Social Psychology of Education (2020) 23:701–719
https://doi.org/10.1007/s11218-020-09555-1

The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research

Mara Šimunović[1] **· Toni Babarović**[1]

Received: 30 November 2018 / Accepted: 6 April 2020 / Published online: 16 April 2020

Abstract
In the domain of science, technology, engineering, and mathematics (STEM) education, the family still presents an untapped resource for promoting students' motivation and achievement. Based on the premises of the Eccles' model of parental socialization and the expectancy-value theory, this paper provides a comprehensive review of the literature on the socializing influence of parental beliefs in the STEM educational domain. More specifically, we discuss the role of parents' values and self-efficacy in STEM, parents' perception of children's ability in STEM, and parents' expectations for children's STEM achievement. Reviewed studies show that all of these beliefs have a potential in explaining variations in students' achievement motivation, performance, and career choices related to STEM. Parents' child-specific beliefs and messages have shown to be the crucial socializing factors in this area. We further integrate and discuss the research findings on the gender differentiation in parents' child-specific beliefs in STEM, possible explanations of this differentiation, and its importance for students' gender-role socialization in STEM. The review also points out that the behavioral mechanisms through which parents may convey their STEM-related beliefs to their children are still unclear, presumably since the quality of parent–child interaction in STEM is often overlooked by researchers. Lastly, we present parent-oriented interventions aimed at fostering parents' self-efficacy and utility value in STEM and at changing stereotypical images of STEM careers and STEM professionals. Based on this comprehensive review, methodological and conceptual implications for future research are discussed and improvements for parental intervention programs are proposed.

Keywords Parents' beliefs · Parental socialization · STEM achievement · STEM motivation

✉ Mara Šimunović
mara.simunovic@pilar.hr

[1] Ivo Pilar Institute of Social Sciences, Marulićev trg 19/I, 10000 Zagreb, Croatia

1 Introduction and theoretical background

A meta-analysis by Hill and Tyson (2009) confirmed that parental involvement has a strong positive relationship with a child's school achievement. However, different types of parental involvement showed a different level of effectiveness. Academic socialization was found to have the strongest positive relationship with the child's achievement in comparison with more direct types of parental involvement like home and school-based involvement. Academic socialization includes parents' influences such as communication of academic expectations for the child, parents' own educational values, or fostering of a child's educational and occupational aspirations. In another meta-analysis on types of parental involvement by Fan and Chen (2001), similar results were found—parental beliefs such as aspirations and expectations for the child's success had the strongest influence in predicting students' school achievement. These results highlight the importance of researching the links between various forms of parental beliefs on the one side, and students' academic outcomes, on the other.

This review paper is focused on the role of parents' beliefs, values, and perceptions in the STEM domain (science, technology, engineering, and mathematics) and its relation to children's STEM-related beliefs, behaviors, and achievement. The structure of the findings that are presented and discussed in this review is based on the two theoretical models developed by Eccles and her colleagues: the model of parental socialization (Eccles 1993, 2007) and the expectancy-value model of achievement-related choices (Eccles 2005a, 2009; Eccles et al. 1983). The model of parental socialization proposes two general mechanisms of the influence of parental beliefs. Firstly, parents' beliefs affect the messages parents communicate to the child in both subtle and overt ways (Jodl et al. 2001). Thus, parents act as the "interpreters of reality" for their children through their perceptions of the child's world, experiences, and abilities. Secondly, parents may convey their beliefs and values by providing the child with different opportunities and experiences, and by engaging in different practices and behaviors (Jacobs and Bleeker 2004). These mechanisms in the STEM school domain will also be discussed.

We find it important to point out that in the research of the social contextual influences on the children's academic outcomes, until relatively recently, the focus was primarily on the general levels of the child's achievement as the targeted outcome, while child's domain-specific competence beliefs and values were relatively neglected (Eccles 2007). However, in the framework of the Eccles' theory, the family has an important influence not just on the achievement but also on the formation of children's academic self and task-beliefs. The expectancy-value theory outlines the *expectancies of success* and *subjective task values* as the two key determinants of performance, persistence, effort, and activity choice (Eccles and Wigfield 2002). For the purposes of this review, it is important to hand out a brief theoretical background on these constructs. Expectancies may be defined as the person's beliefs about how well he or she will do on the upcoming tasks. Eccles et al. (1983) also defined the self-concept of ability as the individuals'

perception of their current competence in a specific domain. Although the self-concept of ability refers to domain-specific beliefs, while expectations are more narrowly defined and refer to task-specific expectations of success (Marsh et al. 2017), these two competence beliefs are highly related and empirically indistinguishable (Eccles and Wigfield 2002). Subjective task value consists of four components: (a) interest—enjoyment a person gets from engaging in the activity; (b) attainment value—personal importance of doing well in a task; (c) utility value—perceived usefulness of the task for future goals; and (d) cost—negative effects of performing an activity (Eccles and Wigfield 2002). In this review, we will discuss the influences of parents' beliefs, values, and perceptions in the STEM domain not just on the child's STEM achievement, but also on these forms of the achievement motivation.

STEM is in the scope of this review because researching socializing influences in this school domain is particularly important if we consider that most European countries face a low number of students interested in pursuing a career in STEM (Kearney 2016) and students are notably less interested in school science compared to other subjects (Jenkins and Nelson 2005). Additional problems in the STEM domain are the persistently low numbers of women who are choosing to pursue careers in STEM compared to men (National Science Foundation 2017). Furthermore, identifying important social forces that may influence students' motivation, choices, and performance in the STEM domain may also have possible practical implications. Therefore, one section of this review is dedicated to recent efforts and future implications for developing and testing interventions intended to influence parents' beliefs in STEM and practices through which parents convey these beliefs to their children. The goal of these interventions is to positively influence not just parents but indirectly also improve students' outcomes in the STEM domain.

2 Method

Literature included in this review was retrieved utilizing several electronic databases (Web of Science, Educational Research Information Center [ERIC], ScienceDirect, and Google Scholar), using combinations of the following keywords: child/ren, adolescent/s, student/s, parent/s, mother/s, father/s, STEM, science, mathematics. The title and abstract of the identified articles were screened to determine inclusion. The reference sections of the selected articles were also screened for other relevant articles. For inclusion, articles were required to examine parental general or child-specific beliefs specifically in STEM fields (i.e. values, attitudes, and stereotypes related to STEM, perceptions of child's competence and interest in STEM school subjects, expectations of child's success in STEM fields). In the reviewed articles, parental beliefs were related to STEM school subjects (e.g., math, science), STEM fields in general, or STEM careers. We primarily included studies that examined the relationship between these parental beliefs and different student outcomes in STEM fields, such as school achievement, interest, competence beliefs, and activity choices. In the reviewed articles, parental data came from self-reports of both mothers and fathers, solely mothers, or from student assessments of their parents. Finally,

we included only articles that examined beliefs of parents of school-age children or adolescents (aged 6–18 years), published in the English language. Following these criteria, only the most relevant articles were cited. In total, in this review, we included 54 articles (50 journal articles, 2 research reports, 2 book chapters) that examined parental beliefs, values, and perceptions in STEM fields. We grouped the parental constructs in these articles following the conceptualization of parents' general and child-specific beliefs in Eccles' model of parental socialization.

3 Parents' general and child-specific beliefs in STEM

3.1 Values

Studies have shown that parents' attitudes and values attached to the STEM domain are positively related to children's attitudes and values of STEM (Acosta and Hsu 2014; Breakwell and Beardsell 1992; Chen 2001; DeWitt et al. 2013a, b), children's STEM achievement (Acosta and Hsu 2014; Simpson and Oliver 1990; Sun et al. 2012), and the course choice in STEM (Svoboda et al. 2016). Perera (2014) found a positive association between parental attitudes towards science and student science achievement across the 15 countries, after controlling for other important student- and school-level factors. Furthermore, it seems that students from low socioeconomic (SES) backgrounds can benefit from the positive parental attitudes towards science as much as the students from high SES backgrounds (Perera 2014). The positive relationship between parents' task-values of STEM and children's STEM achievement was also found in ethnic minority students (Smith and Hausafus 1998).

Here, we should note that there is an evident lack of longitudinal studies that would examine the relationship between parental values and changes in students' values in the STEM domain. In one of the rare longitudinal studies, Frenzel et al. (2010) showed that family values for mathematics were positively related to students' interest for math during grades 5–9, were unrelated to the change trajectory of students' interest. Possible gender differences in the patterns of the relationship between parental values and children's motivational beliefs in STEM are also understudied. Lazarides and Ittel (2013) found that parents' valuing of STEM was related to children's interest in mathematics, but only for girls. On the other hand, Taskinen et al. (2016) found that boys' STEM self-concept of ability was more strongly related to parents' general STEM value than girls' STEM self-concept. These conflicting results indicate that there is a need for more research on how parents socialize STEM values with female and male children. Another important and neglected part in the research of parent-to-child transmission of academic values are the underlying processes of this transmission. The Eccles' expectancy-value model assumes that parents' values affect children's values through their perceptions and interpretation processes. However, recent studies have suggested that children's perceptions of their parents' values in the STEM domain are often quite inaccurate to parents' actual values (Dickhäuser and Stiensmeier-Pelster 2003; Gniewosz and Noack 2012; Noack 2004; Šimunović et al. 2018). It is possible that when interpreting their parents' academic values, children project a part of their own values (Gniewosz and

Noack 2012). This could explain why children's perceptions of their parents' values are often more strongly related to children's own values than the actual parents-reported values (Gniewosz and Noack 2012). Furthermore, Gniewosz and Noack (2012) found that students' perceptions of their parents' math values mediated the relation between parents' values and students' own values only in cases of the high between-parent agreement on the value of math. However, the concept of the between-parent agreement is also understudied in this area, especially since a vast number of studies include only reports from one parent or exclusively from mothers.

3.2 Self-efficacy

According to the expectancy-value model, parents' sense of self-efficacy in a certain activity domain can significantly predict parents' involvement in activities in this domain. Hoover-Dempsey et al. (1992) developed this parental concept in a broader context of researching the factors that promote parental involvement in children's education. In this context, parents' self-efficacy is described as the level of parents' belief that they have the skills and the knowledge needed to help the child to succeed in school. Previous studies have found the direct (Bogenschneider et al. 1997) as well as the indirect links between parents' self-efficacy and child's school performance. Indirect links were found via parents' school involvement (Hoover-Dempsey et al. 2001), parents' aspirations (Wentzel 1998), and through children's self-efficacy and academic aspirations (Bandura et al. 2001). However, there is little research addressing how parents' self-competence beliefs in the STEM area influence their children's performance and motivation in STEM.

Following the premise of the expectancy-value model, Simpkins et al. (2012) examined the mediating processes between different mothers' beliefs, including self-efficacy, mothers' behaviors, and children's beliefs and behaviors in math. It was found that mothers' beliefs, including math self-efficacy, positively predicted mothers' behaviors 1 year later, such as modeling math-related activities at home, providing math-related materials for the child, and encouraging the child to participate in math-related activities. However, studies have also shown that parents often feel incompetent in helping with child's STEM learning at home (Cardoso and Solomon 2002) and this negative attitude, in consequence, can decrease parents' actual STEM involvement (Solomon 2003).

An early work of Eccles et al. (1982) indicated differences between mothers and fathers in their own experiences and attitudes towards mathematics. In this study, fathers in comparison to mothers reported a higher self-competence in math, more enjoyment in doing math, and a higher importance and utility value of math. Fathers also reported that math is easier for them and that they have to put less effort to be successful at math. Future investigations should therefore also address the possible differences in mothers' and fathers' self-concepts in the STEM domain and how these differences are related to children's beliefs. Gunderson et al. (2012) noted that parents' own math anxiety may present an important possible influence on a child's math attitudes. It is further possible that mothers and fathers differ in their levels of math anxiety. Given that same-gender adults often serve as salient role models for

boys and girls, mothers' and fathers' math anxiety may differently influence female and male children. We suggest further research in this area.

3.3 Perception of a child's abilities in STEM

Previous research has shown that children's self-appraisals, expectations, and task-perceptions in the STEM domain are significantly predicted by their parents' evaluations of their abilities (e.g., Bhanot and Jovanovic 2009; Bleeker and Jacobs 2004; Frome and Eccles 1998; Jacobs and Eccles 1992). Research has even shown that students' ability beliefs in math are more directly related to their parents' beliefs about their math ability than with a child's past achievement in the domain (Eccles et al. 1982; Frome and Eccles 1998). Supporting the concept of parents as expectancy socializers, Frome and Eccles (1998) found that parents' perceptions of a child's ability in math partially mediated the relation between the child's math grade and child's math self-appraisals and task-values. This result suggests that parental beliefs about the child's ability indeed may influence the way a child interprets reality. In other words, it seems that a child's self-perceptions are based not just on the information of the objective performance, but also on their parents' interpretations of this reality.

In one of the rare longitudinal studies, Bleeker and Jacobs (2004) found the long-term effects of these parental evaluations. Mothers' perceptions of their middle school children's abilities in math and science were related to adolescents' self-perceptions in this domain in tenth grade. Furthermore, these adolescents' self-perceptions of ability mediated the relation between mothers' initial child evaluations and adolescents' career self-efficacy in the domain of math and science when they were aged 24–25. Mothers' expectations of a child's success in math-related careers were also related to adolescents' probability of choosing a science career over a non-science career. This study also showed that parents' perceptions of child's ability may have different implications for boys and girls. Namely, in the case of girls, lower mothers' evaluations of girls' abilities in STEM were related to the lower probability for girls to later choose a science career over a non-science career. Interestingly, in the case of boys, mothers' perceptions had a minimal effect on boys' later career in science.

In another longitudinal study, Gniewosz et al. (2011) found that during a transition from elementary to secondary school, the impact of math grades on students' academic self-concepts decreased, while the effects of mother's evaluation of child's ability increased. Interestingly, after the school transition was over, the effect of the child's grades increased and the effect of mother's evaluation decreased. It is discussed that during the school transition children lose their usual reference framework and thus rely more on mothers' appraisals. The issue of educational transition should be more often taken into account in this area of research, especially since, for a majority of the children, this is a normative life event in the period of adolescence which has an important influence on their emotional and social development (Rosenblum and Lewis 2003). Furthermore, schools and STEM teachers should more often inform parents on the particular importance of their child-specific appraisals for the

construction of a child's competence beliefs during sensitive periods of educational transitions.

3.4 Expectations for a child's STEM achievement

Parents' expectations for their child's achievement in the STEM fields are related to children's expectations for their own success in STEM, and these children's expectations, in turn, predict objective achievement in the STEM domain (Bleeker and Jacobs 2004; Jodl et al. 2001; Simpkins et al. 2006). Thomas and Strunk (2017) found that parental expectations had an even stronger effect in explaining students' science achievement than students' self-efficacy beliefs in science.

Furthermore, it has been shown that parental academic expectations for their child serve as mediators in explaining the persisting link between family SES and a child's achievement outcomes (Alexander et al. 1994; Halle et al. 1997; Davis-Kean et al. 2002). More educated parents tend to have higher expectations for their child's academic success and these expectations are related to children's achievement.

In the research that included students from the German PISA sample, Taskinen et al. (2016) compared the relative strength of influence of parental values and parental expectations in predicting students' learning motivation, achievement, and career aspirations in the STEM field. As expected, parental expectations were more strongly related to all students' variables than parental values. Although parents had higher expectations for daughters than for sons, these expectations were more strongly related to boys' interests, self-concept of ability, and achievement in the STEM domain.

More general forms of parental beliefs, such as values and efficacy beliefs in STEM, which were previously described in this article, can surely play an important role in socializing students' outcomes in STEM. However, from a theoretical point of view, as well from the research reviewed in this paper, parents' child-specific beliefs, such as ability perceptions and expectations for success have a stronger and more consistent effect. These specific beliefs are powerful predictors of children's academic motivation and achievement, even when independent estimates of children's actual ability, such as teachers' ratings and standardized test scores, as well as demographic characteristics are taken into account (Simpkins et al. 2015a). These child-specific parental beliefs are particularly important in socializing students' achievement beliefs in the STEM domain. Given the crucial role a child's achievement beliefs have in a child's objective school performance and formation of vocational interests, parents should be aware of the tong-term influence their evaluations may have on the socialization of these motivational beliefs. This type of parent-oriented work in STEM education is even more needed if we consider that parents' perceptions of their children are not always based solely on the child's actual performance. These perceptions are often also based on general beliefs the parent holds, child's characteristics, and wider social context. In line with this, we will further discuss gender-related issues in parents' formation of specific beliefs about their children in STEM.

4 Parents' gender-differentiated beliefs in STEM

Previous studies have systematically showed that girls still have lower self-competence beliefs in STEM and report less liking for STEM subjects than boys (Bleeker and Jacobs 2004; Fredricks and Eccles 2002; Watt 2004). This gap continues although by the end of high school girls have higher grades in math and science (Hill et al. 2010) and achieve similar results as boys on standardized math tests (Hyde et al. 2008). Furthermore, even in elementary school, children hold gender stereotypes, like believing that math is a "boys' domain" (Cvencek et al. 2011). It is argued that the part of the reasoning for this persistent gender difference in the STEM domain may lay in the gender-role socialization in the family (Eccles et al. 1993).

Studies have shown that parents of boys in comparison with parents of girls often believe that their children have more ability in STEM courses (Andre et al. 1999; Bhanot and Jovanovic 2009; Frome and Eccles 1998), that this domain is easier for them (Tenenbaum and Leaper 2003), and that they are more interested in STEM (Bhanot and Jovanovic 2009; Eccles and Jacobs 1986; Tenenbaum and Leaper 2003). In contrast, parents tend to perceive daughters as more competent than sons in domains such as reading and language (Eccles et al. 1993). Eccles et al. (1993) also found that parents differed in their views on the amount of effort girls and boys have to invest to do well in English and math. Parents of girls estimated that their daughters have to work harder to gain good grades in math than the parents of boys, while parents of boys reported that their sons have to work harder in English than parents of girls. Furthermore, parents' comparative assessments of their child's effort in math and English did not differ for male children, while in the case of daughters, parents believed that their daughters have to work harder in math than in English.

Parental gender-differentiated beliefs seem to increase with a child's age (Frome and Eccles 1998). Eccels et al. (1990) found that parental ability perceptions of their children did not differ by gender for younger children, but started to differ when children were in sixth grade. Unfortunately, these parental gendered beliefs are often unrelated to the child's real achievement. For example, parents of girls had lower perceptions of the math ability of their children than parents of boys, even when girls received better math grades (Frome and Eccles 1998).

Interestingly, some research has suggested that mothers, in comparison to fathers, tend to endorse more gender-stereotypical beliefs about their children's abilities. Frome and Eccles (1998) found that only mothers overestimated their sons' and underestimated their daughters' math abilities, while fathers' evaluations were more realistic and based on the child's actual achievement. Similar findings were obtained in other studies (Jayaratne 1983; Yee and Eccles 1988). These results suggest that mothers may hold a critical role in children's development of gender-stereotypical views of their abilities in the STEM domain.

Eccles (2005a) proposed possible explanations as to why parental gendered beliefs about their children's ability in math persist despite the lack of real difference in the achievement and the effort of boys and girls. One explanation refers to

causal attributions parents endorse when explaining boys' and girls' achievement and failure. In his work on attributions, Weiner (1974) found that people explain personal and other's success or failure by attributing it to the ability, effort, task difficulty, or luck. Our perception of other person's competence relies on these attributions. This means that parents of boys and girls should develop different perceptions of their children's abilities if they attribute their children's achievement to different factors (Eccles et al. 2000). Yee and Eccles (1988) empirically confirmed this hypothesis by examining the relationship between parents' causal attributions of their child's math achievement and their perception of their child's talent in math 1 year later. The more a parent attributed their child's achievement to the effort (and this type of attribution was higher for daughters than for sons), the lower were their perceptions of their child's math ability 1 year later. Conversely, parents of boys attributed their child's math achievement to the talent more than the parents of girls. As expected, the more parents attributed their child's achievement to natural ability, the more they rated their child as talented in math. Furthermore, parental attributions were confirmed as a mediating variable. Namely, attributing the child's success in math to the talent or the effort statistically explained the correlation between the child's gender and the mothers' perceptions of the child in math (Eccles et al. 1990).

The second explanation for parental gender-differentiated beliefs in STEM may lay in general gender stereotypes that parents endorse (Eccles 2005a). The majority of cultures have different views of the roles and tasks that are appropriate for males and females and members of a culture tend to internalize these cultural views. The STEM domain is culturally often viewed as a more appropriate task for men (Goodnow 1990). Following the hypothesis that general gender stereotypes play a role in shaping parental child-specific beliefs, Jacobs and Eccles (1992) confirmed the significant interaction between parents' general gender stereotypes and their child's gender in predicting parents' perception of the child's ability. Parents who endorsed gender-stereotypical beliefs overestimated their child's math ability when the child was a boy and underestimated it when the child was a girl. These biased parents' perceptions of the child's ability in math, in turn, predicted children's own perceptions of their math ability. The same effect in math was confirmed in a German study which included elementary school children and their parents (Tiedemann 2000). Parental gender stereotypes, in the same way, moderated the correlation between a child's gender and parents' future expectations for their child's attainment in math, regardless of the child's actual abilities (Jacobs 1991). It seems that even parents of very young children endorse gender stereotypes about children's abilities. In a cross-cultural study that included parents from Japan, Taiwan, and the USA, parents of kindergarten children in all three cultures believed that boys are in general better at math and girls at reading (Lummis and Stevenson 1990).

Results in this area of research have clearly demonstrated that besides a child's actual achievement in STEM school subjects, parental perceptions of a child's ability and expectations for a child's success can be significantly shaped by a child's gender and the gender stereotypes parents may endorse. Consequently, girls, who are generally not favored by these stereotypes, may often be affected by less favorable parental messages about their abilities in STEM. As Jacobs (1991) suggested,

since these parental messages have an indirect effect on the child's performance and choices via the child's personal beliefs, they can be often overlooked by parents. Thus, it seems important for parents to become aware of their possible stereotype endorsement and the ways it can affect their child-specific beliefs and ultimately their child's outcomes in STEM. From the research point of view, it is clear that there is a need for newer studies on the role of parental gendered socialization in explaining gender differences in STEM-related aspirations, competence-beliefs, and educational and career choices. There is also a need for new comparative research across STEM disciplines, besides mathematics which is largely overrepresented in the literature. If we take into account the whole STEM domain, it is known that the gender segregation is the largest in engineering, where the proportion of degrees awarded to women has never reached 25% (Mann and DiPrete 2013). Therefore, it is particularly important to identify the family factors which can positively influence girls' and women's persistence in engineering. Since cultural views may play an important role in the gendered socialization, future studies should also explore the described mechanisms in different societies which may significantly vary in dominating cultural beliefs about appropriate gender roles.

5 The relationship between parents' beliefs and behaviors in STEM

The Eccles' model of parental socialization states that parents influence their children not just as the "interpreters of reality", but also by having the role of the "providers of experiences". Specifically, parents' values and beliefs may influence opportunities parents provide to their children, such as the provision of different toys or learning materials, parents' modeling behaviors, the encouragement of child's interests and participation in different activities, and parents' coactivity with the child in a certain domain (Eccles 1993).

These parental behaviors can serve as expressions of parents' general and child-specific beliefs and affect children's values and activity-choices (Jacobs and Eccles 2000). In other words, there is a hypothesized mediating role of these behaviors in explaining the relationship between parents' and students' beliefs and values in STEM. For example, parental attitudes towards STEM are shown to influence positive parents' involvement behaviors in this domain, like museum visits (Szechter and Carey 2009) and homework involvement (Cardoso and Solomon 2002). In turn, parental educational involvement positively affects children's learning motivation and school achievement (Fan and Williams 2010), and STEM career aspirations (Turner et al. 2004). Simpkins et al. (2012) confirmed the hypothesis of the mediating role of parental behaviors by showing that mothers' valuing of math was indirectly related to children's valuing via parents' support behaviors. However, this mechanism was not confirmed in other studies. For example, Bhanot and Jovanovic (2009) found that mothers' encouragement in STEM was not a significant mediating mechanism between mothers' perceptions of the child's STEM ability and children's self-perceptions. Furthermore, in the same study, mothers' discussions about the utility of STEM with their child did not mediate the relationship between mothers' and children's task-value beliefs. Taking into account these mixed results, it seems

necessary for the future studies to capture various other types of parental behaviors that could play a role in the process of parents conveying their beliefs and values of STEM to their children. Also, further research should examine the ways parents convey their gender-stereotyped beliefs in the STEM domain through specific practices with the child. For example, Bhanot and Jovanovic (2005) found that parents of girls communicated their math stereotype beliefs through the uninvited intrusions with the child's math homework. Other types of parental behaviors that can communicate parents' stereotypic beliefs about STEM should be identified.

Considering that there is still a lack of insight on how children learn to internalize their parents' beliefs, values, and perceptions in STEM, there is a need for a more holistic approach in this area of research. Namely, the quality of the parent–child relationship can also play an important role in the transmission of parents' achievement-related beliefs and values (Jodl et al. 2001). It is more likely that a child will internalize parents' academic values if parents provide a positive emotional environment in the family (Eccles 2007). By supporting a child's autonomy, parents help their children in developing a sense of capability and interest, which leads them to be more engaged with their environment (Fei-Yin Ng et al. 2004). Parents' autonomy support and positive affect should be particularly important for the socialization potential of those parental behaviors which include direct parent–child interaction. Parental involvement in a child's educational and leisure activities related to STEM and parental encouragement of a child's activities in STEM represent these types of behaviors. In line with this, it is important to examine not only the mere frequency of specific parental behaviors but also to capture quality aspects of child–parent relationships. These aspects may include parenting style, parents' support for a child's autonomy, and communication patterns between child and parent during coactivity in the STEM domain. These research questions call for a shift in the prevailing methodological approach in this area. While most of the studies rely on children's and parents' self-reports, in order to capture the quality of parental socializing behaviors in STEM, qualitative methods, such as observations of parent–child interactions during STEM coactivity should be used more often.

6 STEM interventions aimed at parents' beliefs

6.1 Fostering parents' self-efficacy in STEM

A specific problem in the STEM domain is that many parents tend to feel incompetent in helping their children with science-related school content (Solomon 2003). It may be that this low self-efficacy is related to dominating parents' reports of negative personal experiences with STEM at school (Kaya and Lundeen 2010; Solomon 2003). Thus, it seems important for schools and teachers to collaborate with parents in a way that can foster parents' sense of efficacy in STEM and promote positive attitudes towards STEM subjects. 'Hands-on' science programs that promote partnerships between families and schools, have shown to increase parents' interest in involvement in their child's school science courses and these programs are perceived

as effective methods of science education among parents (Kaya and Lundeen 2010; Shymansky et al. 2000).

6.2 Utility-value interventions

The utility value of particular school courses can be a salient motivational influence on student educational and career choices (Eccles 2005b). Thus, in order to promote student motivation for STEM education and careers, parents need to help their children in understanding the importance of STEM school subjects. However, Hyde et al. (2006) found that in their helping with child's math homework in 5th grade, mothers rarely had a goal of conveying the importance of math for their child's future and the utility value of math in everyday life.

Recently, some STEM intervention programs have aimed at teaching parents how to successfully communicate their STEM academic values to children, which can, in turn, affect children's own values in STEM fields. Harackiewicz et al. (2012) conducted an intervention program in which parents were thought how to successfully convey the importance and the utility of the STEM domain to their secondary school children. The intervention led to the increased number of elective STEM courses students chose during their last 2 years of high school. The effects of the intervention on student STEM course-taking were mediated by the changes in parents' and students' STEM utility value (Rozek et al. 2015). Intervention further led to the improved student STEM achievement. Five years after the intervention, the higher STEM achievement and the increased STEM course-taking were related to the increased STEM career pursuit (Rozek et al. 2017).

It is argued that conducting the utility-based interventions is beneficial because the perception of the utility of a certain domain can be more easily manipulated than the perception of the attainment value and interest which are by nature more intrinsic and therefore more difficult to change (Rozek et al. 2015). Furthermore, some findings have suggested that parents more easily convey to their children beliefs about the utility than the attainment value of STEM school subjects (Šimunović et al. 2018).

Parental interventions that have the potential to increase students' perception of the relevance of the STEM domain are quite simple to conduct. In the intervention conducted by Harackiewicz et al. (2012), parents were mailed two brochures and presented with the Web site designed to promote communication between parents and their children about the value of STEM. Thus, this type of parent-centered work presents an untapped and attainable form of family-school collaboration in the STEM domain.

6.3 Changing stereotypical images of the STEM domain and scientists

In addition to previously discussed gender stereotypes in STEM, a recent study has shown that parents (and children) often have stereotypical constructions about other characteristics of scientists (DeWitt et al. 2013a, b). During the in-depth interviews parents often referred to scientists as being 'geeky' and over half of the parents held

constructions about scientists as individuals who are 'special' or 'unique'. The discourse that portrays scientists as 'normal' was less frequent. Authors note that the stereotypical and the 'scientist as specialist' discourse can reinforce parents' and children's vision of people who are highly science-engaged as being 'other', which negatively influences students' willingness to take up a science identity. Moreover, research indicates that many parents (and students) have quite narrow views of career pathways in science and they relate studying science dominantly with the careers of a scientist, science teacher or doctor (Archer et al. 2013). In line with this, it seems advisable to aim future parents-oriented interventions at changing the stereotypical beliefs about scientists and STEM and promote constructions of scientists as 'normal' and STEM careers as accessible. This can be encouraged by providing information on a broad range of possible careers in STEM and illustrating examples of scientists who greatly differ from traditional, widely accepted constructions (DeWitt et al. 2013a, b). However, although there is a large number of interventions aimed at providing participants with a wider knowledge about STEM qualifications and jobs, these interventions are mostly targeted towards students, while parents are largely left out. In addition, the interventions in this area are often not scientifically evaluated or the evaluation is poorly conducted (Archer et al. 2014). Different programs and initiatives which aim at improving parents' and students' awareness about STEM careers, such as science festivals or math nights, miss to evaluate possible changes in parents' (and children's) stereotypical beliefs in STEM. Although targeted at students, a recent intervention that included extensive evaluation highlights the possible challenges in changing this type of belief among students and potentially also among their parents. Namely, results showed that activities such as providing contact with real scientists and providing the information on the variety of careers in science had little effect on changing adolescent students' stereotypical images of scientists (Archer et al. 2014). In order to be effective, it seems that interventions in this domain have to provide more than just the positive images of scientists which will oppose the traditional, stereotypical concepts (Archer et al. 2014). Research suggests that longer-term programs that are embedded in the mainstream school curriculum have greater potential in elevating science career awareness among students (Archer et al. 2012b). Furthermore, evidence shows that in most cases children's images of STEM and their STEM aspirations are formed by age 14 and therefore these programs should begin during elementary school (Archer et al. 2012a). In line with this, future interventions should involve systematic and early collaboration between schools and parents in order to enforce parents' positive images about STEM and views of STEM careers as desirable and accessible for their children. This work should particularly focus on socially disadvantaged families that often have less access to knowledge and resources in the STEM domain (Archer et al. 2012a).

7 Future directions

Studies presented in this review clearly indicate the importance of various parental beliefs in the formation of students' motivational beliefs, achievement, and choices in the STEM domain. However, several research points need to be further investigated in order to obtain a more comprehensive understanding of the complex

mechanisms underlying these associations. Firstly, most of the research in this area is focused exclusively on mathematics as one of the STEM school subjects. At the same time, it has been suggested that students' motivational beliefs differ in different STEM school subjects (e. g., Simpkins et al. 2015b) and that students clearly differentiate their interests in different STEM areas (Babarović et al. 2019). Hence, it is plausible that patterns of association between parental beliefs and students' educational outcomes are not the same across the entire STEM academic domain.

Further, most studies have explored the role of mothers' beliefs, while the influence of fathers' beliefs has been relatively neglected. Moreover, some studies presented in this paper found differences in mothers' and fathers' beliefs and values in the STEM domain (Eccles et al. 1982; Frome and Eccles 1998) and differences in patterns of the relations between maternal and paternal beliefs and students' outcomes in STEM (Tenenbaum and Leaper 2003). These results indicate that there is a need for more research to explore specific roles mothers and fathers play in students' STEM educational outcomes. There is also a need to more often include both parents' and child's reports on parental beliefs. This is important since the child's interpretive processes play a crucial role in the parent-to-child value transmission.

Another research gap is related to studies' design, taking into account that most of the studies are cross-sectional. Since it is known that students' motivational beliefs and STEM achievement change throughout students' schooling (Wigfield and Eccles 1992; Frenzel et al 2010), future research should address how parental beliefs impact children across time and during challenging periods of school transition. Longitudinal studies are also required when examining the causal effect of parents' beliefs on students' beliefs and behaviors in the STEM school domain. The Eccles' expectancy-value model, in fact, assumes that influences between parents and children are mostly reciprocal. Parents' beliefs may be significantly shaped by children's beliefs, behaviors, and achievements and it is also expected that this reciprocal influences change as the child grows older (Simpkins et al. 2012). Thus, longitudinal research could provide more understanding of these developmental trajectories.

All of the discussed parent–child relations have not been explored sufficiently in different cultures and different SES backgrounds. It is likely that a number of underlying processes in a relationship between parental beliefs and students' outcomes in STEM differ across countries and ethnic groups due to different cultural views, gender roles, accessible cultural and economic resources, and socially dominating implicit theories about achievement in the STEM domain.

Finally, since the importance of parental beliefs in the STEM domain has been widely recognized, future research directions should be based on more frequent examination of the efficacy of various intervention programs aiming at the different types of parental beliefs and behaviors. Here it is important to take into account the child's characteristics such as age, gender, and previous STEM achievement when examining the efficacy of these parental programs. We should remember that family socialization takes place over different developmental phases in a child's life and in a complex network of child-related factors and socialization contexts. Considering this complexity, we hope that this review offered a more holistic perspective on the role that parents' beliefs, values, and perceptions have in children's outcomes in a challenging and important educational and vocational area such as STEM.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Acosta, S., & Hsu, H. Y. (2014). Shared academic values: Testing a model of the association between Hong Kong parents' and adolescents' perception of the general value of science and scientific literacy. *Educational Studies, 40*(2), 174–195.

Alexander, K. L., Entwisle, D. R., & Bedinger, S. D. (1994). When expectations work: Race and socioeconomic differences in school performance. *Social Psychology Quarterly, 57*(4), 283–299.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching, 36*(6), 719–747.

Archer, L., DeWitt, J., & Dillon, J. (2014). 'It didn't really change my opinion': Exploring what works, what doesn't and why in a school science, technology, engineering and mathematics careers intervention. *Research in Science & Technological Education, 32*(1), 35–55.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012a). Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal, 49*(5), 881–908.

Archer, L., Osborne, J., & DeWitt, J. (2012). *Ten science facts and fictions: The case for early education about STEM careers*. London: King's College London.

Archer, L., Osborne, J. F., Dillon, J. S., DeWitt, J., Willis, B., & Wong, B. (2013). *Interim research summary, ASPIRES project: What shapes children's science and career aspirations age 10–13?*. London: King's College London.

Babarović, T., Dević, I., & Burušić, J. (2019). Fitting the STEM interests of middle school children into the RIASEC structural space. *International Journal for Educational and Vocational Guidance, 19*(1), 111–128.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187–206.

Bhanot, R., & Jovanovic, J. (2005). Do parents' academic gender stereotypes influence whether they intrude on their children's homework? *Sex Roles, 52*(9), 597–607.

Bhanot, R., & Jovanovic, J. (2009). The links between parent behaviors and boys' and girls' science achievement beliefs. *Applied Developmental Science, 13*(1), 42–59.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96*(1), 97–109.

Bogenschneider, K., Small, S., & Tsay, J. (1997). Child, parent, and contextual influences on perceived parenting competence among parents of adolescents. *Journal of Marriage and the Family, 59*(2), 345–362.

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science, 1*(2), 183–197.

Cardoso, M. L., & Solomon, J. (2002). Studies of Portuguese and British primary pupils learning science through simple activities in the home. *International Journal of Science Education, 24*(1), 47–60.

Chen, H. (2001). Parents' attitudes and expectations regarding science education: Comparisons among American, Chinese–American, and Chinese families. *Adolescence, 36*(142), 305–314.

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math–gender stereotypes in elementary-school children. *Child Development, 82*(3), 766–779.

Davis-Kean, P. E., Eccles, J. S., & Schnabel, K. U. (2002). *How the home environment socializes a child: The influence of SES on child outcomes.* Paper presented at the International Society for the Study of Behavioral Development, Ottawa, Canada.

DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, brainy and normal: Children's and parents' constructions of those who are highly engaged with science. *Research in Science Education, 43*(4), 1455–1476.

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2013). Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable. *International Journal of Science Education, 35*(6), 1037–1063.

Dickhäuser, O., & Stiensmeier-Pelster, J. (2003). Gender differences in the choice of computer courses: Applying an expectancy-value model. *Social Psychology of Education, 6*(3), 173–189.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist, 44*(2), 78–89.

Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., et al. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). New York: W. H. Freeman.

Eccles, J. S. (1993). School and family effects on the ontogeny of children's interests, self-perceptions, and activity choices. In J. E. Jacobs & R. M. Ryan (Eds.), *Nebraska symposium on motivation, 1992: Developmental perspectives on motivation* (pp. 145–208). Lincoln: University of Nebraska Press.

Eccles, J. S. (2005a). Influences of parents' education on their children's educational attainments: The role of parent and child perceptions. *London Review of Education, 3*(3), 191–204.

Eccles, J. S. (2005b). Subjective task values and the Eccles et al. model of achievement related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105–121). New York: Guilford.

Eccles, J. S. (2007). Families, schools, and developing achievement-related motivations and engagement. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of socialization* (pp. 665–691). New York: The Guilford Press.

Eccles, J. S., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development, 53*(2), 310–321.

Eccles, J. S., Freedman-Doan, C., Frome, P., Jacobs, J., & Yoon, K. S. (2000). Gender-role socialization in the family: A longitudinal approach. In T. Eckes & H. M. Trautner (Eds.), *The developmental social psychology of gender* (pp. 333–360). Mahwah: Lawrence Erlbaum Associates Publishers.

Eccles, J. S., & Jacobs, J. (1986). Social forces shape math attitudes and performance. *Signs, 11*(2), 367–380.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues, 46*(2), 183–201.

Eccles, J. S., Jacobs, J. E., Harold, R. D., Yoon, K. S., Abreton, A., & Freedman-Doan, C. (1993). Parents and gender-role socialization during the middle childhood and adolescent years. In S. Oskamp & M. Costanzo (Eds.), *Gender issues in contemporary society, Claremont symposium on applied social psychology* (Vol. 6, pp. 59–83). New York: Sage.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109–132.

Fan, W., & Williams, C. M. (2010). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology, 30*(1), 53–74.

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review, 13*(1), 1–22.

Fei-Yin Ng, F., Kenney-Benson, G. A., & Pomerantz, E. M. (2004). Children's achievement moderates the effects of mothers' use of control and autonomy support. *Child Development, 75*(3), 764–780.

Fredricks, J. A., & Eccles, J. S. (2002). Children's competence and value beliefs from childhood through adolescence: Growth trajectories in two male-sex-typed domains. *Developmental Psychology, 38*(4), 519–533.

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence, 20*(2), 507–537.

Frome, P. M., & Eccles, J. S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*(2), 435–452.

Gniewosz, B., Eccles, J. S., & Noack, P. (2011). Secondary school transition and the use of different sources of information for the construction of the academic self-concept. *Social Development, 3*(21), 537–557.

Gniewosz, B., & Noack, P. (2012). The role of between-parent values agreement in parent-to-child transmission of academic values. *Journal of Adolescence, 35*(4), 809–821.

Goodnow, J. J. (1990). The socialization of cognition: What's involved? In J. W. Stigler, R. A. Shweder, & G. Herdt (Eds.), *Cultural psychology: Essays on comparative human development* (pp. 259–280). Cambridge: Cambridge University Press.

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles, 66*(3–4), 153–166.

Halle, T., Kurtz-Costes, B., & Mahoney, J. (1997). Family influences on school achievement in low-income, African American children. *Journal of Educational Psychology, 89*, 527–537.

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science, 23*(8), 899–906.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: AAUW.

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology, 45*, 740–763.

Hoover-Dempsey, K., Battiato, A. C., Walker, J. M. T., Reed, R. P., DeJong, J. M., & Jones, K. P. (2001). Parental involvement in homework. *Educational Psychologist, 36*(3), 195–209.

Hoover-Dempsey, K. V., Bassler, O. C., & Brissie, J. S. (1992). Explorations in parent-school relations. *The Journal of Educational Research, 85*(5), 287–294.

Hyde, J. S., Else-Quest, N. M., Alibali, M. W., Knuth, E., & Romberg, T. (2006). Mathematics in the home: Homework practices and mother–child interactions doing mathematics. *The Journal of Mathematical Behavior, 25*(2), 136–152.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494–495.

Jacobs, J. E. (1991). Influence of gender stereotypes on parent and child mathematics attitudes. *Journal of Educational Psychology, 83*(4), 518–527.

Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development, 106*, 5–21.

Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63*(6), 932–944.

Jacobs, J. E., & Eccles, J. S. (2000). Parents, task values, and real-life achievement-related choices. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 405–438). New York: Academic Press.

Jayaratne, T. E. (1983). *Sex differences in children's math achievement: Parental attitudes.* Paper presented at the Biennial Meeting of the Society for Research in Child Development, Detroit, Michigan. ERIC. Retrieved October 9, 2018 from https://eric.ed.gov/?id=ED235927.

Jenkins, E. W., & Nelson, N. W. (2005). Important but not for me: Students' attitudes towards secondary school science in England. *Research in Science & Technological Education, 23*(1), 41–57.

Jodl, K. M., Michael, A., Malanchuk, O., Eccles, J. S., & Sameroff, A. (2001). Parents' roles in shaping early adolescents' occupational aspirations. *Child Development, 72*(4), 1247–1265.

Kaya, S., & Lundeen, C. (2010). Capturing parents' individual and institutional interest toward involvement in science education. *Journal of Science Teacher Education, 21*(7), 825–841.

Kearney, C. (2016). *Efforts to increase students' interest in pursuing mathematics, science and technology studies and careers. National measures taken by 30 countries—2015*. Brussels: European Schoolnet.

Lazarides, R., & Ittel, A. (2013). Mathematics interest and achievement: What role do perceived parent and teacher support play? A longitudinal analysis. *International Journal of Gender, Science and Technology, 5*(3), 207–231.

Lummis, M., & Stevenson, H. W. (1990). Gender differences in beliefs and achievement: A cross-cultural study. *Developmental Psychology, 26*(2), 254–263.

Mann, A., & DiPrete, T. A. (2013). Trends in gender segregation in the choice of science and engineering majors. *Social Science Research, 42*(6), 1519–1541.

Marsh, H. W., Martin, A. J., Yeung, A. S., & Craven, R. G. (2017). Competence self-perceptions. In A. J. Elliot, C. S. Dweck, & D. S. Yeager (Eds.), *Handbook of competence and motivation: Theory and application* (pp. 85–115). New York: The Guilford Press.

National Science Foundation. (2017). *Women, minorities, and persons with disabilities in science and engineering*. Alexandria: National Center for Science and Engineering Statistics Directorate for Social, Behavioral and Economic Sciences.

Noack, P. (2004). The family context of preadolescents' orientations toward education: Effects of maternal orientations and behavior. *Journal of Educational Psychology, 96*(4), 714–722.
Perera, L. D. (2014). Parents' attitudes towards science and their children's science achievement. *International Journal of Science Education, 36*(18), 3021–3041.
Rosenblum, G. D., & Lewis, M. (2003). Emotional development in adolescence. In G. R. Adams & M. Berzonsky (Eds.), *Blackwell handbook of adolescence* (pp. 269–289). New York: Blackwell.
Rozek, C. S., Hyde, J. S., Svoboda, R. C., Hulleman, C. S., & Harackiewicz, J. M. (2015). Gender differences in the effects of a utility-value intervention to help parents motivate adolescents in mathematics and science. *Journal of Educational Psychology, 107*(1), 195–206.
Rozek, C. S., Svoboda, R. C., Harackiewicz, J. M., Hulleman, C. S., & Hyde, J. S. (2017). Utility-value intervention with parents increases students' STEM preparation and career pursuit. *Proceedings of the National Academy of Sciences of the USA, 114*(5), 909–914.
Shymansky, J. A., Yore, L. D., & Hand, B. M. (2000). Empowering families in hands-on science programs. *School Science and Mathematics, 100*(1), 48–58.
Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of links between choices and beliefs. *Developmental Psychology, 42*(1), 70–83.
Simpkins, S. D., Fredricks, J., & Eccles, J. S. (2012). Charting the Eccles' expectancy-value model from mothers' beliefs in childhood to youths' activities in adolescence. *Developmental Psychology, 48*(4), 1019–1032.
Simpkins, S. D., Fredricks, J., & Eccles, J. S. (2015). Families, schools, and developing achievement-related motivations and engagement. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of socialization theory and research* (2nd ed., pp. 614–636). New York: Guilford Press.
Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls. *Journal of Research in Science Teaching, 52*(10), 1386–1407.
Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education, 74*(1), 1–18.
Šimunović, M., Reić Ercegovac, I., & Burušić, J. (2018). How important is it to my parents? Transmission of STEM academic values: The role of parents' values and practices and children's perceptions of parental influences. *International Journal of Science Education, 40*(9), 977–995.
Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education, 82*(1), 111–125.
Solomon, J. (2003). Home-school learning of science: The culture of homes, and pupils' difficult border crossing. *Journal of Research in Science Teaching, 40*(2), 219–233.
Sun, L., Bradley, K. D., & Akers, K. (2012). A multilevel modelling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong sample. *International Journal of Science Education, 34*(14), 2107–2125.
Svoboda, R. C., Rozek, C. S., Hyde, J. S., Harackiewicz, J. M., & Destin, M. (2016). Understanding the relationship between parental education and STEM course-taking through identity-based and expectancy-value theories of motivation. *AERA Open, 2*(3), 1–13.
Szechter, L. E., & Carey, E. J. (2009). Gravitating toward science: Parent–child interactions at a gravitational-wave observatory. *Science Education, 93*(5), 846–858.
Taskinen, P. H., Dietrich, J., & Kracke, B. (2016). The role of parental values and child-specific expectations in the science motivation and achievement of adolescent girls and boys. *International Journal of Gender, Science and Technology, 8*(1), 104–123.
Tenenbaum, H. T., & Leaper, C. (2003). Parent-child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39*(1), 34–37.
Thomas, J. A., & Strunk, K. K. (2017). Expectancy-value and children's science achievement: Parents matter. *Journal of Research in Science Teaching, 54*(6), 693–712.
Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology, 92*, 144–151.
Turner, S. L., Steward, J. C., & Lapan, R. T. (2004). Family factors associated with sixth-grade adolescents' math and science career interests. *Career Development Quarterly, 53*(1), 41–52.
Watt, H. M. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th-through 11th-grade Australian students. *Child Development, 75*(5), 1556–1574.

Weiner, B. (1974). *Achievement motivation and attribution theory*. Morristown: General Hill Learning Press.
Wentzel, K. R. (1998). Parents' aspirations for children's educational attainments: Relations to parental beliefs and social address variables. *Merrill-Palmer Quarterly, 44*(1), 20–37.
Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review, 12*, 265–310.
Yee, D. K., & Eccles, J. S. (1988). Parent perceptions and attributions for children's math achievement. *Sex Roles, 19*(5), 317–333.

Mara Šimunović is a Ph.D. student in the program of Psychology at the Faculty of Humanities and Social Sciences at the University of Zagreb. She works as a research assistant at the Ivo Pilar Institute of Social Sciences in Zagreb. Her research interest includes parental socialization in adolescence, gender-related topics in educational and professional domains, and adolescents' mental health.

Toni Babarović is a scientific adviser at the Ivo Pilar Institute of Social Sciences in Zagreb and an associate professor at the Department for Psychology at the Faculty of Croatian Studies, University of Zagreb. His primary research interests include work and vocational psychology, career guidance and counseling, psychology of education, research methodology and statistics.