenlijst bestaat uit vragen gericht op subjectieve norm, attitude, zelfeffectiviteit, intentie en gedrag wat betreft het wel of niet gaan promoveren.

Resultaten

De data-analyse laat ziet dat er een positief causaal verband is tussen de attitude ten opzichte van het doen van promotieonderzoek en de zelfeffectiviteit wat betreft het doen van promotieonderzoek, en de intentie van respondenten om wel of niet te gaan promoveren. De data-analyse laat ook zien dat er een positief causaal verband is tussen de intentie en het gedrag van de respondenten.

Conclusies en aanbevelingen

Het SURF NIST Boulder programma heeft een gemiddeld positief effect op de zelfeffectiviteit wat betreft het doen van promotieonderzoek en op de subjectieve norm. De subjectieve norm heeft een gemiddeld positief effect op de attitude ten opzichte van het doen van promotieonderzoek. Het SURF NIST Boulder programma oefent een positieve invloed uit op het gedrag van studenten, gezien de causale relatie tussen de zelfeffectiviteit wat betreft het doen van promotieonderzoek en intentie, en de causale relatie tussen intentie en gedrag.

Het wordt aanbevolen om gebruik te maken van de contacten tussen SURF-studenten en hun collega's; en om een lezing toe te voegen aan de lezingenreeks; om op die manier invloed uit te oefenen op de zelfeffectiviteit wat betreft het doen van promotieonderzoek, de attitude ten opzichte van het doen van promotieonderzoek en de zelfeffectiviteit wat betreft de voorwaarden voor het kunnen doen van promotieonderzoek. Het vormen van nieuwe vriendschappen en een netwerk van collega's kan worden aangemoedigd door het ontwikkelen van een online ontmoetingsplaats. Zo'n ontmoetingsplaats stelt SURF-studenten in staat om contacten te leggen voor het eigenlijke programma begint, en om contacten te onderhouden nadat het programma is afgelopen. Mentoren moeten goed voorgelicht worden over het begeleiden van SURF-studenten, om zo een zo positief mogelijke ervaring in het SURF NIST Boulder programma te verzekeren en de attitude ten opzichte van een carrière in de wetenschap de beïnvloeden.

Het wordt aanbevolen om voormalige SURF-studenten te vragen 'ambassadeur' te worden voor het programma. Het kan overwogen worden om te aandacht te besteden aan welke studenten toe te laten tot het SURF NIST Boulder programma, en om voorrang te geven aan studenten die 'benadeeld' zijn. Dit, om een optimaal effect te sorteren in de populatie van beta-studenten, met het beperkte aantal beurzen die te vergeven zijn. Het wordt aanbevolen om het programma voort te zetten in de toekomst, zodat toekomstige studenten ook kunnen profiteren van deelname aan het SURF NIST Boulder programma.

Discussie en reflectie

De keuze voor de Theorie van het geplande gedrag als theoretisch kader, en de keuze voor een vragenlijst als medium, was geschikt voor het uitvoeren van dit onderzoek. De grootste moeilijkheid wordt gevormd door het aantal beschikbare respondenten. De resultaten van dit onderzoek moeten – vanwege het zeer kleine aantal respondenten – geïnterpreteerd worden als een indicatie, en niet als vaststaande feiten.

Het is lastig om de resultaten van dit onderzoek te generaliseren naar meer algemene studentenpopulaties vanwege het aantal, en de samenstelling van, de respondenten. De constructvaliditeit van de vragenlijst die gebruikt is voor dit onderzoek voldoet aan de verwachtingen. Omdat het niet mogelijk was de vragenlijst meerdere keren af te nemen is het niet mogelijk om de betrouwbaarheid ervan te beoordelen.

Aanvullend en periodiek herhaald onderzoek is aanbevolen om zowel de validiteit als de betrouwbaarheid van de onderzoeksresultaten te verbeteren.

Appendix A: Questionnaire

Dear SURF alumnus,

The survey you are going to take focuses on several aspects of the SURF NIST Boulder program. The questionnaire consists of a number of propositions of which you can indicate to what extent you agree or disagree. You may do this by means of marking one of the given response options:

Proposition example:
Exercising regularly is beneficial.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

This survey does not focus on factual knowledge; therefore there are no right or wrong answers. Your opinion about the propositions is of importance. Some of the propositions may seem very much alike; however they are not the same. Please answer all questions with an answer that best matches your opinion; even when the best option is not the answer that you might prefer. There is a space for comments at the end of the questionnaire. Please use this space for explanation and/or comments you may have.

The questionnaire consists of 26 questions and will take between five and ten minutes of your time. All information collected with this survey will be handled with absolute care and confidentiality. The first part of the survey focuses on your professional accomplishments. The answers to these questions will, with your permission, be used for a SURF alumni database, where you will get access to once the survey is completed. Although your personal information will be asked, it will *not* be possible to link results to a specific person.

Thank you for your time and cooperation!

Personal information

1. What is your age? …….

2. What is your gender?
   [ ] Male
   [ ] Female

3. What is your highest completed educational level?
   [ ] Bachelor program
   [ ] Master program
   [ ] Doctoral program

4. What is/was your overall GPA in college? …….

5. Are/were you attending a selective school?
   [ ] Yes, my school is very selective
   [ ] Yes, my school is somewhat selective
   [ ] No, my school is not very selective

6. Did you participate in science oriented extra-curricular activities while you were in school?
   [ ] Yes
   [ ] No

7. What are your parents' or guardians' highest completed educational levels?

[ ]	Elementary school	[ ]	Elementary school
[ ]	High school	[ ]	High school
[ ]	Bachelor program	[ ]	Bachelor program
[ ]	Master program	[ ]	Master program
[ ]	Doctoral program	[ ]	Doctoral program

8. Which school are you attending/did you attend for your bachelor's program? …….

9. Which school are you attending/did you attend for your master's program? …….
   [ ] Not applicable

10. Which school are you attending/did you attend for your doctoral program? …….
    [ ] Not applicable

11. Did the subject of your SURF research affect your later course selections in college?
    [ ] It made me change my mind about the courses I wanted to take.
    [ ] It had no impact.
    [ ] It reinforced my decision about the courses I wanted to take.

12. Did the subject of your SURF research affect your choice of graduate program?
    [ ] It made me change my mind about the kind of graduate program I wanted to pursue.
    [ ] It had no impact.
    [ ] It reinforced my decision about the kind of graduate program I wanted to pursue.

13. Have you participated in other research experience programs before the SURF NIST Boulder program?
    [ ] Yes → *Please list the other research experience programs: ……*
    [ ] No

14. What year(s) did you participate in the SURF NIST Boulder program? ……..

15. Did you give any talks or seminars based on your work in the SURF NIST Boulder program?
    [ ] Yes → *Please name the occasions of the talks and/or seminars: ……*
    [ ] No

16. Were you an author on any papers based on your work in the SURF NIST Boulder program?
    [ ] Yes → *Please name the paper(s): ……..*
    [ ] No

17. Please list other papers you have published: ……..

18. Please list scholarships and/or fellowships you have received: ……..

19. Please list other awards or recognitions you have received: ……..

Propositions

1. Pursuing a doctoral program is important for getting a career in science.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

2. Pursuing a doctoral program is useful for getting a career in science.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

3. Pursuing a doctoral program is intellectually satisfying.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

4. Pursuing a doctoral program is difficult.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

5. Having a career in science is attractive.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

6. Science is interesting.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

7. Science is enjoyable.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

8. Having a doctoral degree will allow for a higher salary.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

9. Having a doctoral degree will allow for more job satisfaction.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

10. Having a doctoral degree will allow for more job status.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

11. Participating in the SURF NIST Boulder program heightened my appreciation of science.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

12. The following persons think I should pursue a doctoral program:

a) Family	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
b) Parents	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
c) Partner	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
d) Friends	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
e) Teachers	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
f) Mentors/counselors	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree

13. I find it important to meet these peoples' expectations.

a) Family	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
b) Parents	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
c) Partner	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
d) Friends	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
e) Teachers	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree
f) Mentors/counselors	[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree

14. I formed lasting friendships with other SURF students while participating in the SURF NIST Boulder program.

[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree

15. I am confident that I am able to successfully pursue a doctoral program.

[ ] Agree	[ ] Slightly agree	[ ] Undecided	[ ] Slightly disagree	[ ] Disagree

16. Combining a career in science with a personal and/or family life outside of work is not possible.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

17. I am able to finance the pursuit of a doctoral program.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

18. I am able to do my own original research.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

19. I am willing to commit to spend another three years in school after receiving my Master's degree (without taking financial aspects into account).

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

20. Participating in the SURF NIST Boulder program made me more confident in my ability to pursue a doctoral program.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

21. Participating in the SURF NIST Boulder program gave me a deeper understanding of what it is like to be a research scientist.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

22. Participating in the SURF NIST Boulder program improved my chance of getting admitted into graduate school.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

23. I intend to pursue a doctoral program.

[ ]	[ ]	[ ]	[ ]	[ ]
Agree	Slightly agree	Undecided	Slightly disagree	Disagree

24. How did your participation in the SURF NIST Boulder program affect your **intention** to go to graduate school?

[ ] It made me change my intention toward starting graduate school.
[ ] It reinforced my intention to start graduate school.
[ ] It had no impact.
[ ] It reinforced my intention not to go to graduate school.
[ ] It made me change my intention toward not going to graduate school.

25. I am currently pursuing a doctoral degree or have received a doctoral degree in the past.

[ ] Yes
[ ] No, but I have the intention to start a doctoral program in the future.
[ ] No, I do not intend to get a doctorate.
[ ] No, other → *Please explain: ……*

26. How did your participation in the SURF NIST Boulder program affect your **decision** to go to graduate school?

[ ] It made me change my decision toward starting graduate school.
[ ] It reinforced my decision to start graduate school.
[ ] It had no impact.
[ ] It reinforced my decision not to go to graduate school.
[ ] It made me change my decision toward not going to graduate school.

This is the end of the questionnaire. Please use the space below to explain answers and/or write down any comments you may have about this questionnaire.

Thank you for participating in the SURF NIST Boulder survey!

……
……
……

Appendix B: Item scores

Table B: Item scores

Item	Minimum score	Maximum score	Mean score	Std. Deviation
Pursuing a doctoral program is important for getting a career in science.	2	5	3.93	0.99
Pursuing a doctoral program is useful for getting a career in science.	3	5	4.59	0.75
Pursuing a doctoral program is intellectually satisfying.	2	5	4.52	0.80
Pursuing a doctoral program is difficult.	1	3	1.26	0.59
Having a career in science is attractive.	3	5	4.59	0.64
Science is interesting.	4	5	4.93	0.27
Science is enjoyable.	4	5	4.70	0.47
Having a doctoral degree will allow for a higher salary.	2	5	4.33	0.83
Having a doctoral degree will allow for more job satisfaction.	1	5	3.74	1.02
Having a doctoral degree will allow for more job status.	3	5	4.52	0.64
Participating in the SURF NIST Boulder program heightened my appreciation of science.	3	5	4.74	0.53
My family thinks I should pursue a doctoral program.	2	5	3.78	0.93
My parents think I should pursue a doctoral program.	3	5	3.93	0.87
My partner thinks I should pursue a doctoral program.	2	5	3.33	0.73
My friends think I should pursue a doctoral program.	2	5	3.63	0.93
My teachers think I should pursue a doctoral program.	2	5	4.15	0.99
My mentors/counselors think I should pursue a doctoral program.	2	5	4.07	0.99

Note. Scores based on a 5-point Likert scale, ranging from 1 to 5, with the higher scores indicating approval of items and the lower scores indicating disapproval of items.

Table B (continued): Item scores

Item	Minimum score	Maximum score	Mean score	Std. Deviation
I find it important to my family's expectations.[a]	1	5	0.81	1.15
I find it important to my parents' expectations.[a]	1	5	0.85	1.17
I find it important to my partner's expectations.[a]	2	5	0.59	0.89
I find it important to my friends' expectations.[a]	1	5	0.30	1.14
I find it important to my teachers' expectations.[a]	1	5	0.63	0.97
I find it important to my mentors'/counselors' expectations.[a]	1	5	0.56	1.05
I formed lasting friendships with other SURF students while participating in the SURF NIST Boulder program.	1	5	3.30	1.56
I am confident that I am able to successfully pursue a doctoral program.	1	5	4.07	1.14
Combining a career in science with a personal and/or family life outside of work is not possible.	1	5	4.37	1.01
I am able to finance the pursuit of a doctoral program.	1	5	3.74	1.35
I am able to do my own original research.	1	5	3.78	1.19
I am willing to commit to spend another three years in school after receiving my Master's degree (without taking financial aspects into account).	2	5	4.37	0.88
Participating in the SURF NIST Boulder program made me more confident in my ability to pursue a doctoral program.	2	5	3.78	0.97
Participating in the SURF NIST Boulder program gave me a deeper understanding of what it is like to be a research scientist.	4	5	4.85	0.36

Note. Scores based on a 5-point Likert scale, ranging from 1 to 5, with the higher scores indicating approval of items and the lower scores indicating disapproval of items.

[a] Scores based on a 5-point Likert scale, ranging from -2 to +2, with the higher scores indicating a positive motivation to comply with the opinions of significant others and the lower scores indicating a negative motivation to comply with the opinionsof significant others.

Table B (continued): Item scores

Item	Minimum score	Maximum score	Mean score	Std. Deviation
Participating in the SURF NIST Boulder program improved my chance of getting admitted into graduate school	3	5	4.44	0.58
I intend to pursue a doctoral program.	1	5	4.07	1.24
How did your participation in the SURF NIST Boulder program affect your **intention** to go to graduate school?	1	5	3.81	0.68
I am currently pursuing a doctoral degree or have received a doctoral degree in the past.[b]	0	3	1.89	0.97
How did your participation in the SURF NIST Boulder program affect your **decision** to go to graduate school?	1	5	3.70	0.67

Note. Scores based on a 5-point Likert scale, ranging from 1 to 5, with the higher scores indicating approval of items and the lower scores indicating disapproval of items.

[b] Scores range from 0 to 3, with 0 for no intention to start pursuing a doctoral degree to 3 for currently pursuing a doctoral degree or having received a doctoral degree in the past.

Appendix C: Items excluded from factor analysis

Table C: Items excluded from factor analysis

4	Pursuing a doctoral program is difficult.
6	Science is interesting.
7	Science is enjoyable.
9	Having a doctoral degree will allow for more job satisfaction.
11	Participating in the SURF NIST Boulder program heightened my appreciation of science.
12b	My partner thinks I should pursue a doctoral program.
14	I formed lasting friendships with other SURF students while participating in the SURF NIST Boulder program.
16	Combining a career in science with a personal and/or family life outside of work is not possible.
22	Participating in the SURF NIST Boulder program improved my chance of getting admitted into graduate school.
24	How did your participation in the SURF NIST Boulder program affect your intention to go to graduate school?
26	How did your participation in the SURF NIST Boulder program affect your decision to go to graduate school?

Appendix D: Factor structure

Table D: Factor structure

	Factors					
	1	2	3	4	5	6
My family thinks I should pursue a doctoral program.	.621	.292	.504	.198	-.071	-.321
My parents think I should pursue a doctoral program.	.486	.304	.594	.156	.094	-.402
My friends think I should pursue a doctoral program.	.791	.068	-.031	.298	-.048	.272
My teachers think I should pursue a doctoral program.	.882	.173	-.043	.091	.021	.156
My mentors/counselors think I should pursue a doctoral program.	.775	.168	.505	-.036	.154	.011
Pursuing a doctoral program is important for getting a career in science.	.284	.865	.155	-.055	.018	.185
Pursuing a doctoral program is useful for getting a career in science.	.109	.892	.155	.148	.148	-.051
Pursuing a doctoral program is intellectually satisfying.	.111	.718	.007	.555	.054	.100
Participating in the SURF NIST Boulder program made me more confident in my ability to pursue a doctoral program.	.217	.152	.638	.461	-.186	.263
Participating in the SURF NIST Boulder program gave me a deeper understanding of what it is like to be a research scientist.	-.027	.073	.942	.068	.126	.121
Total variance explained	17.834%	14.896%	14.248%			
Cumulative variance explained	17.834%	32.730%	46.978%			
Reliability (Cronbach's Alpha)	.8791	.8543	.7218			

Table D (continued): Factor structure

	Factors					
	1	2	3	4	5	6
I am confident that I am able to successfully pursue a doctoral degree.	.216	.053	.050	.800	-.113	.295
I am willing to commit to spend another three years in school after receiving my Master's degree (without taking financial aspects into account).	.083	.153	.218	.813	.191	-.038
Having a career in science is attractive.	-.184	.237	-.075	.227	.828	.189
Having a doctoral degree will allow for a higher salary.	.012	-.150	.038	-.177	.873	-.139
Having a doctoral degree will allow for more job status.	.352	.249	.169	.092	.633	-.045
I am able to finance to pursuit of a doctoral program.	.050	.193	.337	.044	-.002	.774
I am able to do my own original research.	.197	-.005	-.124	.232	-.009	.798
Total variance explained				12.714%	11.843%	11.037%
Cumulative variance explained				56.692%	71.534%	82.572%
Reliability (Cronbach's Alpha)				.6823	.6839	.5881

Appendix E: Factor scores

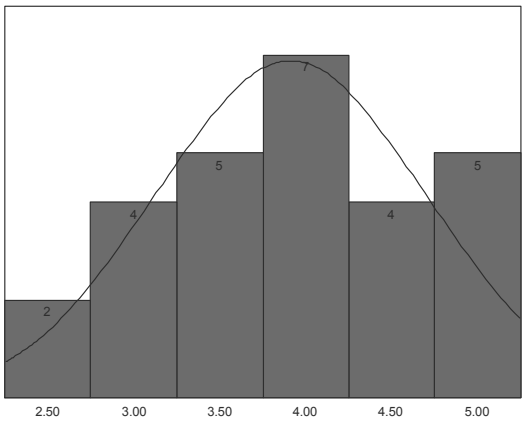

Fig. E1: Factor scores for Subjective norm.

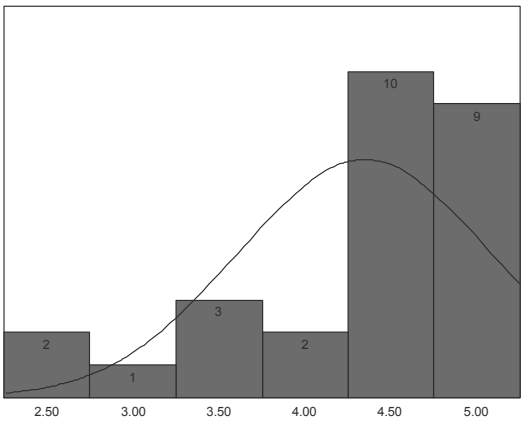

Fig. E2: Factor scores for Attitude – Pursuit of a doctoral degree.

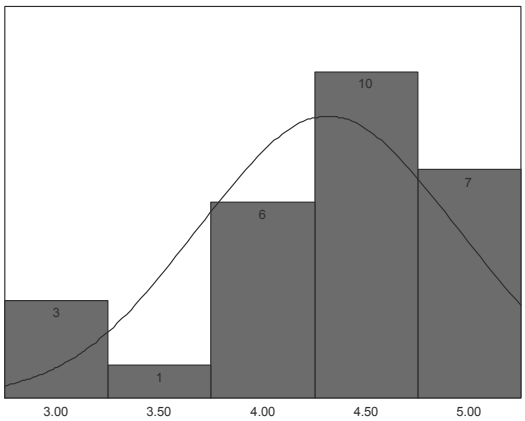

Fig. E3: Factor scores for Effect of SURF.

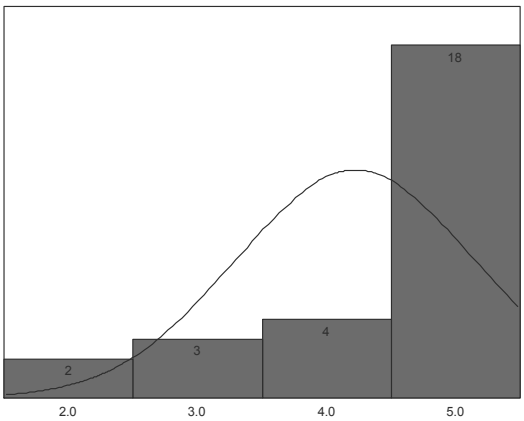

Fig. E4: Factor scores for PBC – Pursuit of a doctoral program.

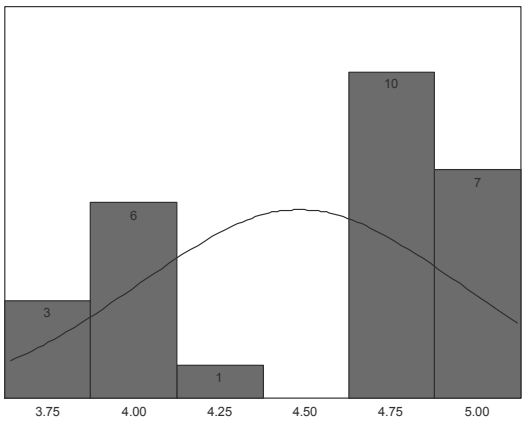

Fig. E5: Factor scores for Attitude – Career in science.

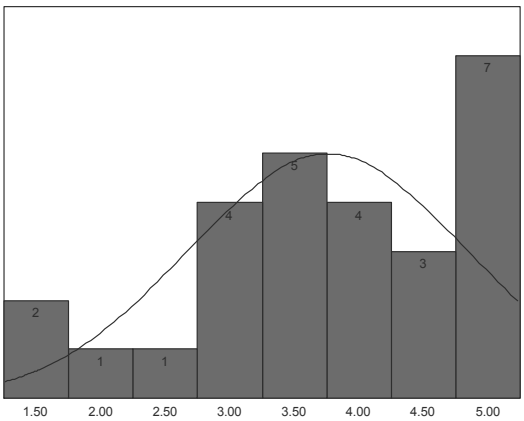

Fig. E6: Factor scores for PBC – Requirements for pursuing a doctoral program.

Appendix F: Descriptive statistics

Table F1: Subjective norm factor scores for socio-economic groups.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Low socio-economic status	2.60	4.40	3.20	0.82
Average socio-economic status	2.40	5.00	3.96	0.73
High socio-economic status	4.00	5.00	4.53	0.50

Table F2: Attitude – Pursuit of a doctoral program factor scores for groups based on participation in extra-curricular activities.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Participation in extra-curricular activities	2.67	5.00	4.22	0.78
No participation in extra-curricular activities	4.33	5.00	4.78	0.34

Table F3: Effect of SURF factor scores for groups based on giving talks and/or seminars based on work done in the SURF NIST Boulder program.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Gave talks and/or seminars based on SURF work	3.50	5.00	4.50	0.43
Did not give talks and/or seminars based on SURF work	3.50	5.00	4.00	0.78

Table F4: Perceived behavioral control – Pursuit of a doctoral program factor scores for groups based on participation in extra-curricular activities and groups based on being an author on non-SURF based papers.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Participation in extra-curricular activities	2.00	5.00	3.67	1.08
No participation in extra-curricular activities	2.00	5.00	4.38	0.84
Author on papers not based on SURF work	4.00	5.00	4.64	0.38
Not an author on papers not based on SURF work	2.00	5.00	4.08	1.02

Table F5: Attitude – Career in science factor scores for groups based on being an author on non-SURF based papers.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Author on papers not based on SURF work	3.67	5.00	4.14	0.60
Not an author on papers not based on SURF work	4.00	5.00	4.60	0.35

Table F6: Perceived behavioral control – Requirements for pursuing a doctoral program factor scores for groups based on gender and groups based on GPA[a].

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Boys	2.00	5.00	4.08	0.85
Girls	1.50	5.00	2.86	1.21
Low GPA[a]	1.50	5.00	3.00	1.54
Average GPA[a]	3.00	4.00	3.50	0.71
High GPA[a]	3.00	5.00	4.19	0.80

[a] Grade point average.

Table F7: Intention factor scores for groups based on the reception of scholarships and/or fellowships.

Groups	*Minimum score*	*Maximum score*	*Mean score*	*Std. Deviation*
Recipient of scholarships and/or fellowships	1.00	5.00	4.29	1.10
Not a recipient of scholarships and/or fellowships	1.00	5.00	3.33	1.51