THE IMPORTANCE OF ROLE MODEL INSTRUCTORS FOR STUDENTS' SCIENCE IDENTITY

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Identitatea științifică este privită drept un factor important în alegerea carierei ocupaționale în sfera STEM. Printre cei mai importanți factori ai dezvoltării identității științifice, instructorii au fost considerați a fi producători de efecte pozitive în identitatea științifică a studenților. Cu toate acestea, puțin este cunoscut despre modul în care acești instructori, din ipostaza unui rol-model științific, influențează identitatea științifică. Astfel, acest studiu operează cu două cadre teoretice: Teoria Modelului de Rol și Teoria Identității Științifice. Acest studiu angajează o cercetare multimodală pentru a investiga implicațiile instructorilor rol-model pentru identitatea științifică a studenților, prin prisma celor trei funcții de role-modelling. Sunt propuse recomandări pentru activitatea de rol-model a instructorilor.

Cuvinte-cheie: *identitate științifică, rol-model, STEM, teoria identității, funcții de rol-model.*

IMPORTANȚA INSTRUCTORILOR ROL-MODEL PENTRU IDENTITATEA ȘTIINȚIFICĂ A STUDENȚILOR

Science identity is often viewed as an important construct for choosing an occupational career in the STEM field. Amongst the most crucial developmental factors for science identity, instructors were proven to produce positive effects. Yet, less is known about how exactly instructors as science role-models influence students' science identity. Thus, this study operates with two main theoretical frameworks: The Role Modelling Theory and Science Identity Theory. The study employs a multi-method research to investigate the implications of role model instructors on student's science identity. Results demonstrate positive implications of role model instructors for students' science identity by drawing on their three role modelling functions. Recommendations for role model activity amongst instructors.

Keywords: *science identity, rol-model, STEM, identity theory, role-modelling functions.*

Introduction

Science identity represents an important factor that determines students' likelihood of pursuing an academic track in the sciences, technology, engineering, mathematics (STEM) field and entering a science occupation later in life (Stets, Brenner, Burke, & Serpe, 2017; Carlone & Johnson, 2007; Lee, 2002; Merolla & Serpe, 2013). When self-identifying as a "science person", one is prone to allocate more time and effort to study sciences, which in turn leads to increased performance. Science identity also predicts the strength of one's feeling of belonging to sciences (Chen et al., 2021) and thus fosters one's motivation to persevere

in sciences. Hence a person with a strong sense of science identity is more likely to flourish and achieve greater success (Chen et al., 2021).

Research attests that science identity in students develops across time, and that its formation is mainly reflected by their performance and competence in STEM disciplines, as well as their sense of recognition as a sciences student (Stets, Brenner, Burke, & Serpe, 2017). Thus, a person with a science identity feels competent, confident and interested in the sciences. However, as present data shows, women and certain ethnic minority groups remain underrepresented in the field of STEM at the higher educational and professional occupation levels (Pew Research Center, 2021). It turns out that minority students, but especially women, are subjected to a decreased sense of belonging, confidence and recognition in sciences (Rainey, Dancy, Mickelson, Stearns & Moller, 2018), which altogether might lead to a weaker science identity.

Thus, a worldwide joint effort has been put to improve present teaching practices and ensure that gender and other (e.g. racial) types of disparities in the STEM field are diminished. Consequently, in an attempt to join this effort, this paper will explore how students' science identity might benefit from their interaction with science role models. The present study is especially innovative because it envisions teaching instructors as science role models.

Among the underlying factors that contribute to the formation of one's science identity, science role models were proven to play a significant role in boosting students' interest in pursuing STEM related disciplines (González-Pérez, Mateos de Cabo & Sáinz, 2020). Interestingly enough, upon a simple search on Google using the keywords "science role models", an extensive range of different platforms and forums are displayed, the majority of which target young girls and women. If the availability of such numerous platforms is to reveal something, it would probably be the growing necessity of women to expand their network. In a world where science continues to be male dominated (Sheltzer & Smith, 2014), women often feel displaced and disconnected from the sciences. Consequently the scope of platforms such as " Women in Tech" or "500womenscientists" are to host workshops and activities where successful role model women scientists are invited ("Events - Women in Technology", 2021; "Picture a Scientist Documentary Screening – 500 Women Scientists", 2021). Thus by fostering meaningful discussions between women across generations, platforms as such can empower and motivate young women to pursue a career in sciences. Indeed, research shows that exposure to counter stereotypical role models can influence future career choices especially in girls (Olsson & Martiny, 2018).

Nonetheless, "teachers as role models" is a commonly adopted perspective in academia, which can be further used to investigate teachers' influence on students across multiple educational domains (Martino, 2009).

Present research clearly demonstrates the important implications that science role-models pose when it comes to boosting students' interest and confidence in STEM subjects (Bashir, Bajwa & Rana, 2014; Shin, Levy & London, 2016). For example, exposure to role models were proven to be beneficial for students' specialty choices (Wright, Wong & Newill, 1997) and better academic outcomes (Zirkel, 2002). In fact, the later quoted study was a 2 years longitudinal study which looked at students with versus without role-models. One of the findings was that students who have a role model are more likely to become invested in academic pursuits (Zirkel, 2002).

Nonetheless, less focus has been put on *how* specifically role-models influence students' science identity. Therefore, this paper aims at exploring students' experiences with science role models, and how these experiences influence students' science identity. Specifically, I will be exploring the different factors that could influence science instructors to become role models to their students, and how role model instructors can contribute to students' sense of recognition, competence and performance during STEM related classes.

Present literature attests that the experiences of undergraduate students in STEM courses play an important role in the general persistence of those who will further pursue STEM specializations and careers (Watkins & Mazur, 2013; Brown et al. 2017). Subsequently, much of contemporary research has been focused on identifying the underlying factors that cause undergraduate students negative experiences in STEM class. For instance, test anxiety was one of the factors that were investigated in undergraduate education, and which was discovered to be negatively correlated with students' grade performance (Chapell et al.,2005).

As highlighted by Kelle (2006), the two main limitations of a mono-method approach are: limited transferability of qualitative data and lack of sociocultural knowledge in case of quantitative research. Subsequently, in this study I propose a mixed methods research design. The reason for using a mixed methods approach is to gather a more comprehensive picture of the phenomena studied in this research, and in this way avoid the possible limitations that a monomethod research can yield.

The quantitative approach explores the theme of "instructors as role-models'' and to what extent students perceive their instructors as displaying role-modelling attributes. This part of the research will be conducted via a survey which was created based on existing literature. During this, a range of different factors will be explored that could potentially lead students to perceive their teachers as science role-models. The qualitative part of the study consists of semi-structured interviews with science students. The exploratory scope of interviews is to gain a better understanding of how students experience their role models and what impact this brings to their science identity. Ultimately, the implication

of this study's findings will be addressed to stimulate more role-model activity amongst instructors.

Theoretical Framework

Identity

The identity of a person is not an unidimensional construct. Instead, identity embodies a range of various perceptions that a person can hold about one self. The existing body of research proposes several definitions for identity. Gee (2000) for example, defines identity as a perceptual affective construct according to which people classify themselves into various categories. This definition supports the idea that a person can appertain to different types of identity categories such as personal, social and role identities (Wang & Hazari, 2018; Carlone & Johnson, 2007).

In this paper, I argue that a person can possess a science identity, which is a domain specific type of identity. To better understand the complexity behind the concept of identity and how it is possible to have different domain specific identities, I will elaborate on a model proposed by Van der Gaag, De Ruiter, Kunnen & Bosma, (2020). This model introduces the so-called identity landscape - a complex dynamic model that reflects the complexity behind identity formation. This model views identity as a constellation of commitments which vary in their context and strength. Furthermore, the model incorporates within itself both qualitative and quantitative aspects of identity. Whereas the qualitative part of identity is defined by the content of one's commitments, the strength of commitment is viewed as the quantitative aspect of identity.

Thus, based on this framework, science identity can be characterized as a domain specific type of identity under which a variety of nested "sub-commitments" are integrated. Examples of commitments that may be considered characteristic to science identity are "I want to make a groundbreaking discovery in sciences" or "I enjoy applying mathematical formulas". By exploring a person's commitments in relation to a specific domain, such as sciences, one may classify science identity related commitments into three separate components.

Science identity

A general conceptual framework for science identity was introduced by Carlone and Johnson (2007) which identifies three dimensions of science identity: recognition, performance and competence. Recognition stands for recognizing oneself as "a science person", as well as being recognized as such by others. Performance in this context was defined as the capacity to demonstrate scientific knowledge to others. Lastly, competence in science is characterized by a combination of scientific knowledge possessed by the person and their motivation.

These three dimensions are viewed as different components of one's science identity. Interestingly, the valence of these dimensions can vary within an

individual. For example, a person can demonstrate high performance in sciences and yet to not self-recognize as possessing a science identity. In other words, the person might have strong commitments towards performing good in sciences, but weak commitments to self-recognize as a sciences person. As Dasgupta (2011, p.232) puts it: "performance and self-efficacy don't always go hand in hand". In fact, many studies have shown that girls have a decreased motivation and lower self-confidence in their science abilities (Rodríguez, Regueiro, Piñeiro et al., 2020) despite the fact that they perform as equally good as boys ("The Programme for International Student Assessment (PISA) 2018", 2021). As suggested above, certain attributes of a person such as motivation or ability beliefs determine the formation of certain commitments, which in turn lead to the development of science identity components. But how does the science identity form and what factors contribute to its development?

From existing literature, it seems like what fosters one's science identity formation is the implications of certain activities and memberships in particular groups or roles. For example, in an attempt to demonstrate the overlap between social identity theory and identity theory Stets & Burke (2000, p.224) argue that "the self is reflexive in that it can take itself as an object and can categorize, classify, or name itself in particular ways in relation to other social categories or classifications". From this two main points are derived: 1) Identity constitutes a continuously "emergenetic" process shaped by various forces and contexts (Van der Gaag et al., 2020; 2) science identity and its components develop in relation to a person's experiences with the context.

Indeed, from a complex dynamic system approach (Van der Gaag et al., 2020), the emergence of science identity in a person can be described as a continuous bi-directional interaction between science identity components and the context. Hence, identity is not something fixed and it can vary across time and context. Van der Gaag and colleagues (2020) argue that fluctuations in identity are produced by a person's explorative behavior (Marcia, 1966) and identity related experiences. In support of this claim, a range of researchers demonstrated that experiences, especially identity-related ones, play a crucial role when it comes to identity formation of a person (Grotevant, 1987; De Ruiter et al., 2017). Furthermore, how a person develops an identity seems to strongly depend on the internationalization of our experiences in specific contexts (Vincent-Ruz & Schunn, 2018). Therefore, based on the above information I suggest that the formation of any type of identity, including, science identity is context dependent. By arguing this, my aim is to demonstrate that it is relevant to explore students' experiences with their role model especially when it comes to studying one's science identity.

Role models

Furthermore, I propose that role models can influence a person's science identity. Role models are often seen as entities capable of motivating others to perform new behaviors and strive for the acquisition of new goals. Role models can also combat science related stereotypes and research shows that exposure to counter stereotypical role models can influence future career choices (Olsson & Martiny, 2018). Thus, as agents belonging to the educational context, instructors can be often viewed as role models which are often held responsible "to create a learning environment that enhances and sustains students' motivation and engages students in learning"(Hornstra et al., 2015, p.364).

Therefore, based on the three main functions that role-models usually display, Morgenroth and colleagues (2015) propose the following definition: "We thus define role models as individuals who influence role aspirants' achievements, motivation, and goals by acting as behavioral models, representations of the possible, and/or inspirations".

1. Behavioral model

A behavioral model is an individual who displays certain skills or behaviors that are desired to be acquired by the role aspirant, which is in our case the student (Kemper, 1968; Bandura, 1977b).

Thus, building on Morgenroth's and colleagues (2015) a role model can function as a behavioral model. This behavioral model is perceived as such because it embodies the existing goals of role aspirants. Via vicarious learning, also known as observational learning, role aspirants learn about "how to do something" that will eventually lead to the achievement of their pre-existing goals. The higher the goal embodiment is perceived, the more role aspirants learn from their role models. In turn, they acquire better skills and start feeling more confident in their abilities.

2. The possible

A second set of definitions highlighted by Morgenroth and colleagues (2015) depicts role models as representations of the possible. In other words, as illustrations of the possible, role models demonstrate that "something is possible''. Role-models are often perceived as representations of the possible via perceived attainability. Attainability is referred to as the '' the degree to which one can imagine being like someone else in the future" and it is known to have important implications for role aspirants' expectations. However, it is only when the role models were perceived as successful that they exercised a positive influence on role aspirants' expectations of success (Lockwood & Kunda,1997).

3. Inspirational entities

The third and last set of definitions revealed that role models can function as inspirational entities. For role-models to function as inspirational entities

"they need to be perceived as desirable by their role aspirants" (Morgenroth et al., 2015). What makes the role model a desirable character very much depends on role aspirants' personal attributes, but generally desirability is seen to prompt personal identification, internationalization and admiration. Desirability for a role aspirant stems from characteristics such as shared group membership (similarity) values of the role aspirant and/or perceived morality between the role model and role aspirant. A role aspirant can be inspired by the role model to achieve certain goals or display certain behaviors. Moreover, role models as inspirational entities can also motivate role aspirants to acquire new goals (Thrash & Elliot, 2004).

Methods

A mixed data collection approach was used to maximize the quality of this research. By combining qualitative and quantitative methods, my aim was to minimize the disadvantages of a mono method approach of which the most relevant to my study are limited transferability of qualitative data and lack of sociocultural knowledge in case of quantitative research, and maximize the accuracy of my exploration.

The survey was created based on existing literature. Two conceptual domains were explored within the survey with an additional third domain concerning personal data. The first domain asked questions about the extent to which instructors display role-modelling functions. For this, participants were asked to rank their perceived importance on several attributes namely: behavioural, inspirational, physical and level of success. The second domain covered a set of questions interested in how important is that instructor for participants' science identity. The questions covered all three components of science identity, plus motivation.

The qualitative data collection part consisted of semi-structured interviews. The general scope was to conduct nuanced research that would allow the exploration of different experiences of students in relation to the above highlighted themes. The reason for choosing a semi-structured format for the interviews was to allow participants to share their experiences in a somewhat organized manner. Hence, the themes and sub-themes were predetermined before interview conduction.

Results

In this study, students were asked to reflect on their personal experiences with their role models. Data was collected via a survey questionnaire and semi-structured interviews. This section first presents the results of the survey and then of the interviews. For both sections, the data was categorized into thematic subsections.

Survey data summary

A majority of 14 out of 20 of respondents chose their university teacher as their role model. Behavioral attributes that make the instructor a role model: confidence, enthusiasm, knowledge and scientific skills. Behavioral attributes scored relatively high. Inspirational attribute of the instructor was identified as relatively important. Generally, physical characteristics (gender, race, age) were not considered important. The majority of respondents found their role-models as successful and believed that their success was attainable.

Interview data summary

The interviews of each participant were summarized into individual case studies and analyzed in conformity with the pre-established coding. In order to answer my research question, the findings were structured in sub-sections. Along with the provided quotations, short contextual information was provided to ensure a better understanding of participants' perspective.

The second research question was addressed by interviews, which revealed information about how specifically role models can influence students' science identity components. First of all, results have shown that science instructors are often perceived as role models. This is because of the three role modelling functions that instructors are perceived to display: behavioral models, representations of the possible and inspirational entities. Instructors can become role models via goal embodiment, shared similarity and attainability, and inspirational qualities. Important to note is that a science instructor does not have to comply with all three highlighted functions in order to become a role model. Ultimately, interviews revealed interesting insights into people's definition of a "science person". Breaking stereotypes was identified as a theme.

Discussion and recommendations

Both the qualitative and quantitative data seems to support the supposition that instructors are often perceived as science role models. Overall, the interview data revealed the importance of fostering positive experiences in class, especially in undergraduate STEM studies. Instructors were deemed crucial in fostering students' interest and motivation to continue to become science professionals.

Important to note is that, in order to become a role model, science instructors do not have to comply with all three previously highlighted role modelling functions. In fact, it is worth noting that there is no such thing as a perfect role model that could possibly incorporate all preferences of students. Frankly, there is no need for one. As long as all instructors strive to embrace these needs, they can altogether become "a collective role model" and have a positive impact on students' science identity. By implementing in their daily educational practices

the aforementioned recommendations, instructors can take advantage of their prolonged interaction with students and strive to become a role model.

Recommendation 1: Have the instructors talk about their experience in the STEM field and about how they achieved certain goals.

Recommendation 2 : Reinforce students' aspirations by emphasising on the relevance and applicability of your subject in relation to their goals.

Recommendation 3: As an instructor, share your enthusiasm and encourage students to work on their own subject of interest.

Recommendation 4: Encourage students to adopt an out-of the box thinking and acknowledge them as science people by treating them as "equals".

Conclusion

So, can the present study address the research question "How role models influence students' science identity?" By investigating student's perceptions of the role model and their influence on them, I managed to reveal the positive effects posed by a science role model. Students' engagement with their role model instructors is beneficial for the development of their science identity. Their sense of belonging, motivation, knowledge, and science related goals are reinforced by their science role models.

Solving gender and racial disparity in the STEM field is a complex issue, which requires action plans on many different levels. Whereas the main actors involved in targeting this problem remain to be the policy makers, with this study I strive to demonstrate that small steps can lead to big changes. Thus, raising awareness about the reflexive nature of identity can motivate science instructors to adopt an inclusive approach in their education, and thus encourage more students to embrace the sciences and ultimately prevent "the leaking pipe" in sciences.

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