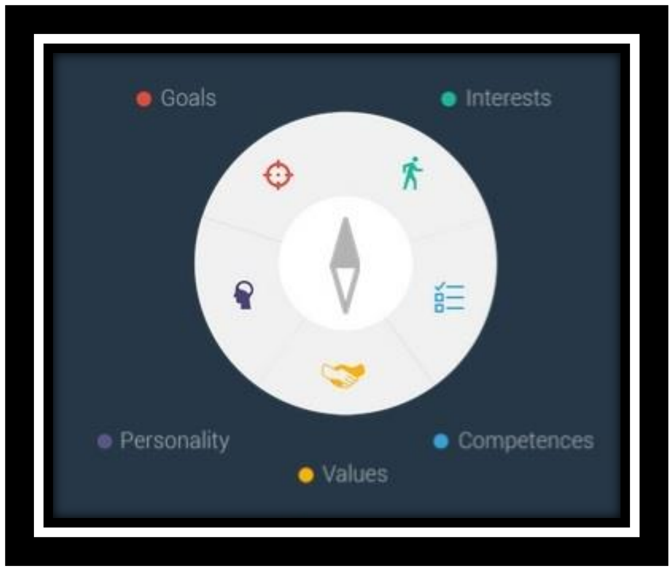
The Career Compass: Discovering Diversity in STEM Students' Professional Identity and its Effects on their Intended Career Choice



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The Career Compass: Discovering Diversity in STEM Students' Professional Identity and its Effects on their Intended Career Choice

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Summary

The Dutch economy relies heavily on the science, technology, engineering and math (STEM) sector. Therefore, highly educated professionals in the STEM sector are important to the Dutch economy. Yet, the Netherlands, like many other countries, experience a shortage of professionals in the technical sector. While in recent years the number of graduates from STEM study programs has risen, only about half of the graduates end up working in the technical sector. One factor that has been shown to influence STEM students' career decisions is *professional identity* (PI); a stable and well developed PI has been shown to keep students on their career path towards the STEM sector. Additionally, it has been shown that providing especially minorities (e.g. women) with a more diverse image of who professionals in the STEM sector are increases the chance that they enter and stay in the STEM sector. Yet, as of now, little is known about the (diversity in) content of STEM students' PI. To date, studies that analyze STEM students' PI are often conducted in a qualitative manner with a small number of participants. Thus large scale research with generalizable insights into the content of PI is missing. Therefore in the current research an instrument was developed to quantitatively measure STEM students' PI. Moreover, since little is known about how differences in STEM students' PI influence their career choice, this research analyzes the relationship between the content, and the strength of STEM students' PI and their career choice. The research is split into two parts. In Study 1a an instrument to measure the content of STEM students' PI was developed, called the Career Compass. For that the educational design research approach was used, with a theory driven design. The instrument was then tested on 760 Dutch STEM students in two higher education institutions. Results showed that the instrument measured the content of STEM students' PI in a reliable manner. Additionally, with the data derived from the newly developed instrument, seven different types of STEM students (*status driven, hip, geeky, uncertainty avoidant, outdoorsy*, *nerdy,* and *creative*) were identified. Study 1b used the same data set as Study 1a and the seven types of STEM students identified previously. Study 1b related STEM students' personal and educational characteristics, their PI, the strength with which they identify with their future profession and their intended career choice. Among other findings, results showed that STEM students' PI did influence their intended career choice. Hereby, *nerdy* and *creative* STEM students were least likely to leave the technical sector and *status driven* and *hip* STEM students showed the most inclination to aim for a career in a different field. Additionally, results indicated that female STEM students intended to get a technical job, but disliked the idea of working in a technical organization. Thus the current research provided insights into who exactly these STEM students are who decide to leave the technical field after graduation.

Problem Statement

In the Netherlands, the technical sector is responsible for one fifth of all employment and two third of all export (Volkerink, Berkhout, Bisschop & Heyma, 2013). Therefore, highly educated science, technology, engineering and mathematics (STEM) students build the foundation for economic success. Hence, it is important for the Netherlands to continuously develop technical talents to survive on the global market. In recent years, the number of university students that graduated in technical programs increased. Nevertheless, recent reports show that about 50% of highly educated graduates from STEM study programs end up working in a non-technical profession (Berkhout, Bisschop & Volkering, 2013; Chen & Soldner, 2013). This is quite remarkable considering that the number of unemployment is very low in the technical sector (Rijksoverheid, 2014). Thus, there are many opportunities for graduates from STEM study programs to find a job in the technical sector, but still relatively few of them are interested in these vacancies. Reasons for the high percentage of engineers who do not opt for a career in the technical sector are thus far unclear.

One factor that has been shown to influence people's motivation to leave their field of work is *professional identity* (PI; Hong, 2010). PI describes individuals' perception of their relevant traits with regard to their occupation (Beijaard, Meijer & Verloop, 2004). PI is a well-defined concept that has been shown to directly influence people's career choices. For example research with teachers suggests that a well-established and strong PI decreases the chances of them leaving their sector (Canrinus, Helms-Lorenz, Beijaard, Buitink & Hofman, 2012). At the same time, Hong's (2010) research on how PI influences teacher's career choices shows that teachers who leave their profession score significantly lower on all facets of PI than their peers in the profession.

A factor that has been shown to influence students' interest into technical classes and their intended career in the technical field are stereotypes (Shin, Levy, & London, in press). Prevailing stereotypes about people in careers in the technical sector concern their gender (mostly male; e.g. Good, Rattan, & Dweck, 2012), race (mostly White or Asian; Carlone & Johnson, 2007), personality (being a loner; Rommes, Van Gorp, Delwel, & Emons, 2010), and intelligence (i.e. high levels of intelligence; e.g. Hong & Lin-Siegler, 2012). Thus the question arises how people who do not adhere to these stereotypes (e.g. women, extroverts) are influenced by them in their career choice. Research indicates that students who do not identify with the stereotypical features of their future profession are less likely to enter a career path in the technical field (e.g. Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). In contrast, contact with less stereotypical people in STEM increases interest in (a career in) the technical field. For example, Shin et al. (in press) showed in their empirical research that reading about a broad mixture of various STEM scientists (with both stereotypical and non-stereotypical traits), increased students' perceived communalities with STEM scientists, interest in STEM topics, and the possibility of a career in the field of STEM. Likewise, interaction of female STEM students with female role models has been shown to improve students' performance in class, identification with the STEM field and intention to pursue a career in STEM after graduation (Stout, Dasguptam, Hunsinger, & McManus, 2011).Thus, a broader image of what a career in STEM entails and who these professionals in the STEM field are (their PI) might encourage more students to enter a career in a technical field.

Unfortunately, as of yet, little is known about the PI of STEM students and professionals. While there is much research on professionals in the medical or educational field, such as doctors (e.g. Beaulieu, Rioux, Rocher, Samson & Boucher, 2008; Pratt, Rockmann & Kaufmann, 2006) and teachers (e.g. Hong, 2010; O'Connor, 2008), the PI of STEM is relatively under-researched. Therefore research on STEM students' PI is needed to understand and support (potential) STEM students in making satisfying career choices.

In order to gain insight in how STEM students' make career choices during the transfer from university to the labor market, a project was started by researchers of the University of Twente to follow STEM students during their career orientation in their last study phase. The current research is part of that project and aims at identifying what students' professional identity entails and how this relates to their career choices. Existing empirical research focusing on PI is scarce and mostly done in the form of small scale qualitative studies (Izadinia, 2013). In these studies, a bottom-up approach is used, where participants describe their PI. However, in order to build a framework to understand how the content of PI develops among large (sub-)groups of STEM students, a top-down, quantitative approach is more suitable, as such an approach can be used to do research with a broader population in order to make predictions about students' career choices (Hair, Black, Babin & Anderson, 2010). Yet, quantitative studies to capture the content of engineers' PI are rare.

In the current research, in order to assess STEM students' PI, an instrument will be developed to quantitatively measure STEM students' PI. As there is a lack of research on the underlying content domains of PI, as well as an elaborate classification of STEM students based on that PI, it is the goal of this research to (1) develop an instrument to measure the content of STEM students' PI and to (2) identify types of STEM students, based on their PI. Furthermore, it is the goal of this research to (3) establish relationships between STEM students' characteristics and content of PI, strength of PI, and future career choice. Finally, (4) the relationship between students with different PIs and both the strength of their PI and their future career plans is analyzed.

Theoretical Framework

In the following sections (professional) identity will be discussed. First, origins of identity theories will be introduced. Second, various definitions of *professional identity* (PI) will be compared and a definition for PI in the context of this research will be provided. Third, the importance of PI and factors that influence PI will be discussed. The section will end with an analysis of how PI is typically assessed in current literature.

Identity

Human beings continuously try to recognize what makes them “who they are” and what distinguishes them from others. In other words, they try to establish their identity (Erikson, 1959 in Crocetti, Avanzi, Hawk, Fraccaroli, & Meeus, 2014). Identity has been researched extensively and is a powerful concept that affects people’s decisions and behaviors in life (Luyckx, 2011). Identity can be defined as an “individuals’ explicit or implicit response to the question of ‘Who are you?’” (Crocetti et al., 2014, p. 1). Such a broad definition is necessary to capture the concept in its entirety, as identity is complex and consists of many facets. Additionally, identity is also viewed from very different perspectives in many fields of research, such as gender identity (e.g. Huffaker & Calvert, 2005), ethnic identity (e.g. Phinney & Ong, 2007) or how identity influences employee performance (e.g. Handley, Sturdy, Fincham, & Clark, 2006). As such, identity is a concept that has been researched extensively, especially in recent years (Cote, 2006). At the heart of all variations in research on identity in social sciences lies the conceptual distinction between identity as a personal or a social concept, or both. To date, this controversy has been part of an ongoing debate in the literature (van Veelen, Otten, Cadinu, & Hansen, 2016). The discussion on the distinction between identity as a personal or social construct will be elaborated upon below.

One of the first scholars to investigate the concept of identity was the developmental psychologist Erikson (1950 in Luyckx, 2011). His epigenetic model in which the individual goes through several stages of identity development still forms the foundation for much research (Luyckx, 2011). At the heart of each stage there is a personal conflict the individual has to overcome, which leads to a further development of personal identity. In this theory, identity development is seen as the integration of previously held identities with newly developed ones (e.g. being an only child and being an older sibling). The two major drivers behind identity formation are *exploration* and *commitment*. Exploration can be defined as an individuals’ process of trying and assessing new roles in life. Commitment can be defined as the degree of personal investment into any such role (Luyckx, 2011). Erikson’s research focused on children, as it was his view that identity formation was completed after childhood. However, it has now been shown that this process takes much longer and young adults are still seeking to define their identity (Schwartz, Cote, & Arnett, 2005). Educational psychologists share Erikson’s view of identity as being personal and argue that the professional identity is an ever developing concept consisting of how people see themselves as professional, the skills and knowledge they should possess and their values and beliefs (Beijaard et al., 2004). In that sense, developmental and educational psychologists conceive identity as a personal construct that develops across the life span and changes with every new phase. Combining these two personal approaches to identity (Erikson’s and educational psychologists’), shows how personal and professional identity relate to one another. Indeed, recent research by Friesen and Besley (2013) shows that among student teachers, a better-developed personal identity is associated with a better-defined professional identity. In other words, professionals who are more aware of who they are as a person are also more likely to be aware of who they are in their profession.

On the other side of the spectrum, social psychologists investigate identity mostly based on Tajfel and Turner’s (1986 in Luyckx, 2011) Social Identity Theory (SIT). Contrary to the more individualized conceptualization of identity from developmental and educational scholars discussed above, SIT focuses on the social identity, which is determined by shared characteristics, beliefs and behaviors of the groups people belong to. Thus, following SIT, identity is understood as a social construct that is relatively static, and that becomes meaningful to the self through the salience in, and comparison with the intergroup context. For example, in comparison to the Italians, the Dutch can be seen as ‘organized’ and ‘punctual’. Yet relative to Germans, the Dutch are more likely seen as ‘liberal’ and ‘direct’. Based on SIT, identification can be defined as the process of categorizing people into social groups, by defining their beliefs and values and comparing ones owns with those of the group. This process of comparing oneself to others in groups is called *self-categorization*. Hereby, groups are usually represented by prototypes, which are “*fuzzy sets of attributes that describe and prescribe perceptions, thoughts, feelings and actions that define the ingroup and distinguish it from relevant outgroups*” (Hogg, 2013; p.542). This process of stereotyping has been understood to be an automatic process with many advantages (e.g. counteracting social anxiety; Hogg, 2013). Nevertheless, in the context of PI such stereotyping can be ‘dangerous’. Perceiving professions in a heuristic manner (i.e., stereotypically) rather than accurately, creates incorrect perceptions about who must be suitable for a certain profession (e.g. Rommes et al., 2010). These incorrect stereotypical inferences may influence potential STEM students from entering the technical field (Cheryan et al., 2011).

The discussion above shows that identity is a subject of research in many fields and researchers are divided in their view on how exactly to define identity: whether it is a fluctuating personal construct that develops in time, or whether identity is a multifaceted but stable construct that a person defines differently depending on the people who surround them. The same division in views can be found in research on professional identity. Literature from both views will be discussed hereafter.

Professional Identity

As indicated by the various theories and disciplines that study identity, different scholars disagree to which extent PI is personal, social or both. Those focusing on social aspects, define PI as "*the degree to which employees identify themselves with the profession that they practice and its typical characteristics*" (Bartels, Peters, de Jong, Pruyn & van der Molen, 2010, p.211). A focus on what professionals have in common as a group often results in the development of stereotypes, a combined view people hold about typical traits and behaviors of a profession. For example when defining professional identity as a social entity, one might argue that a STEM student is typically a quiet person who gets very excited about natural sciences. Supporters of the social view on PI argue, in line with social identity theory, that the development of a PI is an ongoing socialization process throughout which professionals are introduced to and integrate stereotypical traits of their profession into their PI.

Others, who focus on PI as an individual entity, define PI as "*the relatively stable and enduring constellation of attributes, beliefs, values, motives and experiences in terms of which people define themselves in a professional role*" (Ibarra, 1999 p. 1). They argue that PI is the individual's view about their skills, beliefs and motives, unrelated to how others see them and their profession. Thus, taking a view that is more in line with the understanding of identity as a personal construct, such as Erikson (1950 in Luyckx, 2011). Taken together, PI can be described as the identity of a person regarding their job or their career. Integrating prior theories on identity, a professional identity contains both a developmental aspect, as it is not stable but changes over time as one moves further in the career, a social aspect, as it is shaped in part by the people surrounding an individual and an educational aspect, as its development already starts in school (Crocetti et al., 2014). Thus in this research PI will be defined as an ongoing process of integrating various identities regarding the roles a person takes on in a profession.

Most research on PI is focused on the development process of a persons' PI. That is, how do people formulate and stabilize their PI, how does it change over time and which factors influence that process. And again, researchers are divided in their opinion whether this is an individual or a social process (Luyckx, 2011). Yet, no matter whether PI is viewed as more social, more personal, or both, researchers agree that PI consists of two dimensions, namely *identity content* and *identity strength* (Luyckx, 2011). Identity content includes all the components (i.e., characteristics, behaviors, norms) that make up an individual's PI. Identity strength refers to the degree to which an individual commits to these components (Ellemers, Kortekaas & Ouwerkerk, 1999). For example the prototypical content of the PI of an engineer may be "work on technical problems", "design machines" and "work autonomously", while identity strength describes the degree to which they perceive being an engineer as an important aspect of their self-concept. While there is quite some literature on the strength of identification (e.g. Adams, Hean, Sturgis, & Clark, 2006; Kunnen, 2009), to date the content of PI, or the interrelatedness between content and strength has largely been ignored in research (Luyckx, 2011). Thus it is not surprising that very little is known about the content of STEM students' PI.

Kielfhofner (2007, in Luyckx, 2011) suggests that the content of PI is made up of a persons' interests, goals, values and abilities in their occupation. In line with that, Ashforth, Harrison & Corley's (2008) framework on identity also indicates values, goals and abilities as important constituents of identity content, but adds a persons' beliefs and personality traits to that. They argue that the strength of PI consists of three dimensions: the self-definition, the importance of it and the affective significance. While this framework is unique in combining identity strength with content, it has not yet been empirically tested. Therefore, in this research, a combination of both frameworks (Ashforth et al., 2008; Kielhofner, 2007 in Luyckx, 2011)) is used, whereby the content of PI is made up by five domains, to systematically investigate various dimensions in the content and strength of STEM students' PI (see Figure 1).

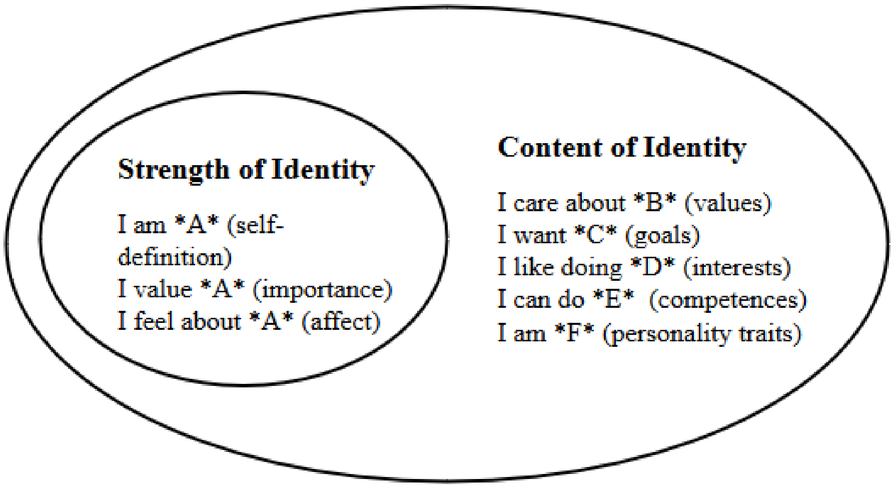

Figure 1. Model of identity (adapted from Ashforth et al., 2008).

The Importance of PI for Career Choices

In recent years, research on how employees are effected by their PI increased. One reason for the increased interest in PI's effects on people's career choices is the change in the world of work (e.g. globalization, knowledge economy, technological innovation) and how people have to be more adaptable to changes in their work environment (Meijer, 2002). At the same time, people find it more difficult to identify with their profession; careers and professions are not as clearly defined as they used to be and their content change constantly which makes it much more difficult for people to develop and confirm their PI (Savickas et al., 2009). Yet, a clear and stable PI has been shown to positively impact personal, study, and career outcomes. For example, literature studies have shown that PI influences a persons' mental well-being (e.g. Luyckx, 2011). Moreover, empirical research shows that PI influences employees' self-efficacy, motivation, career choices and intention to leave a profession in various disciplines, from teachers (Canrinus et al., 2012), to IT specialists (Khapova, Arthur, Wilderom & Svensson, 2007), and nurses (Sabanciogullari & Dogan, 2014). The closer the match between a person's PI and the image they have of a profession or organization, the bigger the likelihood that they will choose that profession or remain in it (Price, 2009). The same holds true for students, as research with high school students shows that a strong and stable PI, which is in line with perceived characteristics of a future profession, increases students' motivation to learn and the quality of their career choices (Meijers, Kuijpers & Gundy, 2013). Likewise, research on college STEM students reveals that a better defined PI increases the likelihood of students continuing their career in the technical sector (Cech, 2015).

On the other hand, students with a less well-defined PI or those who start their studies with a strong but ill-defined PI (i.e. students who believe that being an engineer is important to them, but do not have a well-informed definition of being an engineer) have been shown, by Perez, Cromley, and Kaplan (2014) to be more likely to quit their studies than their better informed colleagues. In their research, the authors analyzed PI development of university STEM students and their intentions about continuing to pursue a career in the technical sector. The results showed that students who explored their PI prior to taking a STEM class felt higher levels of motivation to study, valued their STEM major more and felt lower costs of the major (i.e. the effort they made in relation to the perceived value of graduation) than their less well informed colleagues. Contrastingly, students who did not explore their PI well before entering a STEM major were shown to feel lower levels of confidence in their abilities and perceived their major to be more costly. Hence it is not only important to explore one's PI, but also the profession one is aiming for and investigate whether PI and future profession have sufficient fit. Building on that, Perez et al. (2014) showed that the perceived value of graduation from a STEM related study program positively influenced students' intention to pursue a career in the technical sector, while costs influenced that decision negatively. Thus it appears that students who examine their PI prior to entering a career path in the technical sector and compare it to the image of the profession seem to be better suited for a successful career in STEM than those who enter the field without prior reflection on their PI.

However, even students who do reflect on their PI prior to their studies and not share stereotypical attributes of STEM students (i.e., nerd, introverted) might still be well suited to succeed in this field, because of other personal attributes (i.e., creativity, communication skills).Yet, as these more atypical students see little commonality between their PI and their future profession they decide not to enter the technical sector (Cheryan et al., 2011) or to leave the field (Beasley & Fischer, 2012). However, research on who leaves the technical sector often focuses on groups divided by gender or race (e.g. Griffith, 2010). Little is known about how the content of PI influences the degree to which STEM students find themselves more or less in line with the stereotypical perception of their peers and how that affects their career choice. For that reason, this research aims to gain new insights into the content of STEM students' PI, the relation between content and strength of PI and students' intended career choice in an explorative manner.

Factors Influencing PI

While little is known about the content of STEM students PI, factors influencing PI have been researched more extensively, especially with regard to personal characteristics of students. In particular, the role of gender, level of education, type of STEM study, and time until graduation will be discussed.

While women and men have been shown to have the same intrinsic aptitude for STEM studies (Spelke, 2005), gender has been shown to significantly influence students' decision to stay in a STEM class or higher education course. Specifically, women have been shown to be six times more likely to leave the technical field compared to men (Mau, 2003 in Sadler, Sonnert, Hazari, & Tai, 2012). As has been shown above, PI is a factor that significantly influences STEM students' decision to leave a career in the technical sector. Therefore, gendered differences in PI development might explain the increased likelihood of women leaving the technical field. However, as of yet, no research investigates whether differences between genders with regard to the content of their PI exists. Thus, this research aims at identifying possible differences in PI between genders, with regard to the content of their PI, but also PI strength and career choice.

Another characteristic of STEM students that might influence their PI is their level of education. In the Netherlands adolescents who finish high school have two options to continue studying: either they opt for a university of applied sciences (hoger beroeps onderwijs (HBO)) or they choose a university (wetenschappelijk onderwijs (WO)). Students at HBO level are educated for a specific job or profession (e.g. electrician). Contrary, WO students are educated in a broader manner towards becoming a researcher in a certain field (Hoger onderwijs Nederland, n.d.). These differences in educational goals might be reflected in differences in PI between the two groups of students (HBO and WO). However, as of yet there is no research to investigate this relationship between STEM students' level of education and PI, which is why this research aims to explore that relationship.

In the Netherlands there are four types of study programs: Cluster I study programs are study programs in the technical sector that contain more than 50%technical courses. Cluster II study programs also contain a minimum of 50% technical courses, their focus lies outside the technical sector. Cluster III programs educate science teachers, and cluster IV programs with <50% technical courses (Volkerink, Berkhout & de Graaf's, 2010). Cluster I and cluster II study programs prepare students for a career in the technical sector with at least 50 percent of courses being of a technical topic. The remaining courses are made up of non-STEM related courses, for example management, or marketing classes. For instance, the study program *electrical engineering* is a classical cluster I type of study program with mainly technical classes. On the other hand *industrial engineering and management*, as a cluster II study program, also contains technical classes, but non-technical topics problems form the basis for the courses (e.g. improving supply chain management with mathematical algorithms). Thus, even within the technical field, study programs are more or less technical and therefore also more or less typical for the technical sector. Therefore it could be argued that these two different types of STEM study programs also attract different STEM students. Yet, as of now there is no research on how students from these two clusters of STEM programs differ in their PI. It is for that reason that this research analyzes whether STEM students in cluster I and cluster II differ with regard to the content and strength of their PI and their intended career choice.

Finally, as PI is seen as a fluent concept, it changes with time. Research suggests that students PI and their identification with their future profession changes during the course of their studies (Crocetti et al., 2014; Perez et al., 2014). Researchers pose that through gathering experiences and through interaction with others students gain more insight into what a certain field or profession entails, changing their PI (Krieshok, Black, & McKay, 2009; Meijers & Lengelle, 2012). Therefore, one might expect that students who are closer to graduation and have had more experiences with their profession (e.g. through internships or projects) should have a better defined PI. However, little is known about the exact changes of STEM students PI and strength of identification with their profession in time. Therefore, this research aims at gaining a more detailed understanding of how STEM students' PI and intended career choice differs for STEM students with different time left till their graduation.

Measuring PI

While there is an abundant amount of empirical evidence showing the positive effects of a strongly developed PI on a person's career, and on the factors that influence the development of PI, researchers are less unified in *how* to investigate it. As PI is such a multifaceted concept, researchers are divided on how to measure PI in all its complexity (Luyckx, 2011). The strength and content of PI are usually investigated in separate studies, with the strength mostly being measured in a quantitative manner (e.g. Ellemers et al., 1999), while the content is mainly measured in a qualitative manner (Izadinia, 2013). These latter studies are often done on a small scale with very few respondents, where the focus of the research is on the development of PI in a specific profession. Therefore, many researches produce results which might not represent the entire breadth the PI of people in a certain professions, but only a part of it. For instance, Trede, Macklin and Bridges (2012) reviewed studies on PI in various fields in higher education. Of the 20 analyzed studies, 18 were conducted in a qualitative manner. This makes it difficult to compare various studies, as the results are too different to compare, which in turn impedes developing a holistic framework for the content of students' PI. Due to this lack of a holistic framework, statistical testing to develop a structure of different factors which the PI of students comprises of is also impossible. This is also true for studies on STEM students' PI. It is for that reason that this research aims at both developing a quantitative manner to measure STEM students' PI content and to combine that with measuring the strength with which they identify with their future profession.

The Current Study

In sum, while a review of literature demonstrates that PI has gained much attention in recent years, still little is known with regards to the content of STEM students' PI, factors that influence it and how exactly STEM students' PI influences the strength of their identification with their future profession and their subsequent career choice. Additionally, quantitative research, which produces comparable results, into the content of STEM students PI is lacking. Therefore, the current research aims at gaining new insights into STEM students' PI, both strength and content, and the relation between STEM students' personal characteristics, their PI and the career path they are aiming for. Due to the lack of quantitative research on PI that generates results generalizable for the entire population of STEM students, a qualitative research with a large number of participants is deemed most suitable for the current research.

Research Questions

The research is split into two studies: Study 1a contains the development of a statistically valid instrument to measure PI and the development of a typology of STEM students' PI. Study 1b contains the correlational analysis of demographic and career choice variables, and how they relate to PI. Research questions of the two studies are discussed below.

Study 1a aimed at developing a statistically valid instrument to measure the content of STEM students PI. It aimed to answer two research questions, namely:

- RQ A1: How to develop a quantitative instrument that can measure the content of STEM students' professional identity in the most inclusive manner (capturing both typical and atypical STEM students.
- RQ A2: What type of STEM students (clusters) can be deduced from the instrument to measure the content of STEM students' professional identity.

Study 1b was directed at establishing and analyzing the relationships between PI and the concepts that influence it and are influenced by it, specifically STEM students' personal and educational characteristics, their strength of identification and their intended career choice. In order to investigate these concepts, five research questions were answered (see Figure 2):

- RQ B1: What is the impact of STEM students' personal and professional characteristics (gender, level of education, type of study and time till graduation) on the content of their PI?
- RQ B2: What is the impact of STEM students' personal and professional characteristics (gender, level of education, type of study and time till graduation) on their strength of identification with their future profession?
- RQ B3: What is the impact of STEM students' personal and professional characteristics (gender, level of education, type of study and time till graduation) on their intended career choice inside or outside of the technical sector?
- RQ B4: Are there differences in STEM students' strength of identification with their future profession, depending on the content of their PI?
- RQ B5: Are there differences in the career choice of STEM students (in- or outside the technical sector), depending on the content of their PI?

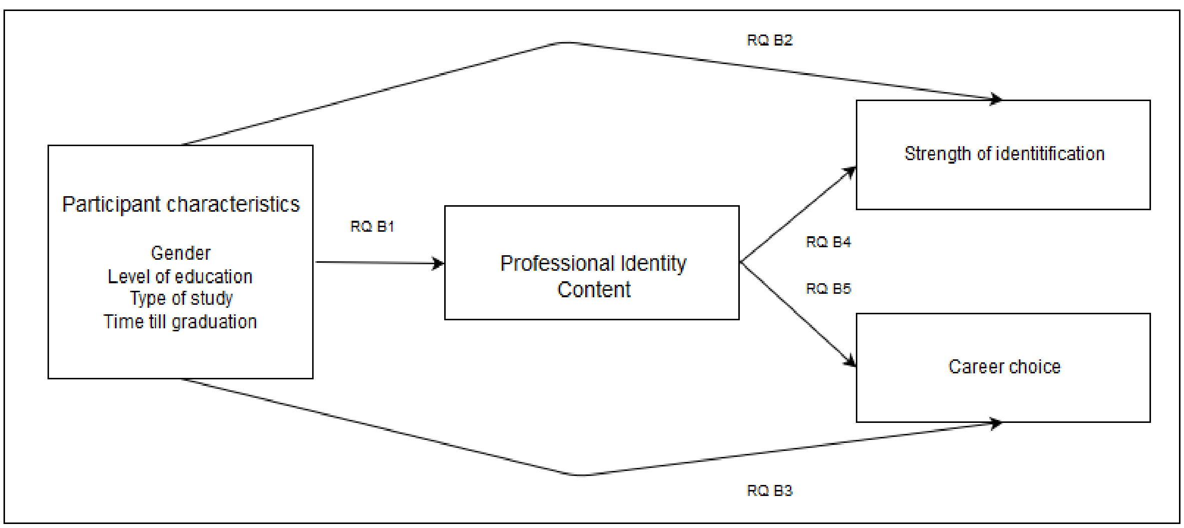

Figure 2. Overview of research questions aimed to answer in Study 1b.

Study 1a

The aim of Study 1a was twofold: (1) to develop a statistically valid measure of the content of PI of STEM students and (2) to identify clusters among high educated STEM students based on the content of their PI.

Research Design

A design research approach was chosen, as this allows for simultaneously using a scientific approach to build a tool, and adapting it for practical purposes. Thus, educational design research (EDR) is based on scientific practices, but allows for adaptions of its rather strict rules to make the research applicable and usable in a realistic environment (McKenney & Reeves, 2008). The study had three different phases, in line with McKenny and Reeves' (2008) model of EDR (see Figure 3).

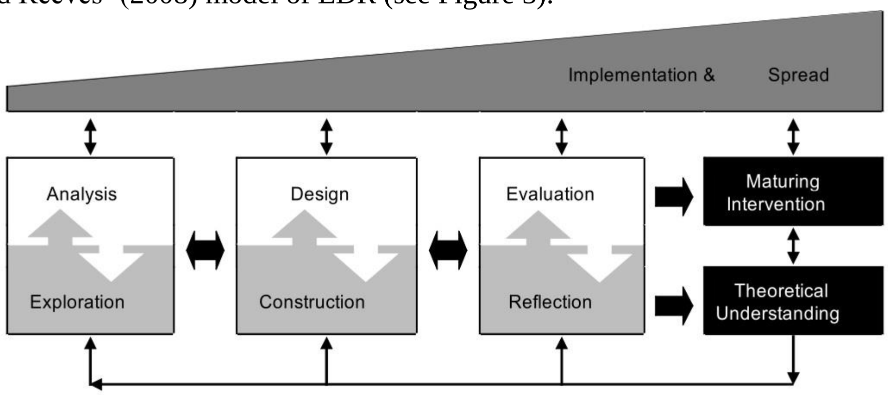

Figure 3. Model of Educational Design Research (EDR) as defined by McKenney and Reeves (2008).

In the first phase (analysis), literature was used to analyze the concept of PI and to develop a first version of the CC. The second phase (design) entailed a pilot to test both this first version of the CC, and the app through which it was delivered to the STEM students. As a result of this pilot, a second version of the CC was developed to optimize it further for the target population. The third phase (evaluation) of the CC development was set out to test the CC on large scale and analyze its internal content structure by means of a series of factor analysis to develop a statistically valid instrument to test STEM students PI. Finally, recommendations for a future version of the CC were made. A detailed description of the three phases can be found below.

Phase 1: Analysis

In this phase, the researcher, in collaboration with a senior researcher at the University of Twente, developed a first version of the Career Compass (CC), based on a literature review of PI in different disciplines in social sciences. For that, scales validated in prior literature were selected and combined to form a representation of the five domains of PI (interests, competences, values, personality and goals, see Figure 4). Scale selection was such that the content of items was both broad enough to measure the entire spectrum of the domain, while at the same time being specific to STEM students.

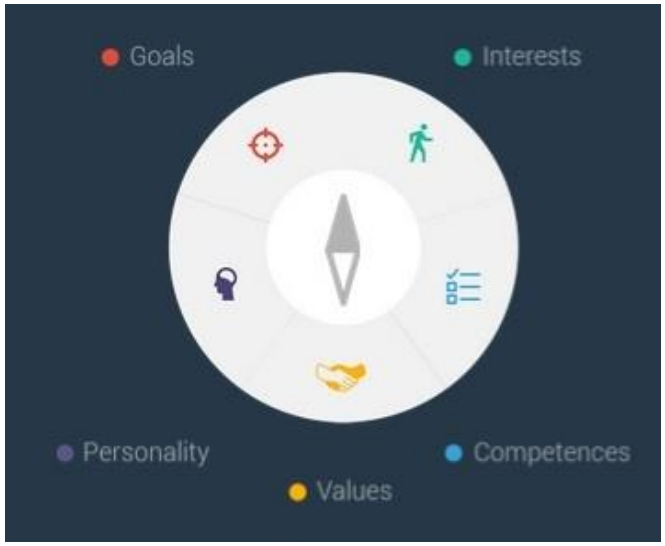

Figure 4. The Career Compass and the underlying domains of Professional Identity

Instrumentation. Without the existence of prior literature on the domains of PI, a qualitative method would have been necessary to discover the components of STEM students' PI content. However, based on the theoretical framework by Ashforth et al (2008), pre-existing scales for each of the five domains (personality, values, goals, competencies, interests) were used. Scales were selected from a wide range of literature. For an overview of the original scales including factors and number of items see Table 1.

Selection procedure. For each of the five domains of the CC, preexisting scales were analyzed. Hereby several criteria were used to select the scales best suited: First, scales had to be proven valid and reliable in previous research. Second, scales had to cover the entire spectrum of the domain, not just one part of the domain. Third, scales had to be broad enough to be suited for a high diversity of types of people in the technical sector, yet, specifically for competences, also specific enough to capture STEM students' specific skills and competencies.

Subsequently, the chosen scales were combined and their number of items reduced as much as possible. Reason for this was that it has been shown that students reading level is a negative predictor for proceeding in the technical fields (i.e. higher reading levels lead to less chance of students taking STEM classes; Guo, Parker, Marsh, & Morin, 2015). Thus it was assumed that a lot of reading would likely negatively influence STEM students' motivation to participate in and finish the questionnaire. For that reason the aim was to keep the Career Compass as short as possible while still ensuring the validity and reliability of the questionnaire. In order to balance these two criteria, the researchers first eliminated several items that were recurring on more than one scale or domain. Several criteria were applied during item reduction. First, the two researchers inspected the various scales separately and decided individually which items in the scales of one domain were overlapping with items in the same domain. Then the two researchers compared notes and in case of overlapping results items were deemed redundant. In case only one of the researchers found an item redundant the researchers engaged in discussion prior to making a mutually consented decision. The similar items were analyzed to decide which one to keep in the questionnaire. To make this decision, factor scores on original scales were inspected, if available, and items were chosen with the highest factor loadings on the original scales.

After reduction of redundant items within domains, items across various domains were compared for their redundancy. Particularly on the domains *goals* and *values* there was quite some overlap between the items. If the items were seen as important to both domains, they were not removed in this initial phase of the CC development. However, if that was not the case, the researchers decided which category they belonged to most and removed the item from the other domain. For example, the item *honesty* was part of both values and personality. It was decided that honesty as a personality trait would also cover honesty as a value, which is why the item was only included in the personality domain. In essence, in most cases, an item was kept in the domain with a higher order level of abstraction.

Table 1
Comparison original scales and scales developed in phase 1

Domain	Scale(s)	Original		After phase 1	
		Factors	n items	Factors	n items
Interests	Hansen and Scullard's (2002)	athletic (1) artistic and intellectual (2) social (3) outdoor (4)	26	athletic (1) artistic and intellectual (2) social (3) outdoor (4)	25
Competences	Male, Bush, & Chapman, 2011 Passow, 2007	problem solving (1), communication (2), ethics (3), life-long learning (4), experiments (5), teams (6) engineering tools (7), design (8), math, science and engineering knowledge (9), contemporary issues (10), impact (11) and unclassified (12)	82	cognitive skills (1), communication (2), life-long learning (3), teams (4), STEM skills (5), management and business (6) and social skills (7)	40
Values	Lyons, Higgins, & Duxbury, 2010 Ros, Schwartz, & Surkiss, 1999	achievement (1), benevolence (2), hedonism (3), power (4), security (5), self-direction (6), stimulation (7), tradition (8), universalism (9), conformity (10) and socialism (11)	68	achievement (1), benevolence (2), hedonism (3), power (4), security (5), self-direction (6), stimulation (7), tradition (8), universalism (9) and socialism (10)	45
Personality	Ashton et al., 2004 Ashton, & Lee, 2009	honesty-humility (1), emotionality (2), extraversion (3), agreeableness (4), conscientiousness (5) and openness to experience (6)	136	honesty-humility (1), emotionality (2), extraversion (3), agreeableness (4), conscientiousness (5) and openness to experience (6)	38
Goals	Roberts & Robins, 2000 Sheldon, Elliot, Kim, & Kasser, 2001	economic (1), aesthetic (2), social (3), relationship (4), influence (5), hedonistic (6), religious (7), personal growth (8), physical well-being (9), theoretical goals (10), autonomy (11), self-esteem (12), money/luxury (13), security (14), and unclassified (15)	65	economy and status (1), family (2), influence (3), universalism (4), physical well-being (5), comfort (6) autonomy (7) and security (8)	28

Results. The results of the item selection procedure will be discussed below, for each domain separately.

Interests. Initially, STEM students' interests were measured with 26 items. During phase 1 only one item was removed from the original scale due to overlap with other domains. The initial factor structure of the four factors (athletic, artistic & intellectual, social and outdoor) was retained.

Competences. For this domain, the number of factors was reduced from 12 to 7, and the number of items from 82 to 40. One of the factors was called *unclassified.* This factor contained items that initially, after merging the two scales did not belong to any factor. After further analysis of the two scales, four of the original factors remained, namely *communication, life-long learning, teams* and *STEM skills*. The two factors *problem solving* and *experiments* merged to one factor called *cognitive skills*. Also, several items previously in an *unclassified* factor and some items of the *teams* factor formed a new factor *social skills*. Finally, several of the items in the *unclassified* factor merged together to form the factor *management and business skills*. Five of the original factors were, due to overlap with other scales, eliminated and not merged into new factors: *ethics, impact, contemporary issues, engineering tools* and *unclassified.*

Values. Based on the two original scales, values were initially captured with 11 factors and 68 items. Only one of the original factors was eliminated, namely *conformity*. Items of this factor were deleted as they overlapped with either personality or goals items. The remaining ten factors were retained, however, their number of items was reduced to 45.

Personality. Originally, the two scales for measuring personality contained 136 items across six factors. During phase 1, the factor structure did not change, however the researchers decided to reduce the number of items to 38 due to overlap within the two scales and with scales in other domains.

Goals. Initially, STEM students' goals were measured with 65 items across 15 factors, compared to 28 items and eight factors after phase 1. As with the competence domain, initial merging of the two scales resulted in a factor called *unclassified,* containing scales which on first glance did not fit with any of the other factors. After further investigation of the two scales, four of the original factors remained: *physical well-being, autonomy, security* and *influence*. After items from each were removed, *economy* and theoretical goals formed a new factor called *economy and status*. *Hedonistic* and *personal growth* merged to *comfort*. Additionally, items in the *religious* factor were rephrased to make the more broadly applicable (i.e. participate in religious activities → be true to my faith) and, together with several previously unclassified items, formed the new factor *universalism*. Finally, items from the original factor relationships were deleted due to overlap and the factor was more appropriately named family. The other five original factors (*aesthetic, social, money, self-esteem* and *unclassified*) could not be retained, as there was too much overlap within goals or with items from other domains.

For an overview of the newly developed factors and the number of items used in each domain see the right panel of Table 1. To conclude, phase 1 resulted in a much shorter version of the CC with 176 items to capture the five domains of PI (compared to the 313 items of the original scales selected). This first version of the content of STEM students' PI was used in the subsequent design phase to pilot in the Career Compass.

Phase 2: Design

The second phase consisted of the development of the CC app and its pilot test. The purpose of the pilot study was to test a first prototype of the CC app to the target population. In doing so, there were two sub-goals:

1. to ensure the comprehension of the content of the selected items,
2. to assess the quality of its design and user-friendliness.

For that several requirements were formulated that the CC had to fulfill. For the first aim it was decided that the app should contain as little text as possible while still being comprehensible. At the same time, items were to be concisely formulated so that they only could be interpreted one way. To ensure comprehension of the CC, complex words or technical terms were avoided.

To fulfill the second goal, the app had to function on many different mobile devices (e.g. laptop, tablet, mobile phone) with all commonly used operating systems (e.g. linux, android, windows) and web browsers (e.g. internet explorer, firefox). Additionally, the design of the app had to evoke a positive attitude in potential users to increase the number of participants and to motivate users to complete the entire questionnaire. Therefore, the app had to be visually appealing and easy to use, suited to users' needs. Thus, it was decided that it should take users no more than 20 minutes to finish the questionnaire. The pilot was used to identify whether this was possible, given the number of items selected in phase 1, and whether motivation was affected by this large number of items. Finally, in order to improve the branding and to make the app visually more appealing, the compass of the name Career Compass had to be integrated into the design.

With these criteria in mind the two researchers from the first phase teamed up with another researcher of the University of Twente, a web designer and a computer scientist to develop a first version of the CC app. This prototype of the app was then pilot tested. One of the main developments due to the above-mentioned requirements was the formulation of the items. In order to increase the user-friendliness of the app, the statements consisted of two parts: (1) a sentence that remained the same throughout one domain and (2) a varying part that made the item unique. For example in the item *I am honest*, the *I am* would remain constant for all items in the domain of personality, but the subsequent word (*honest*) changed constantly. The constant parts for the statements were as follows: *I am interested in* … (interests), *I am good at* …. (competences), *I find .... important* (values), *I am* … (personality) and *In the future I want to* …. (goals). Students were asked to indicate to which degree items applied to them on a seven point Likert-scale, ranging from 1=*not at all* to 7=*very much*. This design choice led to less reading for the users, which in turn was expected to increase students' motivation to finish the CC.

Respondents. Nine STEM students from the University of Twente (UT) were selected to participate in the pilot. Convenience sampling was adopted to select participants from the social network of the researcher. All students were, at that time, enrolled in one of the STEM related study programs of the University of Twente. Six students were in the final year of their master's program, two were in the third, one in the second year of their bachelor's program. Their age varied from 20 to 27 with *M*= 23.70 (*SD*=2.55). Of the nine students, five were female and four were male.

Procedure. During the pilot, students filled out the CC individually and could opt for either an English or a Dutch version of the questionnaire. The nine STEM students were split into two groups. One group, (N=5), was asked to fill in the CC while the thinking-out-loud-method (Ericsson and Simon's, 1996) was applied. Here, the goal was to capture all immediate responses students had towards the app and the content of the questionnaire. However, as this influenced the time they needed to finish the questionnaire, another group (N=4) was asked to fill in the CC as they would normally do and to completely ignore the researcher who was sitting next to them. These students were timed to see how long it would take participants to complete the CC without interference. Afterwards, the students from both groups were asked about their experiences with the CC, specifically focusing on five categories: (1) the clarity of the content, (2) their motivation to finish the questionnaire, (3) content repetition, (4) the design and user-friendliness of the CC and (5) technical glitches. Participants were also given the opportunity to mention feedback outside these categories.

While students filled out the CC, the researcher was sitting next to the participant and took notes whenever participants took more time to react to an item than it did for them to react to the items before and asked specifically about these items after they finished the questionnaire. This was done to not influence participants while they filled in the questionnaire, but to still find out the reasons for their hesitation (specifically, was this due to their inability to understand the item or due to the fact that they had to think about how it related to them). A protocol of the pilot can be found in Appendix A. Students' responses during and after filling in the questionnaire were then categorized in the aforementioned five categories to see in which way the CC could be improved to increase the motivation of the end users to completely fill it in.

Data analysis & results. For participants in both groups (thinking-out-loud group versus timed group) voice records and protocols, written by the researcher, were used to collect data. Voice records were subsequently transcribed and both transcripts and protocols codified for responses in the five categories of requirements noted earlier. The findings and resulting changes to the CC will be discussed in detail hereafter; for an overview see Table 2.

Clarity of content. On several occasions, students reported vaguely formulated items. If more than one participant mentioned an item to be difficult to understand in their respective language it was replaced by a more commonly used synonym. Students mainly mentioned that several of the items were too lengthy and could be written more concisely. Based on their responses, 17 items were rephrased and shortened. With regards to interests students also indicated that several items contained more than one hobby of theirs. This made it difficult for them to react to the statement, as their feelings toward one of the items differed with those of the second (e.g. with regards to the item *I am interested in literature and writing* - they liked literature but not writing). As a result, two *interest* items were split into two separate items to avoid more than one hobby in one item. Another item (cards and games) was merged ((card) games). Also, the following items were identified as difficult to understand and subsequently replaced by a synonym: boastful, exuberant and cunning in the English version of the CC, entertainment in the Dutch version (this item was not replaced by a synonym, but examples were given to explain it more).

Motivation. Five students reported that they found the overall length of the questionnaire acceptable. Three students stated they found the questionnaire to be too lengthy and would have not been motivated to finish it if they would not have been partaking in the pilot. However, they could not exactly pinpoint when their motivation to finish dropped. One student reported that while the overall length of the CC was acceptable, some of the domains (values and competences) contained too many items. Additionally, several students indicated that their motivation to finish the questionnaire decreased largely due to repetition of items in one or several domains. No student indicated that the *personality* domain contained too many items (despite this domain containing the most items). They stated that this was due to the fact that each item consisted of only one word and participants were able to finish that section of the CC quite fast. Thus, the researchers took the chance to increase the reliability of that domain of the CC and added five items.

Repetition. Partly due to responses of participants in the prior category (their motivation to finish the CC), all items that were indicated by one or more participants to be redundant either in their own domain or in one of the other domains of the CC was critically assessed by the two researchers. The two researchers again discussed the necessity of the two individual items and decided whether or not it they were deemed important / different enough to be kept in the CC. In this decision students' responses about their motivation to finish the questionnaire was taken into account as well. Several sections had a negative effect on their motivation (i.e. a section was seen as too long). Items in these sections were more likely to be removed than items from other sections. Responses about their motivation to finish the questionnaire were also taken as a starting point to reexamine the number of items in a certain section and to decrease the number of items in a section, even if students had not mentioned any specific items as repetitive content. This process led to the reduction of five items in the value domain.

Design & user-friendliness. When asked about the layout and user-friendliness of the CC, students' responses were highly positive. Students remarked that especially the design of the item representation (one permanent and one changing part) made for an easier read of the items and for a shorter time to fill in the entire questionnaire. This in turn was indicated to positively influence their motivation to finish the CC in its entirety. Students also expressed positive feelings about the different domains of items that were presented in different background colors and signs at the top of the website. The split in domains was again seen to have a positive effect on students' motivation to completely fill in the CC. Finally, students indicated that the app was very user friendly, especially due to its responsive design, which allowed participants to use app on several mobile devices (e.g. laptop, mobile phone).

Technical glitches. Students reported several technical glitches, most of which were related to the app design not adapting to their browser/ mobile device. Also, two students reported that they were unable to see their responses to open questions (in the second part of the questionnaire). Additionally, one student reported that when returning one question (the maximum participants were allowed to go back in the questionnaire) the app, instead of linking the user to the previous website, send them to the start of the domain they were currently answering questions on. These technical difficulties were resolved before the app was made available for all STEM students in the next phase.

Table 2
Overview of the six categories of responses (left), most important results of the pilot (middle) and subsequent changes to the Career Compass (CC; right)

Response category	Results of the pilot	Changes made to the CC
Clarity of content	- Several lengthy items - Interests: several hobbies asked in one item Difficult words: English version: - Boastful - Exuberant - Cunning Dutch version: - Entertainment	- Many items rephrased - Many items shortened - Splitting two interests items (literature and writing) into two separate items - Synonyms for the English items were used - Examples to further explain entertainment were added
Motivation to finish CC	- CC Not too long: 5 participants - CC too long: 3 participants - Not too long in total but some categories too long: 1 participant - Additionally: 4 students indicated decreased motivation due to repeated items. - no students indicated personality too long	- five items added to personality
Content repetition	- Social contacts – social networks - Fun – pleasure - True friendship – friendship - Irritable – hot-tempered - Routine – structure - Reserved – introvert - Easy life (in values and goals)	- Deletion of five values: Social contacts Pleasure Friendship Structure Easy life
Design & user-friendliness	- Very positive responses about design items, division into categories, responsive design	N.A.
Technical glitches	- App not responsive in certain browsers - Inability to see responses to open questions - Inability to go back to previous page (one case)	- Responsive design for more browsers - Visibility answer open questions - Back skipping resolved for that browser and operating system

All changes based on the results of the pilot were consistently applied in the app across the English and Dutch version, to keep the two versions the same and decrease the chance of different responses due to different language versions. The changes made in this phase of the development of the CC led to a version consisting of 177 items (see Table 3 for an overview of the post pilot version of the CC). Responses of participants in the pilot indicated that the three main aims of this phase (development of an app with clear content, appealing design and layout and good functioning) were met, after changes were made. Therefore, the CC and its underlying concept of professional identity was ready to be evaluated on a broad scale in the next phase.

Table 3
Factors, number of items n and example items of the five domains of the Career Compass at the end of phase 2

Domain	Reference	Factors	n items	Example item
Interests	Hansen and Scullard’s (2002)	athletic (1) artistic and intellectual (2) social (3) outdoor (4)	28	I am interested in… “ dancing”
Competences	Male, Bush, & Chapman, 2011 Passow, 2007	cognitive skills (1), communication (2), life-long learning (3), teams (4), STEM skills (5), management and business (6) and social skills (7)	38	I am good at… “social networking”
Values	Lyons, Higgins, & Duxbury, 2010 Ros, Schwartz, & Surkiss, 1999	achievement (1), benevolence (2), hedonism (3), power (4), security (5), self-direction (6), stimulation (7), tradition (8), universalism (9) and socialism (10)	40	I find…. important “politeness”
Personality	Ashton et al., 2004 Ashton, & Lee, 2009	honesty-humility (1), emotionality (2), extraversion (3), agreeableness (4), conscientiousness (5) and openness to experience (6)	43	I am… “responsible”
Goals	Roberts & Robins, 2000 Sheldon, Elliot, Kim, & Kasser, 2001	economy and status (1), family (2), influence (3), universalism (4), physical well-being (5), comfort (6) autonomy (7) and security (8)	28	In the future I want to be… “who I really am”

Phase 3: Evaluation

In the third phase, the CC was administered on a large scale to STEM students of two higher education institutions to statistically validate the internal validity, factor structure and reliability of the instrument and its underlying concepts.

Respondents. All students enrolled in a STEM related bachelor’s or master’s degree in the Netherlands formed the population for this phase of the research. A mixed purposeful sampling strategy was applied (Onwuegbuzie & Leech, 2007), whereby criterion sampling and maximum variation sampling were combined. This sampling strategy was chosen in order to include all students of STEM related study programs, thus ensuring that no possible group of STEM students was overlooked in the analysis. Thus students from more classical technical study programs, such as mechanical engineering, were included, but also those from more modern and broader technical study programs, such as biomedical engineering. For that, approximately 3500 students were contacted to participate. All students were enrolled in a technical study program of two Dutch higher educational institutions, the University of Twente (UT) and Saxion University of Applied Sciences (Saxion). Dutch technical study programs are classified into four clusters (I nature and science cluster, II programs outside the nature and science cluster with >50% technical courses, III programs for science teachers, and IV programs with <50% technical courses; Volkerink et al., 2010). Study programs from the first and second cluster were taken into consideration in this research.

Primarily, bachelor's (BSc) and master's (MSc) students from the last year of their respective program were contacted (fourth year BSc Sax students, third year BSc UT and second year MSc UT). These students were on the verge of making a decision about their future career, and it was hypothesized that the topic (who am I as a STEM student?) would be highly applicable to them. However, as the questionnaire was presented via a website open to everyone, students from other years participated as well and their data was used in the data analysis.

Of the ~3500 contacted students, a total of 816 filled out the Career Compass (we estimate a response rate of 23.3%). All participants with more than 10% missing answers in the CC were excluded from the analysis. This resulted in 760 participants that filled out the CC with sufficient responses. This is in line with the expected response rate for an online questionnaire of 20% (n=700) for university students (Sax, Gilmartin & Bryant, 2003). Of the participants, 58.9% were male and 34.3% were female (6.7% unknown). Their average age was *M*=22.73 (*SD*=3.03). Most students were Dutch (88.4%), 4.9% was German, and 4.3% were from another nationality (2.4% unknown). Of the 760 students, 32.2% were enrolled in a master's program at the University of Twente, 16.6% in a bachelor's program at the University of Twente, and 46.2% in a bachelors program at the Saxion University of Applied Sciences (5.0% unknown).

Instrumentation. In this phase of the research participants were presented with the version of the CC developed in the earlier two phases. For a detailed description of the CC version used in this phase of the research see Table 3 in phase 2. For a short example test version of the CC see https://surveys-igs-test.utwente.nl/career/#/app/13.

Procedure. Participants were presented with an online survey, the Career Compass. An online survey is highly suited to reach a large number people (Babbie, 2010). The research was promoted via the student advisors of the STEM study programs of the University of Twente (UT) and the Saxion University of Applied Sciences (SA). Students received an email with an invitation to participate, an explanation as to the importance of the study and information on possible rewards for their participation. In line with UT ethical guidelines, participants were informed that their participation was voluntary and that their data would be processed anonymously. However, participants were offered to receive an overview of their individual PI results, to increase the participation rate. This required personal contact information, which was stored separately from the overall dataset, to safeguard anonymity. Additionally, participants were able to participate in a raffle for seven vouchers (two worth 50 euro and five worth 20 euro). Participants answered 224 questions that made up the Career Compass and the additional questions. This process took them approximately 20 minutes. Participants were free to fill out the Career Compass at any location, at any time, but they were requested to take the time to fill it out, and find a place that was not distractive and would allow them to concentrate.

Data analysis. As the scales in the Career Compass were combined and changed in the previous two phases of the design, the reliability and validity of the assumed factor structure of PI had to be tested again for that the procedure suggested by Schmitt (2011) was used. Thus, in a first step, the internal structure of PI was analyzed. To do so, a series of confirmatory factor analyses (CFAs) was conducted to identify the initial expected factor structure of the domains. In case of poor model fit, a series of exploratory factor analyses (EFAs) was performed to establish a statistically sound concept of the five individual domains of PI. These new models of the factor structure of the domains of PI were then tested individually in CFAs. After establishing sufficiently reliable factor models, weighted mean scores were calculated for each newly developed factor. With these mean scores, EFA was performed again, in order to obtain a parsimonious set of clusters of STEM students, based on their PI.

Confirmatory factor analyses. To test the quality of the scales on PI and the construct as a whole, first order CFAs were performed on the individual scales. For that the statistics program R with the *lavaan* package was used. For the first order CFAs the weighted least square means and variance adjusted (WLSMV) estimator was used, as this estimator has been shown to be useful for simple models (Beauducel & Herzberger, 2006). For the higher order CFAs the maximum likelihood (ML) estimator was used, as the

CFAs did not converge with the WLSMV. The ML is the estimator of choice for more complicated models (Beauducel & Herzberg, 2006). Based on Kyndt and Onghena (2014), the five most commonly used fit indices were inspected to identify the quality of the model fit. First of all the chi square and the degrees of freedom were inspected. A chi square to degrees of freedom ratio equal to or smaller than three indicates sufficient model fit. Furthermore the comparative fit index (CFI) and the Tucker-Lewis index TLI) were inspected. For both, values close to .95 or higher are optimal, but values higher than .90 are considered acceptable. Finally, the standardized root mean residual (SRMR) and the root mean square error of approximation (RMSEA) were inspected. For both, a value below 0.08 is seen as sufficient to indicate an acceptable model fit. After both initial and (if necessary) a second CFA based on EFA had been conducted, the chi square ratios of both models were compared to see whether the newly developed model had significantly better model fit than the original one.

Exploratory factor analyses. To conduct Exploratory Factor Analyses (EFA), the 23rd version of IBM's statistics program SPSS was used. To select an EFA that would fit our goals and the data most optimally, a number of factors in relation to (1) the type of analysis (2) the rotation method (3) the sample size (4) the number of factors (5) and the criteria for item removal were made:

- (1) Principal axis factoring (PAF) was chosen as the strategy for analysis (in contrast to the more commonly used principal component analysis), because it takes measurement error into account (Schmitt, 2011). Furthermore, this technique results in a factor structure that is more similar to that of CFA, thus making the developed factor models more suited to the subsequent CFA in this research (Worthington & Whittaker, 2006).
- (2) Based on the assumption that the variables within the five domains are not orthogonal but interconnected to one another, an oblique rotation method was chosen, namely direct oblimin (Field, 2013).
- (3) There are many rules of thumb regarding the minimum sample size for EFA to build a model that is valid (Schmitt, 2011). This research consists of a series of independent EFAs across the five domains of PI. The various domains are measured with 28 to 43 items. Thus, according to Field (2013) the minimum sample size should be 430 participants. Therefore the 760 students who completed the Career Compass (CC) form a sufficiently large sample. Furthermore, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was also analyzed for all individual EFAs to analyze whether the sample was sufficiently large enough. Based on Field (2013) KMO values higher than .60 were deemed acceptable.
- (4)In order to determine the appropriate number of factors, the eigenvalues were analyzed (>1) and scree plots were considered. Furthermore, factors were interpreted for their connection to theoretical content. Finally, Cronbach's (α) were calculated for all developed factors to assess their reliability. Values lower than .60 were seen as poor, between .61 and .69 as mediocre, and higher than .70 as acceptable (DeVellis, 2012).
- (5) Based on Worthington & Whittaker's (2006) recommendations, item reduction was performed if one of the following cases applied: an item's highest significant factor loading is smaller than 0.3; an item is loading on several factors with more than 0.3 in the pattern matrix, the difference between the two highest factor loadings in either the pattern or the structure matrix is smaller than 0.15.

Results. *Initial CFA's.* The results of the initial CFAs (see Table 4) showed poor model fit for almost all models. Only values, competences and goals showed model fit indices pointing at sufficient model fit. For *values*, the ratio of the chi-square and the degrees of freedom were above 3 and the RMSEA and SRMR below .08, indicating sufficient model fit. However, the CFI and TLI indicated poor model fit. Model fit indices for *personality* and *competences* were similarly conflicting. For both domains only two fit indices (SRMR and RMSEA) pointed at sufficient model fit. As for only one of the tested models the majority of model fit indices showed sufficient model fit, the researchers decided to further investigate the concepts of PI in a series of EFAs.

Table 4

Output from the five individual confirmatory factor analyses (CFAs) on the five domains of professional identity

Fit indices	Critical Values indicating sufficient model fit	Interests	Competences	Values	Personality	Goals
Ratio X^2/df	<3	**6.822**	**3.924**	2.964	**3.666**	**3.731**
CFI	≥ .90	**0.454**	**0.710**	**0.657**	**0.508**	**0.698**
TLI	≥ .90	**0.400**	**0.684**	**0.620**	**0.474**	**0.646**
RMSEA	< .08	**0.088**	0.062	0.051	0.059	0.060
SRMR	< .08	**0.100**	0.076	0.077	**0.095**	0.073

Note. Bold indicating insufficient model fit. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean residual.

Exploratory factor analyses. EFAs were conducted for all domains of PI individually, to investigate the internal factor structure of the domains. Thus, a series of EFA's were conducted using principal axis factor analyses (PAFs), with an oblique rotation (direct oblimin). The Kaiser-Meyer Olkin (KMO) measure indicated a sufficient sample size (KMO > .6) for all EFA's (see Table 5). The exact structures developed in the individual EFA's will be discussed subsequently.

Table 5

Overview of the Kaiser-Meyer-Olkin values for all domains of professional identity.

Domain	KMO
Interests	.78
Competences	.82
Values	.81
Personality	.73
Goals	.66

Interests. To re-build the factor structure for STEM students' interests, EFA was performed on the 28 items. This initially resulted in an eight-factor structure. When item deletion was performed, applying the criteria discussed above, only seven items remained, in a two-factor structure. Such limited and narrow structure would not give students enough choice to express all their interests in subsequent research with this scale (i.e. distinguishing various types of STEM students based on their PI). Therefore, it was decided to force al items in a four-factor structure (as this was the number of factors in the original scale). After items that did not fulfill the criteria were removed, 13 items remained across the four factors. These factors had poor ($\alpha = .50$), to mediocre ($\alpha = .64 - .65$) to acceptable ($\alpha = .80$) reliability[1], and explained 60.17% of the total variance. The original scale contained four factors called social, outdoors, artistic & intellectual and athletic. Two of the four newly developed factors were given the same name (social and outdoors), while for the third factor the artistic part was removed and the fourth factor was titled entirely different (craftsmanship). However, the items making up these factors, even for those with the same / similar names, differed immensely from the initial items (see Table 6).

[1] Due to the low reliability of the four-factor structure, a five-factor structure was also developed, but that did not significantly improve reliability.

Table 6
Established factors within the interests *domain of professional identity*

Item	Rotated factor loadings			
	Socializing	Outdoors	Intellectual	Craftsmanship
fashion & design	.813			
shopping	.778			
beauty & health	.714			
dancing	.577			
socializing	.398			
camping		.714		
nature & outdoors		.531		
adventure sports		.448		
reading			.731	
writing			.641	
building & repair				.589
hunting & fishing				.410
gardening				.394
Eigenvalues	3.162	2.342	1.398	.920 [a]
% of variance	24.323	18.013	10.757	7.080
Cronbach's α	.80	.65	.64	.50

[a] eigenvalue <1 due to forcing a four factor structure.

Competences. A combination of two scales with a total of 38 items was used to analyze STEM students' competences. Based on the literature a seven factor structure was to be expected with the following factors: cognitive, communication, life-long learning, teams, STEM, management & business and social skills. The first EFA resulted in a nine-factor structure. Items and established factors were then analyzed on whether they met the established criteria, and if not items were deleted and EFA was performed again. After three rounds of this process, a final seven-factor structure was established, based on 22 items (see Table 7). The seven new factors were partly the same as before (life-long learning), partly a combination of several former factors (management: made up of communication and management), partly split up in new factors (cognitive: into cognitive and scientific) and partly completely new factors (international orientation, design skills and scientific skills). Their reliability differed from poor (α = .54 - .55) via mediocre (α = .61 - .67) to acceptable (α = .76 - .84). Taken together they explained 57.47% of the total variance.

Table 7

Established factors within the competences *domain of professional identity*

Item	Rotated factor loadings						
	Managerial skills	Cognitive skills	Collaboration skills	International orientation	Design skills	Life-long learning skills	Scientific skills
convincing others	.774						
leadership & management	.761						
negotiation	.720						
conflict management	.716						
entrepreneurship	.645						
chairing meetings	.642						
giving a presentation	.537						
analyzing problems		.879					
thinking analytically		.817					
developing solutions to complex problems		.736					
collaborating with people outside my own discipline			.769				
collaborating with peers			.718				
collaborating in a diverse context (i.e. culture, gender, ethnicity)			.629				
speaking a second language (e.g. Dutch, Chinese)				.834			
having an international orientation				.643			
establishing goals for product design					.863		
designing systems and products					.846		
learning independently						.868	
motivating myself						.754	
evaluating myself						.322	
scientific writing							.894
conducting scientific research							.852
Eigenvalue	5.35	2.29	1.47	1.38	1.28	1.17	1.02
% of variance	24.33	10.41	6.72	6.27	5.80	5.30	4.64
Cronbach's α	.84	.79	.61	.55	.67	.54	.76

Values. Based on the initial scale, a ten-factor structure (achievement, benevolence, hedonism, power, security, self-direction, stimulation, tradition, universalism and sociality) was expected for the domain of values (40 items in total). After several EFA's in which item reduction based on the criteria for factor loadings was performed a final five-factor structure, consisting of 20 items was developed. In that structure, four original factors remained, namely hedonism, tradition, stimulation and universalism. Additionally, items from the two initial factors power and achievement were combined to the new factor 'power and achievement". The five new factors varied in reliability from mediocre (α = .65 - .69) to acceptable (α = .84). Together they explained 57.47% of the total variance (see Table 8).

Table 8

Established factors within the values *domain of professional identity*

	Rotated factor loadings				
Items	Power and achievement	Universalism	Stimulation	Hedonism	Tradition
social status	.859				
preserving my public image	.751				
authority	.729				
influence	.715				
a good salary	.686				
success	.634				
social recognition	.516				
taking responsibility for ethical concerns		.754			
protecting the environment		.741			
making a contribution to society		.715			
helping people		.463			
intellectual stimulation			.830		
lifelong learning			.750		
challenge			.671		
fun				.775	
enjoying life				.759	
true friendship				.658	
politeness					-.796
respect for tradition					-.757
honoring parents and elders					-.731
Eigenvalues	4.109	2.813	1.961	1.442	1.168
% of variance	20.545	14.066	9.807	7.212	5.839
Cronbach's α	.84	.69	.65	.65	.68

Personality. Initially, 43 items were used to test STEM students' personality across six factors: extroversion, honesty, emotionality, agreeableness, conscientiousness and open-mindedness. Two cycles of EFA and item reductions were necessary to develop the final factor structure of STEM students' personality, containing 19 items (see Table 9). Note that this version contains two items with two factor loadings slightly above .3 even though this had been a criterion for item reduction. The reason was theory-driven; in keeping these items it was avoided that the factors would collapse. Deleting the two items led to the merge of the two factors honesty and agreeableness. Nevertheless, reliability analysis on the six developed factors showed that honesty and agreeableness had poor reliability score (α = .53 - .59). Open-mindedness was shown to have a mediocre reliability (α = .69) while the remaining three factors had values indicating acceptable reliability (α = .72 - .81). Of the total variance, 63.08% were explained by the six factors.

Table 9
Established factors within the personality *domain of professional identity*

	Rotated factor loadings					
Items	Extraversion	Honesty	Emotionality	Conscientiousness	Open-mindedness	Agreeableness
silent	.855					
reserved	.826					
introvert	.826					
spontaneous	-.642					
enthusiastic	-.530					
arrogant		.712				
devious		.697				
self-centered		.659				
sensitive			.925			
emotional			.879			
slack				-.782		
lazy				-.756		
self-disciplined				.740		
irresponsible				-.572		-.319 [a]
imaginative					.854	
artistic					.853	
hot-tempered						-.736
irritable						-.685
rational		.312 [a]				.553
Eigenvalue	3.251	2.639	2.236	1.632	1.219	1.017
% of variance	17.113	13.889	11.770	8.544	6.414	5.354
Cronbach's α	.81	.59	.81	.72	.69	.52

[a] Items with a second factor loading >.3 that were not removed in order to retain a six factor structure.

Goals. For STEM students' goals, an eight factor structure was initially assumed with the following factors: economic and status, family, influence, universalism, physical thrive, comfort, autonomy and security. This structure contained 28 items. After four rounds of item reduction and EFA, a five factor structure with 14 items was settled on (see Table 10). In this structure, five of the original factors were retained: influence, comfort, physical thrive, universalism and security and no new factors emerged. Reliability analysis for the five factors indicated that two factors were only poorly reliable (α = .55 - .59), one was mediocre (α = .64) and two were acceptable (α = .74 - .76). Combined the factors explained 63.31% of the total variance.

Table 10

Established factors within the goals *domain of professional identity*

Items	Rotated factor loadings				
	Influence	Comfort	Physical	Universalism	Security
be a leader	.819				
be an authority in my field of work	.795				
have an impact on what other people do	.748				
be someone people go to for advice	.597				
avoid hard work		.875			
have an easy life		.770			
be in a good physical condition			-.841		
physical exercise			-.811		
eat healthy			-.681		
have harmonious relationships with my parents and siblings			-.400		
understand my place in the universe				-.887	
know my purpose in life				-.881	
have routine and structure					.878
lead a predictable life					.732
Eigenvalues	2.635	2.130	1.609	1.428	1.062
% of variance	18.821	15.214	11.491	10.203	7.584
Cronbach's α	.74	.59	.64	.76	.55

Final confirmatory factor analyses. Based on the series of EFA's on each dimension of PI, the newly developed factor structure consisted of 27 factors. CFAs were performed on this new factor structure, to analyze whether the model fit of the newly established domains of PI had improved relative to the first CFA's. The RMSEA and SRMR values for all domains of PI were acceptable for the final CFAs. And while none of the CFI and TLI values reached the threshold of .90, their values increased for all domains of PI, with all values being at or above the .80 threshold. The chi square ratios of all domains improved significantly, but stay above 3 for all domains except values and goals (p < .05). See Table 11 for a more detailed description.

Table 11

Model fit indices for the final CFAs of all domains of PI and improvement of model fit compared to initial CFAs

Fit indices	Values indicating sufficient model fit	Interests	Competences	Values	Personality	Goals
Ratio X^2/df	<3	**5.569**	**3.033**	2.819	**3.540**	2.820
CFI	≥ .90	**0.849**	**0.880**	**0.865**	**0.852**	**0.894**
TLI	≥ .90	**0.800**	**0.853**	**0.839**	**0.816**	**0.855**
RMSEA	< .08	0.078	0.052	0.049	0.058	0.049
SRMR	< .08	0.060	0.048	0.056	0.057	0.045
Δ X^2 initial and final CFAs	$p < 0.05$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$

Note. Bold indicating insufficient model fit. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean residual.

Formation of clusters in PI STEM students. As a final step, to arrive at a more parsimonious set of clusters in types of STEM students based on the PI measure, the 27 factors were inserted in an EFA, and weighted mean factor scores were calculated. This resulted in a structure of seven clusters consisting of 21 of the former factors, explaining 61.69% of the total variance (see Table 12). The seven new clusters were given labels to fit the content of the factors, to determine the types of STEM students and titled *status driven, hip, geeky, outdoorsy, uncertainty avoidant, nerdy* and *creative*. *Status driven* STEM students desire status and are driven to influence others. At the same time they are good at managing tasks and people and score lower on the honesty scale of personality. *Hip* STEM students value fun, enjoying life but also tradition. They are more spiritual and more social than other STEM students. At the same time they are also more emotional than their non-hip colleagues. A *geeky* student is “very interested and knows a lot about a particular field or activity” (Geek, n.d.). They are very precise people who are good at motivating themselves to learn and are willing to work hard. The *outdoorsy* type of STEM student is likes nature and being outside, taking an interest in for example camping, fishing or building things. The *uncertainty avoidant* STEM student finds routine and structure very important and values predictability. At the same time, they are not very internationally oriented (i.e. does not seek contact with people from other cultures). A nerd is defined as “a person who is very interested in technical subjects, computers etc.” (Nerd, n.d.). In line with that, the *nerdy* STEM student is very good at conducting scientific research, while also excelling at being analytical and solving problems. Finally, the *creative* STEM student has distinctive design competences and is highly imaginative and artistic.

Table 12

Established seven types of STEM students based on EFA

	Rotated factor loadings						
Initial factor	Status driven	Hip	Geeky	Outdoorsy	Uncertainty avoidant	Nerdy	Creative
Value status	**.873**						
Goal influence	**.697**						
Competence management	**.540**						
Personality honest	**-.436**						
Value hedonism		**.564**					
Value universalism		**.550**					
Personality emotionality		**.540**					
Interest social		**.525**					
Value tradition		**.471**					
Goal universalism		**.371**					
Personality conscientiousness			**.915**				
Competence life-long learning			**.524**				
Goal comfort			**-.396**				
Interest craftsmanship				**.728**			
Interest outdoors				**.582**			
Goal security					**.651**		
Competence international orientation	.191[a]				**-.333**		
Competence STEM						**.652**	
Competence cognition						**.542**	
Competence design							**.594**
Personality open-mindedness							**.552**
Eigenvalues	3.495	2.513	1.726	1.589	1.422	1.171	1.038
% of Variance	16.645	11.964	8.220	7.568	6.711	5.576	4.944
Cronbach's α	.615	.665	.581	.614[b]	.337[b]	.530[b]	.418[b]

[a] item with Δ highest and second highest factor leading > .15 that was not removed in order to avoid factor collapse.
[b] reliability was assessed with Spearman-Brown coefficient rather than Cronbach's alpha, as Spearman-Brown is more reliable for factors consisting of only two items (Eisinga, te Grotenhuis, & Pelzer, 2013).

Conclusion Study 1a

Study 1a aimed to fulfil two goals: (1) to develop an instrument to measure STEM students PI in a reliable and valid manner and (2) to identify types of STEM students based on their PI. To develop this typology, a quantitative research with a large number of participants was used, which is likely to generate good generalizability. Results from this study indicate that these goals were largely fulfilled, as this research succeeded in developing the Career Compass (CC). This instrument was judged by pilot testers to be attractive and usable, while statistical analyses showed sufficient reliability in the internal factor structure. Moreover, this research was the first to identify seven types of STEM students discernable by their PI, namely *status driven*, *hip*, *geeky*, *outdoorsy*, *uncertainty avoidant*, *nerdy* and *creative*. Thus the research succeeded in providing much needed insight into the content of STEM students PI. Moreover, the seven types of STEM students differed much in what made up the content of their PI. Some, such as the nerdy type of STEM student showed more stereotypical traits, for example being very intelligent (Hong & Lin-Siegler, 2012), while others were characterized by traits that are perceived to be less typical for STEM students, such as the hip STEM student being sociable (Rommes et al., 2010). These findings can be used to analyze whether the degree to which STEM students are stereotypical influences their decision to pursue a career inside or outside of the technical sector, as was done in the Study 1b of this research.

Study 1b

The purpose of Study 1b was to examine the relationships between STEM students' personal characteristics, career choices, identification with future profession and the content of their PI, based on the 7 clusters derived from Study 1a.

Method

Research design. Study 1b aimed to identify the relationships between the various concept that influence PI or are influenced by it (Figure 2). A cross-sectional research design was chosen to investigate relationships between variables for this study. This design allowed for data collection from a large population in a short amount of time.

Sample. For Study1b, the same data was used as in study 1a, thus the sample was by enlarge same. However, because there were missing cases on the additional questionnaires, but not on the items measuring PI content, the number of participant in Study 1b was lower compared to Study 1a: From the 760 cases, 651 (85.7%) completed the entire questionnaire. The other 109 cases missed between one and 14 answers, but were all included in the analyses as they answered more than 90% of all questions.

Table 13
Participants' characteristics, possible outcomes of variables and codification

Variable	Categories	Percentage	Code
Gender	Female	34.3	0
	Male	58.9	1
Level of education	University	51.4	0
	University of applied sciences	48.6	1
Type of study	Cluster I[1]	38.8	0
	Cluster II[2]	59.2	1
Time till graduation (in years)	<0.5	46.1	0
	0.5 - 1	21.1	1
	>1	30.8	2

[1]≥ 75% technical courses in study
[2]≥ 50% technical courses in study

Instrumentation & procedure. The procedure and instruments for the CC was similar as in Study 1a. In addition, after filling out the CC students were asked additional questions about their identification with engineers (i.e., strength of PI), their intended career choice, and their personal and educational background. Information about the scales and items used in this study (1b) is discussed hereafter (see for an overview of codification Table 13).

Content of Professional Identity (PI), consisted of seven clusters of STEM students derived from Study 1a, namely *status driven*, *hip*, *geeky*, *outdoorsy*, *uncertainty avoidant*, *nerdy* and *creative* STEM students. *Status driven* STEM students desire to influence others, can manage very well and score lower on the honesty scale of personality. *Hip* STEM students cherish fun and enjoying life but also tradition. They are spiritual, social and emotional. *Geeky* students are very precise people who hardworking and lifelong learners. The *outdoorsy* type of STEM student takes an interest in outdoor activities, such as camping, fishing or building things. The *uncertainty avoidant* STEM student values routine, structure and predictability. At they are not very internationally oriented. The *nerdy* STEM student excels at conducting scientific research and is very analytical. Finally, the *creative* STEM student is imaginative and artistic and possesses great design competences. Exploratory analysis on the seven cluster scores of STEM students showed normal distributed variables with minimum and maximum values between about -4 and 3 and a *SD* of about one scale point (see Table 14).

Table 14
Distribution of the weighted mean scores of the variables of the seven types of STEM students detected in study 1a

Type STEM student	N	Minimum	Maximum	Mean	*SD*
Status driven	760	-3.02	2.95	0.00	.92
Hip	760	-3.79	2.23	0.00	.87
Geeky	760	-3.13	2.24	0.00	.92
Outdoorsy	760	-2.92	2.33	0.00	.83
Uncertainty avoidant	760	-2.61	1.89	0.00	.78
Nerdy	760	-3.10	2.10	0.00	.79
Creative	760	-2.19	2.25	0.00	.78

In addition, correlations between the seven clusters of STEM students were inspected. As the number of participants (n=760) in this study was large, nearly all STEM student clusters correlated significantly with one another. Therefore correlations were interpreted based on effect sizes (.10 = small; .30 = medium; .50 = large; Cohen, 1992). Results indicate mostly small and some medium effect sizes (see Table 15).

Table 15
Correlation between the seven types of STEM students

	Status driven	Hip	Geeky	Outdoorsy	Uncertainty avoidant	Nerdy	Creative
Status driven	1	.10	.16	.10	-.12	.23	.37
Hip	.10	1	.17	-.02[a]	.14	-.07	.29
Geeky	.16	.17	1	.11	-.14	.21	.07[a]
Outdoorsy	.10	-.02[a]	.11	1	-.06[a]	.39	.19
Uncertainty avoidant	-.12	.14	-.14	-.06[a]	1	-.13	-.28
Nerdy	.23	-.07	.21	.39	-.13	1	.24
Creative	.37	.29	.07[a]	.19	-.28	.24	1

[a] Correlation is not significant with p< .05.

Participant characteristics consisted of *gender* (male/female), *educational institution* (university/university of applied sciences) study program (Cluster I/Cluster II; see Table 24) and time until graduation (within half a year/ one year/more than one year).

Strength of PI, or participants' identification with their future profession as engineer, was measured with six items (e.g. "*Becoming an engineer is an important part of how I see myself*." Ellemers et al., 1999) on a 7 point Likert scale (1 = strongly disagree; 7 = strongly agree) Reliability of the scale was high (α= .863).

Intended career choice was measured via two open questions, namely "Please give an example of an organization that you would like to work for (i.e. Shell, Rabobank, University of Twente)." and "What job function would you like to have in the future (i.e. researcher, consultant, manager)?". Open answers were coded in either STEM related or non-STEM related organizations and job functions. The final variable consisted of four categories (0= technical job in a technical organization, 1= non-technical job in a technical organization, 2= technical job in a non-technical organization, 3= non-technical job in a non-technical organization). Coding showed that many participants named several job functions or organizations often mixing both technical and non-technical ones. It was decided that answers with a majority of either technical or non-technical jobs/organizations would count in the corresponding category (e.g. “researcher/ engineer/ manager” was seen as technical), while in case of an even mix between technical and non-technical examples (e.g. “manager/ engineer”), or a generic answer (e.g. big company), the answer was coded as undecided and was not taken into account in the subsequent analyses. This resulted in 22.0% of the answers being coded *undecided* (for an overview of the distribution of other intended career choices, see Table 16).

Table 16
STEM students' intended career choice (in percent)

	Technical job	Non-technical job
Technical organization	20.3	19.6
Non-technical organization	7.4	22.4

Note. Of the STEM students, 22.0% were undecided in job and/or organization, 8.4% did not answer the questions.

Results

Study 1b aimed at answering five research questions (RQs) regarding the relationship between demographic and career choice variables and the professional identity (PI) of STEM students (see Figure 2). Analyses conducted to answer each RQ are discussed below.

RQ B1: What is the impact of STEM students' characteristics on the content of their PI?. To investigate whether STEM students' educational and personal characteristics determined their type of PI, a MANOVA was performed. Only main-effects were included in this MANOVA, as analyzing all interaction effects would have surpassed the scope of this research. Pillai's trace was chosen as test statistic as it has been shown to have the most power in case the group size differs on more than one variable (Stevens, 1980 in Field, 2013). It is also the most robust test statistic for large sample sizes, if there is a varying number of participants across groups and in case of homogeneity of covariance matrices (Bray & Maxwell, 1985 in Field, 2013). This is the case for the data in this research.

Results of the MANOVA demonstrated, significant multivariate effects for all four independent variables on the cluster scores of type of STEM students ($p< .05$, see Table 17). Univariate tests of all IVs whose multivariate tests were significant were then inspected. Analysis of the univariate tests showed that while the influence of the various personal characteristics on STEM students' PI differed, no characteristic influenced the degree to which STEM students were uncertainty avoidant ($p< .05$ in all cases). Generally, effect sizes were quite small ($d= .011 - .202$) and differed considerably with effect sizes for hip, outdoorsy and nerdy STEM students often being biggest. Results from the univariate analyses will be discussed in more detail below.

Table 17
Results of multivariate tests of MANOVA of STEM students' characteristics on their professional identity content.

IVs	Pillai's Trace	F	DF	Error of DF	P
Gender	.331	47.528	7	671	.000
Educational institution	.080	8.331	7	671	.000
Study program	.065	6.675	7	671	.000
Time till graduation	.0.51	2.504	14	1344	.002

Gender. Univariate effects of gender on clusters of STEM students were al significant, except for uncertainty avoidant and creative students. Specifically, on average women scored higher on being hip and geeky compared to men. In contrast, men scored higher on being status driven, outdoorsy and nerdy compared to women (see Table 18).

Table 18
Effects of gender on the type of STEM student.

Type of STEM student	Female		Male		$F(7, 671)$	p	d
	M	*SD*	*M*	*SD*			
Status driven	-.148	.062	.078	.046	8.719	.003	.013
Hip	.496	.050	-.312	.037	171.345	.000	.202
Geeky	.117	.063	-.109	.047	8.417	.004	.012
Outdoorsy	-.309	.054	.172	.040	53.119	.000	.073
Uncertainty avoidant	.062	.054	-.012	.040	1.252	NS	.002
Nerdy	-.140	.051	.111	.038	16.109	.000	.023
Creative	-.047	.052	.007	.039	.717	NS	.001

Educational institution. Only three univariate effects of the educational institution on the type of STEM students were significant, namely hip, nerdy and creative students. University students scored on average higher on being nerdy than students at a university of applied sciences. On the other hand, university of applied sciences students were more likely to fall in the hip or creative cluster of STEM students (see Table 19).

Table 19
Effects of educational institution on the type of STEM student

Type of STEM student	University		University of applied sciences		$F(7, 671)$	p	d
	M	*SD*	*M*	*SD*			
Status driven	.-041	.058	-.028	.062	.022	NS	.000
Hip	-.043	.047	.228	.050	13.759	.000	.020
Geeky	.034	.059	-.026	.063	.421	NS	.001
Outdoorsy	-.074	.050	-.063	.054	.018	NS	.000
Uncertainty avoidant	-.020	.050	.070	.054	.1303	NS	.002
Nerdy	.159	.047	-.189	.051	21.949	.000	.031
Creative	-.147	.049	.107	.052	11.121	.001	.016

Study program. Univariate effects of the type of study program (cluster I or cluster II) on the type of STEM student were significant in four cases: status driven, hip, outdoorsy and nerdy. Generally, cluster I STEM students were slightly more outdoorsy and nerdy, while cluster II students were more status driven and hip (see Table 20).

Table 20
Effects of study program on type of STEM student

Type of STEM student	Cluster I		Cluster II		$F(7, 671)$	p	d
	M	*SD*	*M*	*SD*			
Status driven	-.150	.063	0.81	.046	8.736	.003	.013
Hip	.003	.051	.181	.037	7.983	.005	.012
Geeky	-.019	.064	.027	.047	.340	NS	.001
Outdoorsy	.016	.055	-.153	.040	6.292	.012	.009
Uncertainty avoidant	.087	.055	-.038	.040	3.364	NS	.005
Nerdy	.093	.052	-.123	.038	11.301	.001	.016
Creative	-.068	.053	.039	.039	2.124	NS	.003

Time till graduation. Univariate analysis of the time a STEM student has to study till they graduate and the cluster of STEM student they belong to showed significant effects for three cluster if STEM students: status driven, outdoorsy and creative. Students who had less than half a year to study proved to be the most outdoorsy (while students with more than one year to study being the least outdoorsy). Students with more than one year till graduation were the most status driven and creative types (students with remaining study time between a half and one year coming in second in both cases, see Table 21).

Table 21
Effects of time till graduation on type of STEM student

Type of STEM student	< .5 year		.5 – 1 year		> 1 year		*F* (14,1344)	p	d
	M	*SD*	*M*	*SD*	*M*	*SD*			
Status driven	-.137	.054	-.060	.081	.092	.071	3.074	.047	.009
Hip	.160	.044	.029	.066	.087	.057	1.740	NS	.005
Geeky	.080	.055	-.120	.083	.051	.072	2.362	NS	.007
Outdoorsy	.029	.047	-.028	.070	-.207	.061	4.318	.014	.013
Uncertainty avoidant	.061	.047	.008	.071	.005	.062	.376	NS	.001
Nerdy	-.038	.044	.067	.067	.041	.058	.618	NS	.002
Creative	-.113	.046	.068	.068	.101	.059	3.744	.024	.011

RQ B2: What is the impact of STEM students' characteristics on the strength of their identification with their future profession?. To investigate whether STEM students' personal and educational characteristics influenced their level of identification with their future profession, a one-way independent ANOVA was performed. Results showed significant effects for all characteristics, except students' time till graduation. Overall, male students showed higher levels of strength of PI than female students. At the same time results indicated higher levels of strength of PI for university students than for students enrolled in a university of applied sciences. When comparing students from a cluster I and those from a cluster II study program, cluster I students identified more with their future profession (see Table 22).

Table 22
Influence of STEM students' personal characteristics on the strength of their PI

Characteristic		*M*	*SD*	*F*(1, 677)	p	d
Gender	Female	4.574	.073	6.589	.010	.010
	Male	4.805	.054			
Educational institution	University	4.849	.068	8.980	.003	.001
	University of applied sciences	4.530	.073			
Study program	Cluster I	4.837	.074	10.230	.001	.015
	Cluster II	4.543	.055			
Time till graduation	< .5 years	4.690	.064	.386[a]	NS	.013
	.5 – 1 year	4.631	.096			
	> 1 year	4.748	.083			

[a] *F*(2,677)

RQ B3: What is the impact of STEM students' characteristics on their intended career choice?. To investigate how STEM students' personal and educational characteristics influence their future career choices, first, loglinear analysis was performed to investigate whether student characteristics influence career choice and whether interaction effects exist. Results showed overall a significant model fit with significant main and two-way interaction effects, but insignificant three-, four and five-way effects (see Table 23).

Table 23

Main effects and one- till five-way interaction effects of student characteristics on their intended career choice

	K	df	Pearson Chi-Square	Sig.
K-way and Higher Order Effects	1	143	1554.950	.000
	2	133	935.901	.000
	3	99	112.190	NS
	4	47	19.519	NS
	5	10	.241	NS

Afterwards all main effect were further analyzed with Pearson's Chi-square test, however, interaction effects were not analyzed due to the scope of the research. Cramer's V was used to calculate the effect sizes, as this is an adequate for designs for contingency tables larger than 2x2 as is the case in this research (Field, 2013). Coding of the possible career choice outcomes are presented in Table 24.

Table 24

Categories for STEM students' intended career choice

	Technical job	Non-technical job
Technical organization	0	1
Non-technical organization	2	3

Overall, results show significant association between the personal and educational characteristics of STEM students and their intended career choice. However, effect sizes of these associations remain rather small as Cramer's V <.5 in all cases (Field, 2013; see Table 25)

Table 25

Individual Pearson's Chi-square tests of STEM students' personal and educational characteristics on their intended career choice

	X^2	p	Cramer's V
Gender	56.428	.000	.336
Educational institution	36.088	.000	.267
Type if study	67.070	.000	.358
Time till graduation	28.019	.000	.164

Gender. Pearson's Chi-square test indicated a significant association between the gender of a STEM student and their intended career choice. Results indicated that women were significantly more represented in categories 2 and 3, while men were significantly higher represented in categories 0 and 1. Thus, male STEM students appeared to be more interested in a career in a technical organization, while for female students a non-technical environment (i.e. organization) seemed to be more desirable (regardless whether the job was technical or non-technical, see Table 26).

Educational institution. Pearson's Chi-square test showed a significant association between the educational institution of STEM students and their intended career choice in all but one category, namely category 3. Overall, university students were more likely to fall into categories 0 or 1, while university of applied science students were more likely to aim at a career in category 2. While most students tended to choose for a technical job, university students seemed significantly more interested in working in a technical environment than students from a university of applied sciences. Thus, university students were significantly more interested in working in a technical environment, while students from the university of applied sciences chose more often for a technical job in a non-technical organization. No differences were found with regards to a career completely outside the technical sector (category 3).

Type of study. Pearson' Chi-square tests indicated significant association between the type of study of STEM students (cluster I/ cluster II) and their intended career choice for all but one category, namely category 1. The outcome indicated that cluster I STEM students were more likely to choose a career in category 1, while cluster II students were more likely to choose category 2 or 3. This showed that cluster I students were significantly more interested in a purely STEM related career (technical job in a technical organization), while cluster II students were much more interested in a career in a non-technical environment than their peers from the respective other cluster.

Time till graduation. Pearson's Chi-square indicated significant association between the time a STEM student has left till graduation and their intended career choice in all categories, except for category 1. Students with less than a half year till graduation were significantly more represented in category 1 than students who had more than one year left before graduation (no significant difference with students who graduated within one year). Students with more than one year till graduation were significantly more likely to intend a career in category 2 than all students with a shorter time till graduation. They were also significantly more likely to choose category 3 than students with less than half a year till graduation (no significant difference with students who graduated within one year). This implied that time till graduation did significantly influence career choice in all cases except for students who were interested in a career in both a technical job and technical organization. This was indicated by the fact that students who nearly graduate significantly differ from students who need to study for more than one year in all categories but category 0.

Table 26
Effects of STEM students' personal characteristics on their intended career choice

		0	1	2	3
Gender	Female	18.7	17.6	20.3	43.4
	Male	35.0	33.8	5.4	25.9
Educational institution	University	34.7	32.3	3.6	29.5[a]
	University of applied sciences	22.6	23.7	18.3	35.4[a]
Type of study	Cluster I	45.3	32.5[a]	3.9	18.2
	Cluster II	18.7	25.2[a]	15.0	41.1
Time till graduation	< .5 years	31.3[a]	34.6[a]	7.4[a]	26.7[a]
	.5 – 1 year	29.5[a]	29.5[a b]	6.3[a]	34.8[a b]
	> 1 years	24.7[a]	18.7[b]	18.1	38.6[b]

Note. Data in percentage within characteristic (i.e. 18.7% of all *female* STEM students opted for a category 0 career).
[a, b] Differences between these groups are not significant in that category.

RQ B4: Are there differenced in STEM students' strength of identification with their future profession, depending on the content of their PI?. A Multiple regression analysis was performed to identify in what manner the various types of STEM students' PI influence students' strength of identification with their future profession (Q5). The R^2 and adjusted R^2 were analyzed to estimate to what extent STEM students' strength of identification can be predicted by their type of STEM student PI. Results show a significant association between STEM students' cluster of PI and their strength of PI ($F(7,752) = 19.311$, $p = .000$) with an $R^2 = .152$. Looked at individually, strength of identity was significantly influenced by the cluster of STEM student in all but two cases (status driven and geeky students) for which $p< .5$ did not apply. The cluster hip STEM students showed the only negative relationship of cluster STEM student to strength of PI, while all other cluster of STEM students positively influenced strength of PI. Comparing the magnitude of the effects, the cluster uncertainty avoidant showed the most impact (β=.219), while being creative had the least impact (β=.104) on how much STEM students identified with their future profession (see Table 27).

Table 27
Effects of the type of STEM student on the strength of their PI

Cluster STEM student	b	SE b	β	t	p
Constant	4.670	.038		124.487	.000
Status driven	.030	.045	.025	.670	NS
Hip	-.201	.048	-.156	-4.169	.000
Geeky	.032	.043	.027	.742	NS
Outdoorsy	.235	.050	.174	4.739	.000
Uncertainty avoidant	.314	.052	.219	6.006	.000
Nerdy	.259	.054	.184	4.771	.000
Creative	.148	.058	.104	2.546	.000

RQ B5: Are there differences in the career choice of STEM students, depending on the content of their PI?. Multinominal logistic regression was performed to determine how the seven types of STEM students determine STEM students' career choice. Nagelkerke's adjusted value was used to analyze the effect size measures for the model. Additionally, the 'odds ratio' was used to analyze in what manner students' PI influenced their career choice.

First, the intercept only model, which assumes only random errors, was compared to the model that assumes systematic variation between STEM students' career choice and the cluster they belong to. Comparing the intercept model and the final model, model fit indices and log likelihood indicated indeed systematic variation (Δ AIC = 153.784, Δ BIC = 64.093, Δ -2LL = 195.783). Person and deviance statistic tests were both insignificant, indicating sufficient model fit. Looking at Nagelkerke's adjusted value showed that the model explained 33.3% of the variance. Analysis of the individual clusters of STEM students revealed that all significantly influenced students' intended career choice (see Table 28).

Table 28
Influence of the individual predictors (clusters of STEM students) on the intended career choice

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	1300.978	1390.669	1258.978	59.624	3	.000
Status driven	1298.994	1388.684	1256.994	57.640	3	.000
Hip	1276.127	1365.817	1234.127	34.773	3	.000
Geeky	1253.431	1343.122	1211.431	12.077	3	.007
Outdoorsy	1255.386	1345.077	1213.386	14.032	3	.003
Uncertainty avoidant	1272.042	1361.733	1230.042	30.688	3	.000
Nerdy	1270.518	1360.208	1228.518	29.164	3	.000
Creative	1251.048	1340.739	1209.048	9.695	3	.021

The magnitude and direction of the influence of the cluster of STEM students on their intended career choice was also analyzed (see Table 29). This indicated that being a *status driven* STEM student increased the likelihood of being in either category 1 or category 3 by about 2.6, but did not affect their likelihood to opt for a career in category 2. Thus, being status driven resulted in an increased interests in a career in a non-technical job either in a technical or non-technical environment. On the contrary, *hip* STEM students were far more likely to end up in a non-technical organization, with either a technical (exp(b) = 3.109) or a non-technical job (exp(b) = 1.795). Being *geeky* influenced STEM students' career choice only in one way, namely that they were more likely to end up in category 3 (exp(b) = 1.585), thus aiming for a non-technical job in a non-technical organization (being geeky also signified marginal significance (α = .064) for an increased likelihood for opting for category 1). Being an *outdoorsy* STEM student did not significantly predict any differences in likelihood of opting for a career in either category 0, 1, or 2 and only marginally significantly (p = .061) predict that students were less likely to opt for a career in category 3 (exp(b) = .728). Thus indicating that the outdoorsy type had little discriminative power. Looking at the results for *uncertainty avoidant* STEM students showed no significant differences between opting for category 0 or 2, but did indicate that uncertainty avoidant STEM students were significantly less likely to choose a career in either category 1 or 3 (exp(b) = .619 and = .370 respectively). Thus, indicating that uncertainty avoidant students were very motivated to find a technical job in either a non-technical or technical environment. Results for the *nerdy* STEM students show that they ae significantly less likely to choose a career in any other category than 0 (exp(b) <1 in all three categories 1, 2, 3), showing that nerdy STEM students were mostly interested in a career in both a technical job and a technical organization. Finally, *creative* STEM students showed no significant difference when comparing their intended career choice in either category 0 or 2, but were significantly less likely to intend a career in category 1 or 3 (exp(b) =.603 and =.575 respectively), indicating that creative STEM students were more likely to choose a technical job in either a technical or non-technical environment.

Conclusion Study 1b

Results of Study 1b showed that the concepts of STEM students' personal and educational characteristics, their PI, the strength of their identification with their future profession and their intended career choice are indeed closely connected. First, in relation to RQ B1 results show that all four characteristics of STEM students (gender, level of education, type of STEM study and time till graduation) influence the content of PI. Hereby, the personal characteristics of STEM students showed the highest effects on the degree to which STEM students are *hip, outdoorsy* or *nerdy*. In relation to RQ B2, STEM students' strength of PI was influenced by three of the four characteristic (gender, level of education, and type of study program). Males, university students, and cluster I students showed higher levels of PI than their female, university of applied science or cluster II students, respectively. Additionally, answering RQ B3, all four personal characteristic of STEM students influenced their career choice. Most notably, female students, while aiming for a technical job, were eager to find a job in a non-technical environment. In relation to RQ B4, analysis of how STEM students' PI influenced the strength of their identification with their future profession revealed that all but two types of STEM students (status driven and geeky) significantly affect the strength of PI. Hereby being *uncertainty avoidant* or *nerdy* had the most impact on STEM students' strength of PI. Finally, referring to RQ B5, all seven types of STEM students influence STEM students' intended career choice within or outside the technical field. Results indicated that *nerdy* and *uncertainty avoidant* STEM students were least likely to pursue a career outside the technical sector, while *status driven* and *hip* STEM students were most likely to leave the technical sector after graduation.

Findings from both Study 1a and Study 1b will be discussed in more detail hereafter.

Table 29
Influence of the type of STEM student on their intended career choice

		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	95% Confidence Interval for Exp(B) Upper Bound
1 non-technical job + technical organization	Intercept	.028	.133	.045	1	.831			
	Status driven	.974	.165	34.704	1	.000	2.647	1.915	3.660
	Hip	.049	.169	.083	1	.773	1.050	.754	1.461
	Geeky	.268	.145	3.432	1	.064	1.307	.985	1.735
	Outdoorsy	.251	.166	2.277	1	.131	1.285	.928	1.779
	Uncertainty avoidant	-.480	.180	7.070	1	.008	.619	.435	.882
	Nerdy	-.553	.187	8.740	1	.003	.575	.399	.830
	Creative	-.506	.196	6.688	1	.010	.603	.411	.885
2 technical job + non-technical organization	Intercept	-1.165	.203	33.095	1	.000			
	Status driven	.073	.221	.108	1	.742	1.075	.697	1.658
	Hip	1.134	.243	21.759	1	.000	3.109	1.930	5.007
	Geeky	-.032	.195	.027	1	.870	.969	.660	1.421
	Outdoorsy	-.250	.222	1.269	1	.260	.779	.504	1.204
	Uncertainty avoidant	-.301	.250	1.444	1	.229	.740	.453	1.209
	Nerdy	-.743	.249	8.876	1	.003	.476	.292	.776
	Creative	-.372	.267	1.944	1	.163	.689	.408	1.163
3 non-technical job + non-technical organization	Intercept	.043	.134	.100	1	.752			
	Status driven	.956	.170	31.733	1	.000	2.601	1.865	3.627
	Hip	.585	.173	11.484	1	.001	1.795	1.280	2.518
	Geeky	.461	.150	9.372	1	.002	1.585	1.180	2.128
	Outdoorsy	-.317	.169	3.516	1	.061	.728	.523	1.014
	Uncertainty avoidant	-.995	.191	27.192	1	.000	.370	.254	.537
	Nerdy	-.988	.194	25.897	1	.000	.372	.254	.545
	Creative	-.553	.200	7.643	1	.006	.575	.389	.851

Note. Reference category: 0 technical job + technical organization.

Discussion

The aim of this research was fourfold: (1) to develop a statistically valid measure to capture the content of STEM students' professional identity (PI), (2) to identify different types of STEM students based on their PI, (3) to establish relationships between STEM students' personal characteristics, the content and strength of their PI, and their intended career choice, and (4) to analyze whether STEM students' type of PI influenced their strength of identification and intended career choice. The following sections will discuss how the four aims of the research were achieved, whether the findings are in line with existing research and what limitations to consider when interpreting the results. This will be done separately for the four goals. Additionally, some methodological limitations concerning more than one goals of the research will be presented. Afterwards, practical implications that derive from this research will be discussed and suggestions for the further development of the Career Compass will be offered. Subsequently, final conclusions about the current research will be drawn.

Goal 1: development of an instrument to measure STEM students' PI

The first aim of the current research was to develop an instrument to validly measure the content of STEM students' PI. In order to do so a questionnaire was developed in Study 1a, following the educational design research approach (McKenney & Reeves, 2008). At the same time, the development was theory driven, as already existing literature on PI was used as a starting point, thus combining a theoretical foundation with practical research. In doing so, this research confirms the assumption that PI consists of five dimensions, namely interests, competences, values, personality and goals (Ashforth et al., 2008; Kielhofner, 2007 in Luyckx, 2011). Additionally, in line with Ashforth et al.'s (2008) identity model, it was demonstrated that the content and strength of PI are strongly related to one another. This was particularly true for STEM students who integrated the most prototypical features of the identity of professionals in the technical sector into their self-concept. For example, male STEM students showed higher levels of strength of PI than their female colleagues and *uncertainty avoidan*t or *nerdy* STEM students had the highest levels of identification with their future profession of all seven types of STEM students.

One of the strong points of this research is the combination of measuring both the content and strength of STEM students' PI simultaneously. Previous research on PI mostly focuses on either the content or the strength of identity, but a combination of the two in one research is rare (Barbour & Lammers, 2015). Combining both strength and content of PI in the current research made it possible to connect these two parts of PI and analyze directly how the content of PI influenced the strength of identification. For instance, the results of this research indicated not only that the content of PI influenced the degree to which STEM students identified with their profession, but also in what way students identified with their future profession (e.g. *uncertainty avoidant* STEM students showed the highest level of identification, while being a *hip* STEM student decreased the level of identification).

At the same time, most research on the content of PI use small scale studies to analyze the concept of individuals' PI, rather than aiming to make statements about the PI of all people in a certain profession (Trede et al., 2012). By applying a broad scale approach in the current research, results are more generalizable to the entire population of STEM students (Babbie, 2010), which is another strong point of the current research.

Additionally, the large number of participants questioned in the current research also increased the reliability of the results (Field, 2013). Indeed, reliability analysis for the developed factor structure showed sufficient reliability overall. However, for a small number of the developed factors, only mediocre reliability was achieved. One of the reasons for the sometimes low reliability scores might be the small number of items that made up some of the developed factors (Field, 2013). For example, the goal *security* and the competence *international orientation* were measured with only two items and had low reliability scores. The two factors combined were used to identify the degree to which STEM students were *uncertainty avoidant*. It is therefore not surprising that the reliability score of that cluster of STEM students was even lower. In line with the mediocre reliability of these factors, the less stable and reliable clusters showed also the least unambiguous patterns. For instance, none of the four personal characteristics of STEM students significantly predicted the uncertainty avoidance of STEM students. In order to increase validity and reliability of the developed factors, items should be added to future versions of the Career Compass (CC) to measure factors that are currently measured by less than three items. As participants from the pilot test indicated that the general length of the original CC, consisting of 177 items, was not too long, adding items to the newly developed 82 item version of the CC should not pose an imposition to future users.

Moreover, looking at the results from the final confirmatory factor analysis (CFA), model fit indices were in some cases still not sufficient. However, research with CFAs on personality revealed that it is unlikely to find models that gain sufficient model fit for complex concepts, such as personality (Ashton, Lee, Goldberg, & de Vries, 2009). Arguing that most domains of PI are equally complex concepts as personality, and seeing that model fit indices were only barely insufficient, the reliability of the developed instrument was deemed acceptable.

Thus, as the overall reliability of the constructs was sufficient and model fit indices indicated sufficient model fit for the five domains of PI, the research succeeded in the development of a valid and reliable measure for STEM students' PI, called the Career Compass (CC). Data derived from the CC was then used to further investigate STEM students' PI and their intended career choices completing the subsequent three research goals.

Goal 2: development of a typology, based on STEM students' PI

The current researches second goal was to identify different types of STEM students, based on their PI. For that, in Study 1a the newly developed CC was used to identify seven clusters of STEM students, namely (1) the *status driven* type of STEM student, which desired status and wantes to influence others. (2) *Hip* STEM students found fun and enjoying life important, as well as tradition. At the same time they were more spiritual and emotional than their peers. (3) *Geeky* STEM students were lifelong learners who were willing to work hard and were very interested in a particular activity or field. (4) The *outdoorsy* STEM student liked being outside and was interested in activities such as camping, fishing or building things. (5) *Uncertainty avoidant* STEM students particularly valued routine and structure, and avoided the unknown (new cultures etc.). (6) The *nerdy* type of STEM student excelled at conducting scientific research and problem solving. They were very analytical people. Finally, (7) the *creative* kind of STEM student was very good at designing and had a highly imaginative and artistic mind. Contrary to the prevailing view on professionals in the technical field as one homogenous group of people (Rommes et al., 2010), these seven types of STEM students indicated high variety in the identity content of young professionals in the technical sector. For instance, the *nerdy* type of STEM student was mostly male and very interested in technology, which is much in line with how most people expect STEM students to be (Good et al., 2012). On the other hand, *hip* STEM students, who were often female and very sociable, fit much less with stereotypical images of STEM students (Rommes et al., 2010).

While the results from the CC provide interesting insights into the diversity of STEM students, there are limitations to the study that are noteworthy when looking at the developed clusters of STEM students. Firstly, although the developed clusters were reasonably reliable, they are based on exploratory factor analysis (EFA). This means that the developed clusters do not really distinguish between different types of STEM students, but rather indicate the degree to which a STEM student is for example *status driven* or *nerdy*. A method better suited to developing clusters of people is latent profile analysis (LPA; Pastor, Barron, Miller, & Davies, 2007). However, this type of complex analyses was beyond the scope of this master thesis.

Secondly, due to the theory driven approach to this research, even more types of STEM students might exist, that were not discovered in this research, as their characteristics fall outside the five measured domains of PI. For example, STEM students might be distinguishable by their study program (e.g. mechanical engineering or applied mathematics). Yet, as this was not part of the existing literature on and scales to measure PI, the instrument developed in this research would not be able to distinct these STEM students from other STEM students. Thus, additional research applying a more bottom-up approach to identifying STEM students' PI could, depending on the results, validate the instrument developed in this research, or broaden the scope of it. However, the current choice for a theory-driven approach, offering short stimuli to assess PI was a suitable choice for STEM students, as it has been shown that STEM students are less inclined to reading (Guo, et al., 2015). Thus, a bottom up approach that requires a lot of reading might prove difficult and therefore less suitable for STEM students.

Goal 3: relating personal characteristics of STEM students to the content and strength of their PI, and their intended career choice

The current research was conducted in response to the large number of STEM students who leave the STEM sector either during or after finishing their higher education program. Little research currently exists on who these STEM leavers are (Bernold, Spurlin, & Anson, 2007). For that reason, the developed typology of the content of STEM students' PI was used in the second part of this research to link STEM students' characteristics, the content, and the strength of their PI and their intended career choice. Hence, it was the first goal of Study 1b to further investigate STEM students' PI and career choices, based on their personal characteristics (gender, level of education, type of STEM study, and time till graduation). The results suggested that, in line with previous research on STEM students, gender did indeed influence students' career outlook (i.e. strength of PI and intended career choice; e.g. Mau, 2003 in Sadler et al., 2012), such that women were more likely to opt for a career outside the technical sector compared to men. Interestingly, results in the current study suggested that it was specifically the technical work environment and not the technical job per see that influenced women's inclination to leave the technical sector (i.e. women more often intent to work in a non-technical organization). This had not been shown in previous research and has important implications for how the masculine culture of technical companies may misfit with young female technical talent. For example, previous research shows that female employees in the technical sector feel left out by the masculine culture (e.g. generic use of "he", conversation topics that mostly include male interests), which might cause the low retention of females in the technical sector (Faulkner, 2009). Thus research on how to counteract this (perceived) masculinity of organizations in the technical sector might result in more women aiming for a career in both a technical job and a technical environment.

Next to the influence of gender on STEM students' strength of PI and career preferences, the research at hand also investigated how STEM students were influenced by other background factors (i.e. type of study, level of study, etc.). As research on STEM students' PI is scarce, the current research revealed several insights that had not yet been found earlier in research. For instance, while strength of PI was not influenced by time till graduation, the further away STEM students were from graduation, the more inclined they were to work in a non-technical organization. This showed that STEM students initially did not want to commit to a career in the technical field. However, the closer STEM students were to finishing their study program, the more intent they were on pursuing a career in the technical sector, indicating a higher level of identification with their profession. This is in line with previous research that showed that the more information students gather about a certain profession and the more interaction they have with their future job, the more consolidated the strength of their PI (Krieshok et al., 2009; Meijers et al., 2013).

Furthermore, the findings from the current research suggest that cluster I (study program in the technical sector with more than 50% technical courses) STEM students were more likely to prefer a career in a technical job and organization than their cluster II peers (study program with more than 50% technical classes outside the technical sector). This is not surprising, as STEM students enrolled in a cluster I study program already decided for a career in the technical sector when they chose their study program. On the other hand, students enrolled in a cluster II study program show much aptitude and interest in STEM related concepts as shown by their initial choice of a highly technical program. Yet, they are less likely to actually pursue a career in the technical sector than their cluster I colleagues. Thus, identifying what attracts cluster II students to technical study programs, but keeps them from pursuing a subsequent career in the technical field may result in valuable insights to persuade more cluster II students to aim for a career in the technical sector.

Moreover, not researched previously, university students were more likely to choose a career in a technical organization than STEM students enrolled at a university of applied sciences. This indicated that both university students and students enrolled at a university of applied sciences initially chose for a technical program, thus set out for a career in the technical sector. However, throughout the course of their studies university of applied sciences students became discouraged to pursue their initially chosen career path and decided to leave the technical sector. Reasons for this decision are unclear so far and have to be identified in future research.

Conclusively, findings from the current research showed that, in line with expectations, the more stereotypical STEM students (male, enrolled in a cluster I study program) identified stronger with a profession in the technical sector and were also more likely to pursue a career in the technical sector. Simultaneously, it appeared that during the course of their study program, through interaction with and reflection on their future profession, STEM students solidified their career choice in the technical sector.

After the effects of STEM students' personal characteristics on the strength and content of their PI and the career path students aimed at were analyzed, the current research looked more closely on how the content of STEM students' PI influenced the strength of their identification, and their intended career choice.

Goal 4: relating the content of STEM students' PI to the strength of identification and their intended career choice

Previous research has shown that different STEM students identify more or less with their future profession, and make different choices whether to stay on a path towards a career in the technical sector or take on a new profession (e.g. Chen, 2013; Perez et al., 2014). However, little is known about how the content of STEM students PI influences that decision. For that reason, it was the second goal of Study 1b to investigate how different types of STEM students identify to various degrees with their future profession and have different outlooks on their career.

Thus far, mostly qualitative case studies exist on why individual STEM students abandoned their field (e.g. Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). This study added to that research through a systematic quantitative analysis of a large number of STEM students, hence making the results more generalizable than these case studies. Results indicated a strong relationship between content of PI, strength of PI and STEM students' intended career choice. Findings showed that in general, STEM students with a high level of identification with their future profession were much more likely to aim at a career in the technical sector. For instance, *uncertainty avoidant* and *nerdy* students showed the strongest PI of all types of STEM students. Simultaneously, the *nerdy* type of STEM student showed much preference for a technical job in a technical organization, while the *uncertainty avoidant* type was also adamant on a technical job in either a technical or non-technical organization. On the other hand, types of STEM students with the lowest levels of PI, *status driven* and *hip* STEM students, were most likely to leave the technical sector as they intended a career either in a non-technical job (*status driven* STEM students) or a non-technical organization (*hip* STEM students). These insights are highly interesting as they offer much needed knowledge on who exactly the STEM students are who leave their chosen profession.

Relating the personal characteristics of the type of STEM students to these finding showed that the types of STEM students who scored higher on strength of identification and were more likely to aim for a career in the technical sector had many stereotypical traits of STEM students. For instance, nerdy students were more often than not male or were enrolled in a cluster I study program. Contrary, types of STEM students with lower levels of PI were more often characterized by atypical traits for STEM students (i.e. being female or enrolled in a cluster II study program). These findings confirm previous research that more stereotypical STEM students are more likely to stay on a career path towards the technical sector, while more atypical STEM students often choose to select a career in a different field (Cheryan et al., 2011; Shin et al., in press). This decision of more atypical STEM students to leave the technical field might be explained by Social Identity Theory (SIT) and self-categorization theory (SCT). SIT and SCT argue that individuals compare themselves to others in a specific group and based on similarities in that group they define themselves (Turner, 1986 in Luyckx, 2011; Turner, et al., 1987). For example STEM students might define themselves as being interested in science. However, as individuals belong to several groups (e.g. women, STEM students, university students, etc.) they can have salient identities, depending on the context. For example, a female STEM student in a room full of male STEM students might define mostly as a women, while when being in a room with both male and female students from various disciplines she might identify mostly as a STEM student. As such, more atypical STEM students, while being in high school, might have identified quite much with being a STEM student, due to them being, for example, more interested in science than their peers. However, after choosing a study program in the technical sector the atypical STEM students might identify less with being a STEM student, due to being surrounded by more typical STEM students. This decrease in identification might cause their decision to leave the technical sector throughout the course of their studies or after graduation. However, research is needed to investigate this process.

When looking at how either STEM students' personal characteristics or the content of their PI influenced students' intended career choice, it is especially noteworthy that the working environment seems to be a very influential factor. This is suggested by, for example, the fact that women and *hip* STEM students, while interested in both technical and non-technical jobs, were much more prone to work in a non-technical organization. These insights indicated that STEM leavers might be less stimulated by their future job and more by their future work environment. Yet, further research is needed to gain more insights as to what discourages these STEM students to work in a technical organization. As there is a lack of research on this, a more bottom-up qualitative can be useful to gather information about specific motives to prefer work in a non-technical environment. Moreover, as it is also unclear when exactly students decide to leave the technical sector, longitudinal research might be most insightful. An approach combining longitudinal and qualitative research is *life history research* (LHR; Adriansen, 2012). Focusing for example, on female STEM students, LHR can be used to determine critical incidents during their studies that influence them to aim for a technical job in either a technical or non-technical environment (Germeten, 2013). Comparing views from different students might give further insights into which factors influence STEM students to look for a career in a non-technical environment. Findings from the current research might be useful as a starting point for such a research, as the findings can be used to identify STEM students who are more likely to leave the technical sector.

Methodological limitations

During the execution of the research at hand much was done to ensure reliable and valid results. Yet, there were some limitations in the methodology used to achieve the four major goals of this research. These have been discussed in the individual sections on the goals of the research above. However, there were three major limitations that applied to the methodology of several parts of the current research, which is why they will be discussed separately below.

Firstly, when interpreting the results on STEM students' career choice it is important to keep the categorization process of STEM students' career choice in mind. During the research, only one researcher coded STEM student choice as inside or outside of the technical sector. This, in combination with the fact that many students gave ambiguous answers (i.e. naming several jobs or organizations they would like to work in), influenced the reliability of the results on STEM students career choice. Hence results about STEM students intended career choice have to be interpreted carefully. In future research with the CC reliability should be increased by having several researchers code job descriptions into categories and to discuss decisions until sufficient inter-rater reliability is achieved. Alternatively, instead of open questions, multiple choice questions might be used to generate comparable responses. Answers from the data derived from the current research can be used to offer options that fit STEM students' language and common choices.

A second limitation to the methodology in several parts of the current research was the fact that only main effects were analyzed in all statistical analyses. This was due to time restrictions. Investigating interaction effect, both within variables (e.g. gender and type of education), but also between variables (e.g. personal characteristics and type of PI), might have provided a more holistic view on which traits of STEM students influenced their career decisions. Analysis of interaction effects might have shown for example that typical STEM students to leave the technical sector are both male and status driven (as opposed to the research at hand that can only show separately that male students, and status driven students are prone to leave the technical field).

Thirdly, when interpreting the results of the research at hand, it is noteworthy that this research assumes a causality between various concepts. It is, for example, assumed that the content of PI influences the strength of PI and not vice versa. This causality cannot be proven in this research, due to the cross-sectional design approach, a drawback of this design approach that has been discussed in previous literature (e.g. Mann, 2003). Therefore, longitudinal research is needed in which STEM students' are followed throughout their career path from entering their study program until they choose a job (and maybe even sometime longer) in order to investigate which concepts influences the other. For instance, a qualitative panel study would make it possible to investigate the development of STEM students PI throughout the course of their studies (Babbie, 2010). This would make it possible to identify whether a STEM students' content of PI changes first, which in turn influences the degree to which they identify with their future profession, or whether the strength of PI changes initially and in turn, STEM students develop a different content of PI.

Yet, despite the limitations discussed here and earlier, findings from the current research may prove valuable for many people and practical implications of the results will be discussed hereafter.

Practical implications

Findings from this research have practical implications for many STEM related parties, such as (potential future) STEM students, career guidance counselors at educational institutions, and companies in the technical sector. This research shows that the content of STEM students PI is diverse and that these differences in PI account for STEM students' decision to leave or stay in the technical sector. It is for that reason that career counselors at various educational institutions might find conclusions from this research helpful to support STEM students who question their persistence in the technical sector. Highlighting diversity between STEM students might especially help minorities and less stereotypical STEM students to identify with their colleagues and their profession, thus securing them in their decision to pursue a technical career. For example, Shin et al. (in press) showed in their research that students exposed to diverse descriptions of professionals in the technical sector increased the perceived compatibility between their own PI and the profile of a professional in the technical field. Thus, the developed typology from the current research and resulting insights into diversity of professionals in the technical sector might motivate STEM students to finish their selected study program and attract students enrolled in non-technical courses to a career in the technical sector.

Additionally, the CC offers study counselors the support needed in guiding STEM students towards a confident career choice. Research shows that in the technical sector, the topic of study counselling focuses significantly less often on self-reflection than in other fields (Kuijpers & Meijers, 2012). Yet, reflection has been identified as one of the four competencies necessary for successful career self-management (Kuijpers & Meijers, 2012). Reflection tools, in combination with dialogues with counsellors have been shown to increase students' career capabilities (Mittendorff, Jochems, Meijers, & den Brok, 2008). For that reason, instruments for high school students to reflect on who they are and what their career intentions are have been developed before (e.g. BètaMentality, n.d.). However, a comparable version for STEM students in higher education had not yet been developed previous to the current research. Thus the current research fills STEM students' need for a tool supporting them in making career choices. Additionally, the instrument developed in the current research provides a more detailed distinction between STEM students than previously developed typologies of STEM students, such as for example the *BètaMentality* tool. The *BètaMentality* tool is an instrument designed for high school students to measure their aptitude for and interest in a career in the technical sector. The authors use criteria on five domains to distinguish between students: negative attitude towards future world, humanity and social orientation, practicality, interest in STEM, and status orientation. Based on these five dimensions four types of students can be distinguished: concrete STEM students, career STEM students, humanity oriented STEM students and non-STEM students (BètaMentality, n.d). However, as the tool is designed for all students and not specifically for STEM students, the typology remains quite superficial. For instance, one type of student (non-STEM students) is not interested in a career in the technical sector at all. The second type of student (humanity oriented STEM students) is only distinguished from other students by seeing technology as a means to an end to help humanity. The final two types of students (concrete and career STEM students) only differ in the degree to which they are more theoretical or more practical (with concrete STEM students being far more practical). Thus the beta mentality tool only succeeds to distinguish between three types of STEM students and only on a rather superficial level. On the other hand, the instrument developed in the current research, the CC, was specifically designed to distinguish STEM students, and investigate students' identity on a far deeper level. As such, the CC is able to distinguish between seven types of STEM students, based on all aspects of their identity, as derived from previous research (Ashforth et al., 2008; Kielhofner, 2007 in Luyckx, 2011). Hence, the CC can be used by STEM students as a tool to reflect on their PI and all its components, thus evaluating what is important to them and what are their abilities with regard to their future profession, supporting them in making a deliberate career choice.

Next to students and career counsellors companies can also profit from findings from this research. With the CC they can identify which types of STEM students they attract (i.e. which types of technical employees already work in their company) and which STEM students they lack. This is especially important in view of the current shortage of people in the technical sector (Chen & Soldner, 2013). When companies are more aware of the type of STEM students they currently miss in their company they can specifically target these groups when advertising themselves on the labor market. This might enable them to attract more professionals in the current war for talent. For example, as women have been shown in this research to be interested in working in a technical job but not in a technical company, broadcasting a less stereotypical image might give companies the advantage over their competitors in attracting female graduates from STEM related study programs.

In general, identifying which type of STEM student is more likely to leave the technical sector enables all sorts of entities (e.g. companies, educational institutions, government organizations) to further investigate what drives these types of STEM students towards their decision. Based on these insights specific measures can then be developed to counteract STEM students leaving the field at any point in their education or career.

Suggestions for further development of the Career Compass

Looking at how participants perceived the developed instrument, feedback from participants of the pilot indicated that the Career Compass (CC) was well received by its target population. Pilot testers complimented the design of the instrument (both the looks, as the decision to present the items in blocks of the five domains of PI). Especially the design of the items with one part being consistent for all items in one domain and one variable part (e.g. consistent part: *I am interested in*, variable part: *team sports* / *reading* / *gardening*) positively influenced students' attitude towards the Career Compass, as it enabled them to answer the large amount of items in a relatively short time.

However, STEM students did criticize the output they received after participating in the study. As there were no clusters of STEM students developed yet, students only received an overview of the items that applied most or least to them. In order to give meaning to the output, the newly developed clusters of STEM students must be integrated into the feedback sent to participants after filling in the CC. In order to further give meaning to the clusters, research to identify where exactly technical professionals in a certain cluster end up working is needed. Testing the CC in technical companies might not only give insight into which types of STEM students do indeed end up working in a technical job in a technical company, but also show whether certain types of companies attract certain types of STEM students. Additionally, analyzing professionals in companies might also shed light on whether the CC, as it is now, does map all types of professionals in the technical field or whether there are different types of STEM PIs, not yet measured with the CC.

Final conclusion

The Dutch economy is in high demand of highly educated professionals in the technical sector. Yet, many STEM students decide to leave the field during their studies or after graduation. Reasons for that decision are mostly unclear. The current research successfully developed an instrument, the Career Compass (CC), which was able to reliably measure STEM students' PI, a concept that has been closely linked to STEM students' career choices. In this research, the CC was used to distinguish seven types of STEM students, showing a large diversity of STEM students. By linking STEM students' characteristics, PI and intended career choice, the research at hand gave insight into who these STEM students are who decide to change their career path and intend to leave the technical sector. Findings are in line with previous research that more atypical STEM students are more likely to leave the technical sector than their peers with more stereotypical traits. Additionally, perceived diversity between STEM students has in previous research been shown to increase the likelihood of STEM students remaining on their career path. Therefore, findings from this research take another step in closing the gap between university and labor market by showing more atypical STEM students that they too are suited for a career in the technical sector.

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Appendix A

Protocol for pilot study

Participant number:
Age:
Gender:
Study program:
BSc / MSc:
Time to finish CC:
Time to finish entire questionnaire:

Category	**Participants response**
Clarity of the content	
Motivation to finish questionnaire	
Content repetition	
Design / user-friendliness	
Technical glitches	
Other observations / remarks	