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Dropping out of an online mentoring program for girls in STEM: A longitudinal study on the dynamically changing risk for premature match closure

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Abstract

Premature closure of mentoring relationships decreases positive effects of mentoring or can even lead to negative effects for mentees. Past studies retrospectively investigated mechanisms of premature match closure. However, a deeper understanding of the dynamics that lead to premature match closure is still missing. In our study, we longitudinally examined the preprogram characteristics, program adherence, as well as program communication and networking behavior of girls ($N = 901$, $M = 13.80$ years) who took part in a 1-year online mentoring program in science, technology, engineering and mathematics (STEM), comparing girls who dropped out of the program prematurely ($N = 598$) with girls who were considered as non-dropouts ($N = 303$). We used survival analysis methods to simultaneously analyze time-independent characteristics and time-dependent dynamics of mentees' communication and networking behavior. Besides mentees' interest in STEM and compliance with program specifications, a frequent and steady communication with their mentors decreased the risk for premature match closure, especially, if it focused on STEM. Mentors' mentoring experience,

mentees' program-wide networking and their networking with other mentees reduced the risk for premature match closure. Regarding the STEM focus of networking, we found competing influences, which need to be further explored in future research.

KEYWORDS
girls in STEM, longitudinal study, online mentoring, premature match closure, survival analysis

1 | INTRODUCTION

Mentoring can be a highly effective measure to support individuals in their personal, academic, or professional development (Bloom, 1984; Bloom & Sosniak, 1985; Grassinger et al., 2010; Lipsey & Wilson, 1993; Roch, 1979; Subotnik et al., 2021). However, if not implemented appropriately, its effects remain moderate to small (Allen et al., 2004; Christensen et al., 2020; Dickson et al., 2014; DuBois et al., 2002, 2011; Eby et al., 2008; Eby et al., 2013; Kammeyer-Mueller & Judge, 2008; Raposa et al., 2019; Tolan et al., 2014; Underhill, 2006; van Dam et al., 2018; Wood & Mayo-Wilson, 2012) or can even be negative (Govekar-Okoliš, 2018; Herrera & Karcher, 2014; Laco & Johnson, 2019; Morris, 2016; Wheeler et al., 2010). One factor that has been shown to crucially compromise mentoring success in previous research is premature match closure (Grossman et al., 2012; Grossman & Rhodes, 2002; Herrera et al., 2011; Karcher, 2005; Slicker & Palmer, 1993; Spencer, 2006). Premature match closure becomes an especially pressing issue in mentoring practice as studies indicate that between one-third and more than half of the mentoring relationships end prematurely (Bernstein et al., 2009; DeWit et al., 2016; Grossman & Rhodes, 2002; Herrera et al., 2013; Keller & Spencer, 2018; Rhodes, 2002; Styles & Morrow, 1992). To maximize positive effects of mentoring and avoid negative effects of premature match closure, a more comprehensive understanding of the underlying reasons and mechanisms is needed. Previous research has focused on identifying reasons and risk factors for premature match closure retrospectively, when match closure has already occurred (DeWit et al., 2016; Grossman et al., 2012; Grossman & Rhodes, 2002; Heppe et al., 2019, 2021; Herrera et al., 2013; Keller & Spencer, 2018; Kupersmidt et al., 2017a, 2017b; Lyons & Edwards, 2022; McQuillin & Lyons, 2021; Raposa et al., 2016; Schwartz et al., 2011; Shlafer et al., 2009; Spencer, 2007; Spencer et al., 2017, 2018, 2020; Stelter et al., 2018). However, as dropping out of a mentoring program is not an abrupt event but rather a long-term process, a longitudinal analysis of the dynamics of a mentoring relationship is needed to better understand the dynamic development and cumulation of risk factors that lead to premature match closure. A better understanding of these dynamic processes is critical to enable mentoring researchers and practitioners to predict premature match closure early enough to still be able to prevent it. Therefore, in our study we longitudinally investigated the dynamically changing risk for mentee-initiated premature match closure in mentoring. We conducted our study within an online mentoring program for girls in science, technology, engineering and mathematics (STEM), taking advantage of the online setting to track dynamic processes.

1.1 | Mentoring paradox

Mentoring can be defined as a relatively stable dyadic relationship between one or more experienced persons (mentors) and one or more less experienced persons (mentees), characterized by mutual trust, goodwill and the

common goal of advancement and growth of the mentee (Stoeger et al., 2009). In formal mentoring programs, frequently implemented formats are one-on-one mentoring, group mentoring or a hybrid form of both (National Academies of Sciences Engineering and Medicine, 2019). Research has shown that mentoring can be a highly effective measure to support individuals in their personal, academic, or professional development (Bloom, 1984; Bloom & Sosniak, 1985; Grassinger et al., 2010; Lipsey & Wilson, 1993; Roch, 1979; Subotnik et al., 2021). However, for mentoring programs to succeed, they require adequate planning and implementation (National Academies of Sciences Engineering and Medicine, 2019). In fact, several meta-analyses reported only moderate to small effect sizes (Allen et al., 2004; Christensen et al., 2020; Dickson et al., 2014; DuBois et al., 2002, 2011; Eby et al., 2008; L. T. T. Eby et al., 2013; Kammeyer-Mueller & Judge, 2008; Raposa et al., 2019; Tolan et al., 2014; Underhill, 2006; van Dam et al., 2018; Wood & Mayo-Wilson, 2012) or even found negative effects of mentoring (Govekar-Okoliš, 2018; Herrera & Karcher, 2014; Laco & Johnson, 2019; Morris, 2016; Wheeler et al., 2010). This unexpectedly wide range of reported mentoring effectiveness can be described by the recently introduced term mentoring paradox (Ziegler et al., 2021). One factor that has been repeatedly identified as detrimental to mentoring success in previous research is the premature termination of the mentoring relationship (i.e., premature match closure) (Grossman & Rhodes, 2002; Grossman et al., 2012; Herrera et al., 2011; Karcher, 2005; Slicker & Palmer, 1993; Spencer, 2006).

1.2 | Premature match closure

Premature match closure has been described as either clearly planned and communicated, gradually dissolving, or abrupt and without any communication (Keller, 2005; Spencer et al., 2017, 2021). It is not a rare phenomenon in mentoring. Studies have reported a premature match closure rate of one-third to more than half of the mentoring relationships within the first year, with most terminations occurring within a few months after matching (Bernstein et al., 2009; DeWit et al., 2016; Grossman & Rhodes, 2002; Herrera et al., 2013; Keller & Spencer, 2018; Rhodes, 2002; Styles & Morrow, 1992). This is problematic because the effectiveness of mentoring depends on the duration of the mentoring relationship. Grossman and Johnson even suggested match length to be one of the best predictors of overall program effectiveness (Grossman & Johnson, 1999). In fact, research has shown that benefits from mentoring for youths become larger with greater match length (Grossman & Rhodes, 2002; Grossman et al., 2012; Herrera et al., 2011; Karcher, 2005; Slicker & Palmer, 1993; Spencer, 2006). For example, Grossman and Rhodes (2002) found that positive mentoring outcomes in youth mentoring were greatest, when the relationship between mentee and mentor persisted for at least 12 months. In contrast, mentees in relationships that ended prematurely, that is, 3–6 months after the beginning of a year-long program, showed progressively less favorable outcomes, and mentees in relationships that ended within the first 3 months of mentoring even experienced negative impacts (e.g., a decline in self-worth and perceived scholastic competence), compared to a control group that did not receive mentoring. In sum, research implies that premature match closure can have a negative impact on mentees, for example, decreases in self-worth and negative perceptions of scholastic competences (Britner & Kraimer-Rickaby, 2005; Karcher, 2005; Spencer et al., 2021), or feelings of disappointment and abandonment (Spencer, 2007; Spencer et al., 2021). Thus, preventing premature match closure is one strategy to maximize the positive impact of mentoring and to avoid possible negative effects on mentees. However, preventing premature match closure requires a comprehensive understanding of the reasons and underlying mechanisms leading to this phenomenon.

1.3 | Previous research on reasons for premature match closure

Previous research has identified reasons and risk factors for premature match closure at the participant, environment, and program levels (DeWit et al., 2016; Grossman & Rhodes, 2002; Grossman et al., 2012;

Heppe et al., 2019, 2021; Herrera et al., 2013; Keller & Spencer, 2018; Kupersmidt et al., 2017a,2017b; Lyons & Edwards, 2022; McQuillin & Lyons, 2021; Raposa et al., 2016; Schwartz et al., 2011; Shlafer et al., 2009; Spencer et al., 2017, 2018, 2020; Spencer, 2007; Stelter et al., 2018). In these studies, either participants were surveyed or interviewed after or at the time of premature match closure about their experiences and their understanding of the reasons for mentoring termination, or mentoring programs were compared on various program characteristics to identify risk factors for premature match closure.

At the individual level, research distinguishes between risk factors associated with mentees such as age, gender, risk status, and level of interest or satisfaction with mentoring, and risk factors associated with mentors such as gender, marital status, income, mentoring expectations, interpersonal skills, and degree of preparation for mentoring. Regarding mentees' age, previous studies have shown that older mentees are more at risk for premature match closure and tend to have shorter match lengths than younger mentees (Grossman & Rhodes, 2002; Kupersmidt et al., 2017b; Spencer et al., 2020). One explanation for this result might be, that mentees in their adolescence become more autonomous and peer-focused, as well as less communicative and responsive to guidance of adults (Darling, 2005). Additionally, mentees' risk status (i.e., emotional, behavioral, or academic problems, risky health behaviors and risky family backgrounds) has been related to shorter match lengths (Grossman & Rhodes, 2002; Grossman et al., 2012; Kupersmidt et al., 2017b; Schwartz et al., 2011; Spencer et al., 2020; Stelter et al., 2018). Furthermore, mentees' extrinsic motivation to join the program (DeWit et al., 2016) and their disinterest or dissatisfaction during mentoring (Herrera et al., 2013; Spencer, 2007; Spencer et al., 2017, 2020) have been related to premature match closure.

Regarding mentors, one study has shown that mentors with lower income and those who are aged 26–30 and married, have shorter mentoring relationships (Grossman & Rhodes, 2002). Matches with female mentors have been found to end earlier than those with male mentors (DeWit et al., 2016; Grossman & Rhodes, 2002; Kupersmidt et al., 2017b; Spencer et al., 2018). Furthermore, mentors with unrealistically high expectations for mentoring (Herrera et al., 2013; Spencer, 2007; Spencer et al., 2017; Styles & Morrow, 1992), those who overestimate their own commitment (Shlafer et al., 2009), and those who feel overwhelmed or burdened by mentoring (Kupersmidt et al., 2017b; Spencer, 2007) have shown higher rates of premature match closure. Difficulties in communication (Shlafer et al., 2009) and mentors' inability to bridge cultural divides also has been related to premature match closure (Spencer, 2007). Moreover, mentors who have not been well prepared for their role as mentors (e.g., via mentor trainings) tend to have shorter mentoring relationships (Kupersmidt et al., 2017a; McQuillin & Lyons, 2021).

At the environmental level, changes in life circumstances (e.g., time constraints or moving) are one of the main reasons for premature match closure (Herrera et al., 2013; Keller & Spencer, 2018; Shlafer et al., 2009; Spencer, 2007; Spencer et al., 2017, 2020). In contrast, supportive parents who encourage mentees or mentors can decrease rates of premature match closure (DeWit et al., 2016; Spencer et al., 2020). Although an appropriate definition of the role of parents in mentoring can be difficult, and the involvement of parents into mentoring can be challenging (Miller, 2007; Morrow & Styles, 1995), research has highlighted the positive effect of parents' support for mentors on preventing premature match closure (DeWit et al., 2016; Spencer et al., 2020). Furthermore, when mentees experience emotional support from their parents, it can lead to greater trust of mentees in their mentors (Britner & Kraimer-Rickaby, 2005).

At the program level, premature match closure is influenced by mentee–mentor matching, overall number of implemented mentoring key factors, frequency of mentee–mentor–contact, as well as training and support of participants. Regarding mentee–mentor matching, dyads with shared racial identity show a reduced risk for premature match closure (Lyons & Edwards, 2022). In contrast, research found an increased rate of premature match closure for dyads with a similar disability (i.e., visual impairment) (Heppe et al., 2019, 2021). Two studies (Kupersmidt et al., 2017a; Stelter et al., 2018) investigated the overall impact of the implementation of research-based key factors for successful mentoring (National Academies of Sciences Engineering and Medicine, 2019) on preventing premature match closure. The overall number of implemented key factors (e.g., participants' agreement on frequency of contacts, training opportunities for participants, supervision and support by staff members) was

associated with match length. Concerning frequency of mentoring contacts, participants with weekly contact show a reduced rate of premature match closure (DeWit et al., 2016). Furthermore, training opportunities for mentors, mentees and mentees' parents (Heppe et al., 2021; Kupersmidt et al., 2017a, 2017b; McQuillin & Lyons, 2021; Spencer et al., 2020) as well as ongoing intense and professional support, supervision and mediation by staff members (Kupersmidt et al., 2017b; McQuillin & Lyons, 2021; Spencer, 2007; Spencer et al., 2020) has been found to be crucial for preventing premature match closure.

1.4 | Current study

Previous research has identified several risk factors for premature match closure at the individual participant, environmental, and program-level. However, previous research on premature match closure has three important limitations. First, most of the existing research targets children and adolescents who are at risk (e.g., concerning their academic achievement or health) or show risk behavior (e.g., aggressive behavior or substance abuse), and is based on community-based youth mentoring programs. Those programs strongly rely on the relational bond with a non-parental caring adult as the key factor for effectuating youth outcomes (Christensen et al., 2020). Thus, although detrimental effects of premature match closure have also been found in programs with a stronger instrumental focus (Grossman et al., 2012), it is not entirely clear to what extent results generalize to other target groups and other mentoring contexts. Second, most previous studies do not differentiate between mentor-initiated premature match closure and mentee-initiated premature match closure. While mentor-initiated premature match closure may be of greater concern regarding detrimental effects for mentees in relationally-focused youth mentoring programs, understanding reasons and risk factors for mentee-initiated premature match closure becomes especially important in more instrumentally focused programs, where the mentoring relationship serves as a context for the mentee's skill development and academic advancement. Third and most importantly, previous research has only retrospectively investigated reasons and risk factors for premature match closure. However, dropping out of a mentoring program is not an abrupt event but rather a long-term process. Therefore, to better understand the dynamics that lead to premature match closure, longitudinal studies are needed that continuously track mentoring relationships from the time of matching to their premature closure. To the best of our knowledge, longitudinal studies that explore how the risk for premature match closure changes dynamically throughout program participation are missing. A better understanding of this issue is, however, crucial for research and practice.

In the present study, we investigated the dynamically changing risk for premature match closure. Specifically, we were interested in mentee's risk to initiate premature match closure. To this end, we tracked the development of mentoring relationships longitudinally and analyzed the role of various potentially influencing factors and of changes in the mentoring relationship for premature match closure. Because online mentoring is particularly well suited to capture such dynamic changes in participant behavior, we conducted our study in the context of an online mentoring program for girls in STEM (science, technology, engineering, and mathematics). In doing so, we additionally extended previous research on premature match closure to a different mentoring context and target group.

What makes our study special is that we investigated, besides static variables on the mentee or mentor level, the role of dynamic processes, that is, changes in the mentoring process and networking, that lead to premature match closure. First, we examined to what extent premature match closure can be explained through individual-level characteristics of the mentees, namely their age and their interest in STEM. Based on previous research on premature match closure (Kupersmidt et al., 2017b; Spencer et al., 2020), we expected younger girls to be less at risk for premature match closure than older girls. We also expected that girls who expressed higher interest in STEM upon entering the program would be less likely to be at risk for premature match closure, because mentees' motivation and interest influence premature match closure (Herrera et al., 2013; Spencer, 2007; Spencer et al., 2017, 2020).

Second, we investigated the role of compliance with program specifications for premature closure. We considered this factor because it is crucial for mentoring success (DuBois et al., 2002, 2011). In particular, studies have shown that adherence to predefined program practices have a preventive effect on premature match closure (Kupersmidt et al., 2017a).

Third, we investigated the role of various aspects of the mentoring process for premature match closure. We explored how the frequency and kind of communication between mentees and their personal mentors relate to premature match closure. Because the quality of a dyad's relationship is associated with premature match closure (DeWit et al., 2016; Lyons & Edwards, 2022; Spencer et al., 2020), we were interested in the stability and steadiness of mentees' communication with their individual mentors. We investigated the amount of communication within the dyad each month, which helps us to get a comprehensive picture of the development of the mentoring communication, and also enables us to take acute changes within the mentee−mentor communication into account when examining premature closure. Furthermore, because not only the amount but also the kind of communication between mentees and their personal mentors relate to premature closure (Parra et al., 2002; Stoeger et al., 2016, 2017, 2021), we investigated mentees' focus on STEM (the main focus of the program) when communicating with their mentors as well as changes in their STEM communication over the course of the mentoring. Previous research has shown that mentoring success is critically influenced by characteristics of mentee −mentor communication such as frequency and duration of their contacts and the extent to which their communication is focused on the program content (Ayoobzadeh, 2019; DuBois et al., 2002, 2011; Higgins & Kram, 2001; Parra et al., 2002). With respect to online mentoring for girls in STEM, participants' STEM communication is associated with mentees' developmental trajectories in key indicators of mentoring success (Stoeger et al., 2016, 2017, 2021). We also took the level of mentors' previous mentoring experience into account, as previous findings have shown that misalignment of expectations as well as mentors' unrealistic ideas about mentoring are associated with premature match closure (Herrera et al., 2013; Kupersmidt et al., 2017b; Shlafer et al., 2009; Spencer, 2007; Spencer et al., 2017; Styles & Morrow, 1992). Additionally, trained mentors tend to have longer mentoring relationships (Kupersmidt et al., 2017a; McQuillin & Lyons, 2021). Taken together, these results suggest that mentors' level of mentoring experience might influence premature match closure.

Fourth, we investigated the role of mentees' networking and communication with other program participants (i.e., other mentees and mentors) for premature match closure. Especially in mentoring for girls in STEM, networking is an important factor for mentoring success (Freeman et al., 1979; Higgins & Kram, 2001; Stoeger et al., 2017). For this reason, we investigated whether mentees' networking – more concretely their (STEM) communication with other mentors and other mentees on the program's online platform – is related to premature match closure. This also enabled us to investigate the differential role of these two groups for premature match closure. Previous research has shown that mentees' outcomes can be influenced by adult role models as well as by peers (Dasgupta, 2011; Dasgupta & Stout, 2014; Hopp et al., 2020), however, little is known about which group might have a more important impact on premature match closure. Specifically, we examined dynamics in mentees' networking and its influence on premature match closure. By analyzing the monthly amount as well as the STEM focus of mentees' networking we were able to investigate the role of (STEM related) networking and changes in (STEM related) networking for premature match closure.

2 | METHOD

2.1 | The online mentoring program CyberMentor as a study setting

The study was conducted within the CyberMentor program, Germany's largest research-based online mentoring program for girls and women in STEM. The goal of CyberMentor is to increase participation rates of girls and women in STEM. Online mentoring was chosen to achieve this goal because its regional independence and time

flexibility make it possible to find enough women working in a STEM field who are willing to volunteer as mentors and role models — independent of the low participation rates of women in STEM in Germany (Bundesagentur für Arbeit, 2020; German Federal Bureau of Statistics, 2021). In CyberMentor female students in secondary education (mentees) are matched with individual mentors, female experts working in a STEM field. Each year, up to 800 girls aged 10–19 years and their respective mentors participate in the program for at least one year. Mentees and mentors commit to communicate with each other for at least 30 min per week. The communication about STEM topics and careers and joint work on STEM projects takes place on a secure online platform via email, private chat and forum. In addition to mentoring, the program offers networking opportunities with other mentors and mentees on the platform. Important structural and organizational key aspects of successful mentoring (DuBois et al., 2002, 2011) are adhered to. For example, the program ensures an appropriate program duration of at least 1 year, frequent mentor-mentee communication and provides structured activities (STEM project phases) within the mentoring year, as well as training and ongoing support for the program participants. The matching of mentees and mentors is based on similar STEM and personal interests, and takes special requests into account. The program is free of charge. The mentors are volunteers and often sign up several times. Various studies have shown the effectiveness of the program to support girls in STEM (Stoeger et al., 2013, 2016). Besides the general effectiveness (in comparison to a wait-list control group), for example, the role of networking with other participants, of mentees' communication behavior, or of relationship quality for mentoring success have been investigated (Stoeger et al., 2019, 2021).

2.2 | Sample and procedure

In the present study we analyzed the preprogram characteristics, program adherence, as well as program communication and networking behavior of girls ($N = 901$, $M = 13.80$ years, standard deviation [SD] = 1.97 years, age-range 10–19 years) who took part in an online mentoring program for girls in STEM. We combined data from three mentoring years[1] (2013–2016) and included only mentees who registered to the mentoring program for the first time. We compared girls who dropped out of the program prematurely (dropouts, $N = 598$, $M = 13.73$ years, SD = 2.02 years, age-range 10–19 years) with girls who participated for at least one mentoring-year or re-registered for a second year (non-dropouts, $N = 303$, $M = 13.93$ years, SD = 1.85 years, age-range 10–18 years). We did not include mentoring dyads in the sample in which mentees dropped out of the program after premature match closure was initiated by the mentors ($N = 260$).

For registration, besides demographic variables, mentees indicated their interest in physics, chemistry, biology, mathematics, engineering, and computer science. Before the mentoring started, all mentees were asked to fill out a voluntary online questionnaire (serving for program evaluation purposes). On average, 77.18% of mentees filled out the questionnaire. In the present study, the proportion of the filled-out questionnaire at the beginning of the program served as a proxy for initial program adherence. During mentoring, participants' platform activities and communication were recorded via anonymized log files. To allow for a longitudinal analysis of the dynamics of mentoring and networking behavior over time, communication and activity data were preprocessed as follows for each month separately throughout the mentees' mentoring year. We counted mentees' anonymized email and chat messages as well as forum posts for each addressed group of participants, that is, their personal mentors, other mentors than their personal mentor, or other mentees. Furthermore, the content of these messages — more particularly their STEM relatedness — was analyzed. To assess the amount of written STEM words we used the text-analysis program LIWC (Pennebaker et al., 2015) and a STEM-word dictionary consisting of 1926 words (Heilemann, 2015). Since single chat-messages were often very short but numerous, we combined all chat messages of one day between the same two individuals into one chat session. This allowed for better comparability between

[1]The duration of each mentoring round differed slightly and was partly longer than 12 months. To standardize the mentoring duration, we chose a cut-off after 365 days.

chat sessions and emails. Note, however, that if mentees wrote multiple chat messages to different recipients in one day, we counted these as multiple chat sessions. To observe participants' general ongoing activity on the online program, we analyzed their platform logins.

2.3 | Variables

2.3.1 | Status of program participation

Mentoring time until last login

We defined the mentoring time until last login as the time (in days) that had elapsed from matching between mentee and mentor until the mentee's last platform login within her mentoring relationship. It also indicates the duration of activity of a mentee on the online mentoring platform within her mentoring relationship. Note, that if a mentee terminated her mentoring relationship prematurely but stayed active on the platform, we considered her last login within the mentoring relationship as ending point.

Dropout-Status

The dropout-status indicated whether a mentee dropped out of the online platform and ended her mentoring relationship prematurely[2], or whether she either completed an entire mentoring year together with her mentor or signed up again for a second mentoring year. The variable was scaled dichotomously (0 = no premature match closure, 1 = premature match closure).

The value 1 for premature match closure was assigned if either a mentee informed the program team that she no longer wished to participate in the program ($N = 53$) or if a mentee became inactive on the online platform, hence, did not log in into the online mentoring platform anymore ($N = 545$). In the latter case, we considered a mentee as inactive if her last login was longer ago than 36 days while the mentoring year was not fully completed.

2.3.2 | Mentees' individual-level characteristics

Age

At the beginning of the mentoring mentees reported their age (in years).

STEM interest

At program registration, each mentee indicated her interest in physics, chemistry, biology, mathematics, engineering and computer science on a 6-point Likert-type scale (1 = no interest at all, 6 = very high interest). The values of the six items were averaged to indicate interest in STEM.

2.3.3 | Compliance with program specifications

Initial program adherence

The proportion to which a voluntary questionnaire (serving for program evaluation purposes) was filled out by the mentee at the beginning of the mentoring year served as proxy for program adherence before the mentoring year

[2]Note that it is not entirely clear to which extent mentees who dropped out of the online platform in fact experienced premature match closure, as they may have continued their mentoring relationship using communication channels outside the online platform. This would yield to an overestimation of the number of dropouts.

had started. The variable was analyzed in 10%-steps (0.00 = questionnaire was not filled out, 10.00 = questionnaire was completely filled out).

Longitudinally-averaged platform logins

We calculated for each month the number of the mentee's platform logins longitudinally-averaged over all months since matching. For example, if we considered a mentee in her third month of mentoring and she had six logins in the first month, zero logins in the second month and four logins in the third month, her longitudinally-averaged platform login was 10/3 for the third month of mentoring. If she then had in the next month two further logins, her longitudinally-averaged platform login for month four was 12/4. Mathematically, the variable longitudinally-averaged platform logins x at month n reads: $\bar{x}_n = \sum_{i=1}^{n} \frac{x_i}{n}$.

2.3.4 | Mentoring process

Mentoring experience of the mentor

The number of previous matchings with other mentees was counted as proxy for the mentoring experience of the mentee's personal mentor at the beginning of the mentoring. Note that this variable is restricted to the mentor's experience within the online mentoring program of the study setting and does not consider previous matchings outside this program.

Written emails to the mentor

We counted the number of emails to the personal mentor written by the mentee in the month of consideration.

Chat sessions with the mentor

We counted the number of the mentee's chat sessions with the personal mentor in the month of consideration.

Acute change in frequency of written emails to the mentor

To identify large changes in the frequency of mentee–mentor communication, we computed the difference between the number of mentee's emails to the personal mentor in the month of consideration and the month before.

Longitudinally-averaged written STEM words in emails to the mentor

We calculated for each month the number of the mentee's written STEM words in emails to the personal mentor longitudinally averaged over all months since matching.

Longitudinally-averaged written STEM words in chat sessions with the mentor

We calculated for each month the number of the mentee's written STEM words in chat sessions with the personal mentor, longitudinally averaged over all months since matching.

2.3.5 | Networking

Written emails to other mentors

We counted the number of emails to other mentors written by the mentee in the month of consideration.

Chat sessions with other mentors

We counted the number of the mentee's chat sessions with other mentors in the month of consideration.

Longitudinally-averaged written STEM words in emails to other mentors

We calculated for each month the number of the mentee's written STEM words in emails to other mentors, longitudinally averaged over all months since matching.

Longitudinally-averaged written STEM words in chat sessions with other mentors

We calculated for each month the number of the mentee's written STEM words in chat sessions with other mentors, longitudinally averaged over all months since matching.

Written emails to mentees

We counted the number of emails to mentees written by the mentee in the month of consideration.

Chat sessions with mentees

We counted the number of the mentee's chat sessions with mentees in the month of consideration.

Longitudinally-averaged written STEM words in emails to mentees

We calculated for each month the number of the mentee's written STEM words in emails to mentees, longitudinally averaged over all months since matching.

Longitudinally-averaged written STEM words in chat sessions with mentees

We calculated for each month the number of the mentee's written STEM words in chat sessions with mentees, longitudinally averaged over all months since matching.

Forum posts

We counted the number of forum posts of the mentee in the month of consideration.

STEM words in forum posts

We counted the number of written STEM words in forum posts of the mentee in the month of consideration.

2.4 | Plan of analysis

In the following, the event of interest is the platform-dropout of a mentee, operationalized through unsubscription from the mentoring program or through ongoing inactivity on the platform, and with that the mentee's last login within the mentoring relationship. We compared the timestamps of the last login of the mentees with those of their mentors and with the timestamps of the duration of their mentoring relationships. Thereby, we categorized the participants as either dropouts initiated by the mentee, dropouts initiated by the mentor, or non-dropouts. Mentees who re-registered for a second year were counted as non-dropouts, although we could observe in several cases an inactivity on the online platform before re-registering. In the following model, we will consider these mentees as *right censored*, that is, the information about the mentee's progress is incomplete but will not be neglected. Ignoring available censored information may yield to unnecessary bias, however, treating the time until inactivity as time to dropout would underestimate the model. Both can be avoided through censoring (Kaplan & Meier, 1958).

Since one should differentiate between a mentee who dropped out early in the program and a mentee who dropped out at a later point of time, for instance during the last period of mentoring, it was not sufficient to simply distinguish between two groups of mentees in our modeling, namely between dropouts and nondropouts. Hence, the interaction of two measures indicated the dependent variable of our study, namely the time that has elapsed since matching to the mentee's last login on the platform within the mentoring relationship as well as the dichotomous variable describing the dropout status of a mentee. In other words, we aimed to analyze the risk for

mentees for dropping out of the online mentoring (platform) at a certain point in time. In doing so, we took time-dependent changes and dynamics of mentees' behavior in the mentoring program into account which were longitudinally observed when predicting premature match closure. The aspects mentioned above can be analyzed using survival analysis methods. Research has indicated that the fact that survival analyses methods can handle censored data provides a significant advantage over other classification techniques when it comes to predicting dropouts and at the same time investigating dynamic processes (Ameri et al., 2016).

2.5 | Survival analysis and time dependent Cox regression

Hereinafter, we want to briefly outline the theoretical framework of survival analysis based on the semi-parametric Cox hazard regression model (Cox, 1972; Kalbfleisch, 2002). While parametric models assume a specific form of the distribution of the survival data, the Cox proportional hazard model is semi-parametric, so that we can model survival data without making any further assumptions about the shape of the hazard function itself (Cox, 1972). When the proportionality assumption is fulfilled, meaning, when the effect of risk factors remains constant over time, one speaks of proportional hazard models (Breslow, 1975). However, using time-varying data, for example, when communication between mentoring dyads changes dynamically throughout time, a generalization of the proportional hazard model will be necessary. An extended model (Aalen, 1975; Aalen, 1978) uses a multivariate counting process formulation to address time-dependent predictors of survival time (Andersen & Gill, 1982; Fisher & Lin, 1999). Then, and while the event of interest (e.g., the last login of a mentee within her mentoring relationship) has not yet happened before time t, the risk for an individual (e.g., the mentee) that the event will happen at time t is given by the hazard function,

$$h(t) = h_0(t)\exp\left\{\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_1' X_1'(t) + \beta_2' X_2'(t) + \cdots\right\} = h_0(t)\exp\{\beta X + \beta' X'(t)\},$$

where $h_0(t)$ is a positive-defined unspecified baseline hazard function, and X and $X'(t)$ are time-independent and time-dependent covariates which may influence the likelihood of the event. The parameters β_i and β_i' measure the effect of the covariates on the risk for the occurrence of the event and are estimated by maximizing partial likelihood (Cox, 1975). For instance, a positive value of β_i (or β_i') indicates that an increase of the value of the i-th covariate X_i (or $X_i'(t)$) causes a higher hazard rate and with that, the survival time decreases. The underlying approach is that each mentee experiences in each month a risk for premature match closure. Then, a smaller hazard rate, that is, a smaller risk for premature match closure indicates a longer duration of the mentoring relationship. Note, that every time-dependent covariate can be treated as time-invariant if its value does not change over the time of the study or when it is collected only at one time point within the study. Since we include in our current study time-independent as well as time-dependent variables, this is the model of our choice. The time-independent variables are mentee's or mentor's static attributes, which were collected during registration for the mentoring program or at the beginning of the mentoring (i.e., mentees' age, STEM interest and initial platform adherence as well as mentors' previous mentoring experience). The time-varying variables are longitudinally collected communication and networking data. Cox regression analyses can deal with multiple continuous and nominal predictors, as long as an adequate sample size is available. However, the power of the survival analysis is more closely related to the number of occurring events than the number of the considered individuals. Thus, multivariable models become problematic, if the number of events per number of potential predictive variables becomes small, so to say, less than 10 (Harrell FE et al., 1985; Peduzzi et al., 1995). In that case regression coefficients become more biased and overfitting may be a serious issue. In the present study we observed $N = 598$ events and considered 2, 4, 10, and 20 different variables in four models, therefore, the number of events per variable was at least 29.9 and remained large enough.

Survival analysis was carried out with the R package survival 3.3-1 (Therneau, 2022; Therneau & Grambsch, 2000). Using the counting process formula, we reformatted our data from one record-per-mentee to one record-per-month per mentee, clustering records over time for each mentee later on. Testing collinearity through variance inflation factors showed that multicollinearity was not a concern, see Table 1. Coefficients were estimated by maximizing partial likelihood and reported with robust standard errors.

3 | RESULTS

3.1 | Descriptive statistics

Table 2 shows means, standard deviations and ranges for all collected measures per month. Age, STEM interest, platform-adherence and the mentoring experience of the mentor are static variables collected at the beginning of the mentoring year. All other measures are time-dependent and change for mentees throughout mentoring. To receive insights into the average communication and networking activities on the platform per month, we provide means and standard deviations for these measures regardless of whether they were later used in longitudinal

TABLE 1 Variance Inflation Factors.

	VIF
Age	1.15
STEM interest	1.08
Initial program adherence	1.05
Longitudinally-averaged platform logins	1.41
Mentoring experience of the mentor	1.06
Written emails to the mentor	2.41
Chat sessions with the mentor	1.29
Acute change in frequency of written emails to the mentor	1.80
Longitudinally-averaged written STEM words in emails to the mentor	1.37
Longitudinally-averaged written STEM words in chat sessions with the mentor	1.30
Written emails to other mentors	1.65
Chat sessions with other mentors	1.78
Longitudinally-averaged written STEM words in emails to other mentors	1.80
Longitudinally-averaged written STEM words in chat sessions with other mentors	1.31
Written emails to mentees	1.22
Chat sessions with mentees	1.90
Longitudinally-averaged written STEM words in emails to mentees	1.30
Longitudinally-averaged written STEM words in chat sessions with mentees	1.16
Forum posts	1.30
STEM words in forum posts	1.23

Note: To test collinearity, we provide variance inflation factors for all variables.

average. In doing so, we calculate means and standard deviations taking all months mentees participated in the mentoring program (in total $N = 6083$) for all mentees together. Overall, there were large variations in mentees' communication and networking behavior and mentees used the online platform in very different ways. Table 2 provides the descriptive statistics of the time-dependent variables for each month of the mentoring year. On average, communication between mentees and their mentors as well as between mentees and other participants decreased over the course of the mentoring year. The main communication tool for exchange between mentees and the personal as well as other mentors was the mailing system. Furthermore, Table 3 shows that on average the main receiver of mentees' emails was the personal mentor. Note that the means and standard deviations for each month were calculated including only mentees who were still active in mentoring during the reported month. Figure 1 shows the decrease of the percentage of the number of active mentees on the platform over the course of the mentoring year. Figure 2 shows mentees' last platform logins within the mentoring year and differs between the groups of dropouts and nondropouts.

TABLE 2 Descriptive statistics for measures per month, taking all months (in total $N = 6083$) mentees participated in the mentoring program together.

	M	SD	Range
Age (in years)	13.80	1.97	10–19
STEM interest	3.54	0.98	1.5–6.0
Initial program adherence (in %)	77.18	39.12	0–100
Platform logins per month†	5.83	9.85	1–184
Mentoring experience of the mentor	0.91	1.41	0–7
Written emails to the mentor per month	1.54	2.31	0–39
Chat sessions with the mentor per month	0.22	0.73	0–10
Written STEM words in emails to the mentor per month†	1.63	4.53	0–90
Written STEM words in chat sessions with the mentor per month†	0.33	2.54	0–138
Written emails to other mentors per month	0.29	1.35	0–41
Chat sessions with other mentors per month	0.15	1.39	0–44
Written STEM words in emails to other mentors per month†	0.31	3.27	0–108
Written STEM words in chat sessions with other mentors per month†	0.11	3.84	0–285
Written emails to mentees per month	0.56	2.62	0–150
Chat sessions with mentees per month	0.81	5.97	0–295
Written STEM words in emails to mentees per month†	0.22	1.39	0–42
Written STEM words in chat sessions with mentees per month†	0.22	1.59	0–49
Forum posts per month	0.94	4.1	0–157
STEM words in forum posts per month	0.42	2.9	0–128

Note: To receive insights into the average communication and networking activities on the platform per month and although several variables (indicated by: †) were calculated in longitudinal average, we provide in this table the descriptive statistics of the collected measures independent of their longitudinal average to receive insights into the average communication and networking activities on the platform per month, taking all months mentees participated in the mentoring program (in total $N = 6083$) for all mentees together.

Abbreviation: STEM, science, technology, engineering, and mathematics.

TABLE 3 Descriptive statistics of the time-dependent variables for each month of mentees' (up to $N = 901$) mentoring year.

	M												SD											
	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Longitudinally-averaged platform logins	11.08	10.09	9.21	8.36	7.94	7.61	7.18	6.77	6.36	6.30	6.37	7.05	13.51	11.55	10.72	8.91	8.32	7.93	7.57	6.96	6.22	6.22	6.20	6.69
Written emails to the mentor	3.43	2.06	1.62	1.28	1.20	0.92	0.83	0.69	0.63	0.76	0.70	0.99	3.05	2.73	2.22	1.89	1.84	1.48	1.50	1.41	1.26	1.56	1.14	1.93
Chat sessions with the mentor	0.46	0.29	0.22	0.17	0.18	0.18	0.11	0.09	0.09	0.11	0.12	0.19	1.06	0.80	0.75	0.68	0.64	0.64	0.48	0.37	0.41	0.51	0.51	0.71
Acute change in frequency of written emails to the mentor		−1.58	−0.57	−0.38	−0.15	−0.37	−0.13	−0.19	−0.09	0.09	−0.13	0.13		3.48	2.54	2.17	1.83	1.80	1.52	1.45	1.27	1.40	1.55	1.74
Longitudinally-averaged written STEM words in emails to the mentor	5.05	3.72	3.14	2.76	2.51	2.29	2.12	1.98	1.90	1.85	1.75	1.98	7.42	4.80	4.02	3.58	3.31	3.01	2.77	2.57	2.41	2.31	2.13	2.28
Longitudinally-averaged written STEM words in chat sessions with the mentor	0.7	0.58	0.59	0.46	0.45	0.46	0.43	0.39	0.37	0.37	0.42	0.43	2.93	1.91	2.37	1.34	1.26	1.24	1.17	1.08	1.08	1.05	1.16	1.05

TABLE 3 (Continued)

	M												SD											
	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Written emails to other mentors	0.49	0.42	0.41	0.27	0.22	0.20	0.14	0.13	0.14	0.12	0.13	0.17	2.03	1.57	1.73	1.10	1.16	1.13	0.61	0.56	0.69	0.68	0.58	0.65
Chat sessions with other mentors	0.51	0.24	0.10	0.07	0.05	0.07	0.04	0.02	0.01	0.02	0.02	0.02	2.83	2.11	0.62	0.43	0.40	0.65	0.32	0.2	0.12	0.15	0.16	0.14
Longitudinally-averaged written STEM words in emails to other mentors	0.57	0.52	0.54	0.40	0.37	0.38	0.37	0.24	0.22	0.21	0.22	0.29	4.55	3.49	3.73	2.71	2.78	3.11	2.96	1.20	1.15	1.13	1.16	1.31
Longitudinally-averaged written STEM words in chat sessions with other mentors	0.46	0.34	0.28	0.09	0.08	0.08	0.08	0.07	0.05	0.05	0.06	0.08	9.55	6.00	4.82	0.50	0.42	0.40	0.36	0.31	0.24	0.23	0.23	0.26
Written emails to mentees	1.42	0.86	0.82	0.32	0.26	0.23	0.21	0.20	0.15	0.13	0.13	0.22	3.47	1.88	5.69	1.12	1.07	0.78	0.84	0.73	0.64	0.52	0.56	1.15
Chat sessions with mentees	3.04	1.42	0.66	0.23	0.25	0.17	0.10	0.05	0.06	0.05	0.05	0.09	10.60	10.80	3.83	1.14	1.46	0.91	0.51	0.32	0.34	0.33	0.35	0.57
Longitudinally-averaged	0.54	0.49	0.40	0.35	0.30	0.28	0.25	0.23	0.21	0.20	0.21	0.26	2.23	1.48	1.18	0.98	0.85	0.78	0.71	0.68	0.64	0.61	0.63	0.70

(Continues)

TABLE 3 (Continued)

	M												SD											
	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
written STEM words in emails to mentees																								
Longitudinally-averaged written STEM words in chat sessions with mentees	0.92	0.65	0.52	0.41	0.37	0.34	0.32	0.25	0.23	0.22	0.21	0.22	2.93	2.26	1.72	1.35	1.21	1.16	1.07	0.71	0.65	0.61	0.58	0.62
Forum posts	2.41	1.36	0.87	0.80	0.72	0.42	0.33	0.35	0.19	0.33	0.39	0.42	7.71	4.87	2.94	2.88	4.02	1.76	1.47	1.51	0.76	1.13	1.70	1.42
STEM words in forum posts	1.03	0.70	0.28	0.16	0.21	0.28	0.24	0.32	0.06	0.08	0.72	0.35	2.91	3.09	1.72	1.30	1.86	2.59	2.78	3.62	0.71	0.57	8.45	2.00
Number of mentees	901	821	745	653	584	506	449	392	346	290	237	158	901	821	745	653	584	506	449	392	346	290	237	158

Note: We provide descriptive statistics of the time-dependent variables for each month, taking in each month only mentees into account who still participate in mentoring.
Abbreviation: STEM, science, technology, engineering, and mathematics.

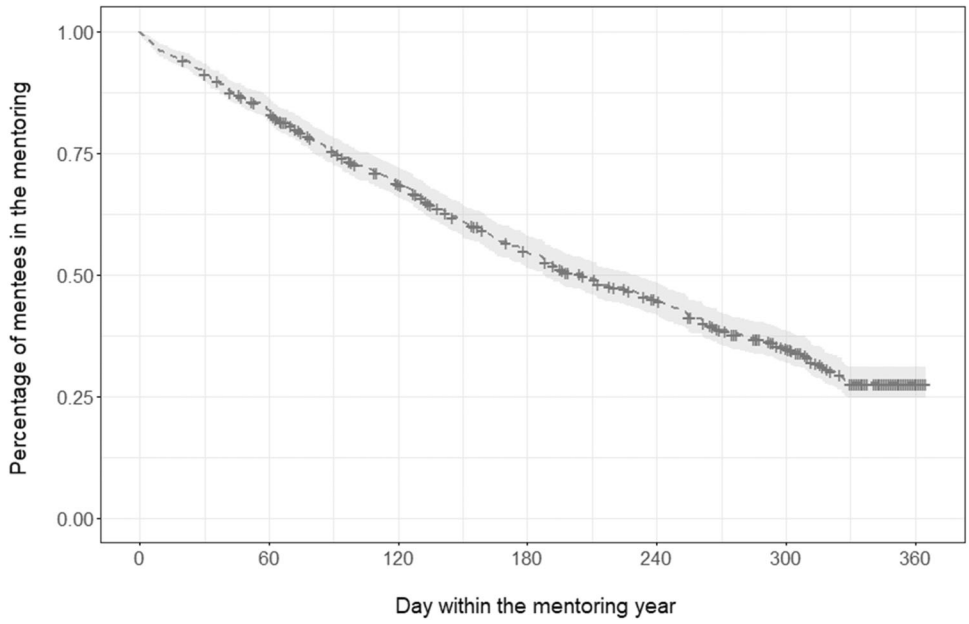

FIGURE 1 Decrease of the Percentage of Active Mentees on the Platform over the Course of the Mentoring Year. Crosses indicate the events of censoring, for example, when mentees who were counted as nondropouts ended their participation in mentoring ($N = 303$).

3.2 | Prediction of premature match closure

Table 4 provides the results of the four successive Cox regression models taking time-independent and time-dependent variables into account to evaluate risk factors of mentees for premature match closure. More precisely, the risk factors predict the event of mentees' last platform login within their mentoring relationship before dropping out. Since by definition this always is followed by premature match closure, in the following we will speak of a risk for premature match closure instead of a risk for having a last platform login. For the sake of simplicity, in the following, we designate all estimates of the regression coefficients as "β," regardless of whether time-independent or time-dependent coefficients are described. Furthermore, we will discuss the results of the Cox regression models in the following using a percentage description of decrease or increase of mentees' risk for premature match closure. An increase of one unit within a variable corresponds to a change of the mentees' risk for premature match closure, given by a change in their hazard function through an additional factor of $\exp\{\beta\}$ compared to their previous hazard function with no change in the variable. Using a percentage description of decrease or increase in mentees' risk, this corresponds to a change in risk compared to their previous risk by $|1 - \exp(\beta)|\%$. Note that the decrease or increase of risk in Cox regression is not linear but exponential. This means that, for example, increasing the variable by twice a unit does not correspond to a decrease or increase of risk by twice the percentage but must be calculated through $|1 - \exp(2\beta)|\%$, since we receive for each increase of the variable by one unit an additional multiplicative factor of $\exp(\beta)$.

In Model 1, we examined to what degree mentees' age and interest in STEM predicted the likelihood of mentees dropping out of the mentoring program. Since the estimates of the model were not significant, we concluded that age and STEM interest alone did not adequately predict premature match closure (Log likelihood ratio test: $\chi^2(2) = 4.3$, $p = 0.1$). Therefore, in a second model, we included variables indicating the compliance of mentees with the program specifications.

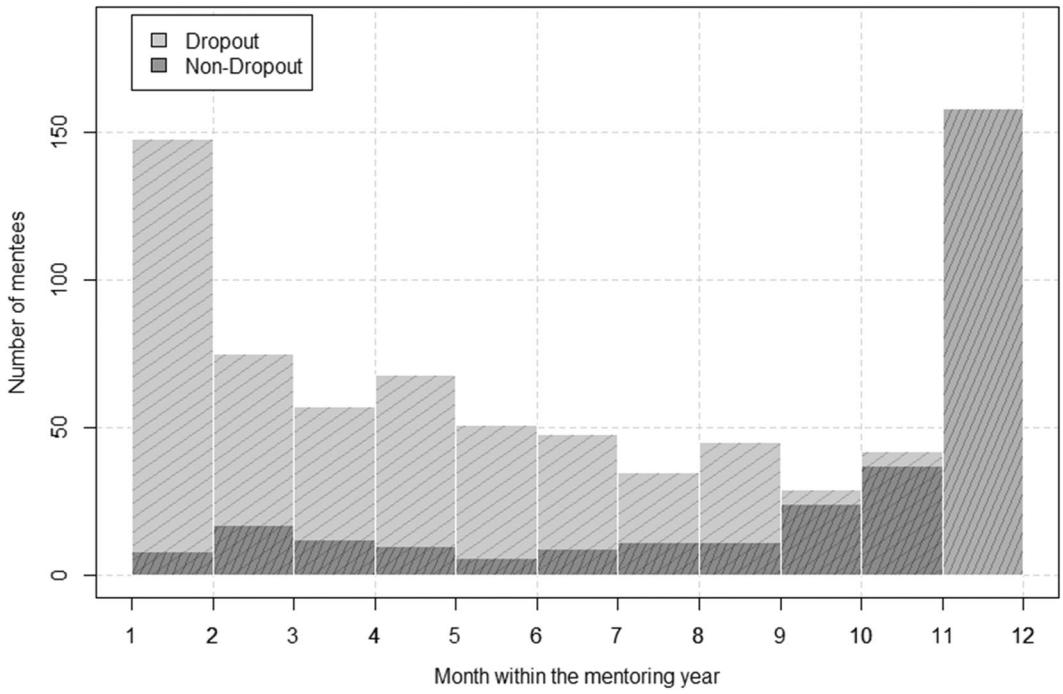

FIGURE 2 Dropouts' and nondropouts' last platform logins within the mentoring year. Mentees who informed the program team that they no longer wanted to participate in the program or who appeared to be inactive on the online platform were counted as dropouts ($N = 598$). We observed two kinds of non-dropouts ($N = 303$). First, we observed mentees who completed an entire mentoring year with their personal mentors and are counted thus as nondropouts. Second, we observed mentees who did not complete an entire mentoring year and had a last platform login within the mentoring year, but signed up again for a second mentoring year. Therefore, they were counted as non-dropouts as well.

In Model 2 (Log likelihood ratio test: $\chi^2(4) = 297.3$, $p < 0.000$), age, initial program adherence and longitudinally-averaged platform logins were significant predictors of premature match closure. In contrast, STEM interest was not a significant predictor. In this model, after controlling for all other covariates in the model, a 1-year increase in mentees' age was associated with a 5% decreased risk for premature match closure ($\exp(\beta) = 0.95$, $p = 0.017$). Program adherence measured at the beginning of the mentoring year proved to be a good predictor for a later platform dropout ($\exp(\beta) = 0.95$, $p < 0.000$). Remember, that as a proxy for mentees' initial program adherence we had chosen the proportion (in 10%-steps) to which a voluntary questionnaire was filled out by mentees at the beginning of their mentoring year. Hence, if mentees' questionnaire completion rate increased by 10%, their risk for dropping out decreased by 5%. Furthermore, after controlling for all other variables, the number of longitudinally-averaged platform logins was a significant predictor for the risk for mentees to dropout ($\exp(\beta) = 0.86$, $p < 0.000$). Thus, when mentees had on average one extra login per month, that means one extra login in each month of their program participation, their risk that the month of consideration was the month with their last login within mentoring decreased by 14%.

Model 3 examined the influence of the personal mentor on the risk for premature match closure after accounting for age, STEM interest and compliance with program specifications (Log likelihood ratio test: $\chi^2(10) = 423.2$, $p < 0.000$). First, comparing the predictive power of age, STEM interest and compliance with program specifications with their predictive power in the previous model, age was not a significant predictor, but STEM interest was ($\exp(\beta) = 0.91$, $p = 0.036$), indicating that an increase in STEM interest by one point in a

TABLE 4 Estimates of four successive cox regression models for time-independent and time-dependent variables ($N = 901$).

		β	exp(β)	SE (β)	95% CI exp(β) LL, UL	p	z
Model 1	Age (in years)	−0.04	0.96	0.02	0.92, 1.00	0.069	−1.82
	STEM interest	−0.05	0.95	0.04	0.88, 1.04	0.279	−1.08
	Likelihood ratio test: $\chi^2(2) = 4.3$, $p = 0.1$						
Model 2	Age	−0.05	0.95*	0.02	0.91, 0.99	**0.017**	−2.39
	STEM interest	−0.07	0.94	0.04	0.86, 1.02	0.137	−1.49
	Initial program adherence	−0.06	0.95****	0.01	0.93, 0.97	**0.000**	−4.99
	Longitudinally-averaged platform logins	−0.15	0.86****	0.01	0.83, 0.88	**0.000**	−10.39
	Likelihood ratio test: $\chi^2(4) = 297.3$, $p <$ ***0.000***						
Model 3	Age	−0.02	0.98	0.02	0.94, 1.03	0.456	−0.75
	STEM interest	−0.09	0.91*	0.04	0.84, 0.99	**0.036**	−2.10
	Initial program adherence	−0.04	0.96***	0.01	0.94, 0.98	**0.000**	−3.73
	Longitudinally-averaged platform logins	−0.11	0.90****	0.01	0.87, 0.93	**0.000**	−7.11
	Mentoring experience of the mentor	−0.11	0.90***	0.03	0.84, 0.96	**0.001**	−3.36
	Written emails to the mentor	−0.24	0.79****	0.05	0.71, 0.88	**0.000**	−4.43
	Chat sessions with the mentor	−0.42	0.66**	0.14	0.50, 0.86	**0.002**	−3.10
	Acute change in frequency of written emails to the mentor	0.13	1.14**	0.04	1.05, 1.23	**0.001**	3.19
	Longitudinally-averaged written STEM words in emails to the mentor	−0.11	0.90****	0.02	0.87, 0.94	**0.000**	−5.21
	Longitudinally-averaged written STEM words in chat sessions with the mentor	−0.15	0.86	0.09	0.73, 1.02	0.086	−1.72
	Likelihood ratio test: $\chi^2(10) = 423.2$, $p <$ ***0.000***						
Model 4	Age	−0.03	0.97	0.02	0.93,1.02	0.254	−1.14
	STEM interest	−0.09	0.91*	0.04	0.84, 0.99	**0.030**	−2.17
	Initial program adherence	−0.04	0.96***	0.01	0.94, 0.98	**0.000**	−3.65
	Longitudinally-averaged platform logins	−0.09	0.92****	0.01	0.89, 0.94	**0.000**	−5.92
	Mentoring experience of the mentor	−0.10	0.90**	0.03	0.85, 0.96	**0.001**	−3.25
	Written emails to the mentor	−0.19	0.83***	0.05	0.75, 0.92	**0.000**	−3.60
	Chat sessions with the mentor	−0.33	0.72*	0.13	0.55, 0.94	**0.014**	−2.46
	Acute change in frequency of written emails to the mentor	0.14	1.14***	0.04	1.06, 1.26	**0.001**	3.39
	Longitudinally-averaged written STEM words in emails to the mentor	−0.11	0.90****	0.02	0.86, 0.93	**0.000**	−5.23
	Longitudinally-averaged written STEM words in chat sessions with the mentor	−0.15	0.86	0.09	0.72, 1.02	0.088	−1.71

(Continues)

TABLE 4 (Continued)

	β	exp(β)	SE (β)	95% CI exp(β) LL, UL	p	z
Written emails to other mentors	0.04	1.04	0.12	0.82, 1.32	0.727	0.35
Chat sessions with other mentors	−0.03	0.97	0.15	0.72, 1.31	0.834	−0.21
Longitudinally-averaged written STEM words in emails to other mentors	0.01	1.01	0.07	0.88, 1.17	0.848	0.19
Longitudinally-averaged written STEM words in chat sessions with other mentors	−0.36	0.70	0.24	0.43, 1.12	0.134	−1.50
Written emails to mentees	−0.30	0.74****	0.07	0.64, 0.86	**0.000**	−4.03
Chat sessions with mentees	−0.11	0.90	0.08	0.76, 1.06	0.190	−1.31
Longitudinally-averaged written STEM words in emails to mentees	0.19	1.21**	0.06	1.07, 1.37	**0.003**	2.94
Longitudinally-averaged written STEM words in chat sessions with mentees	−0.04	0.96	0.07	0.83, 1.11	0.583	−0.55
Forum posts	−0.21	0.81**	0.08	0.70, 0.95	**0.008**	−2.65
STEM words in forum posts	−0.37	0.69**	0.14	0.52, 0.91	**0.009**	−2.63
Likelihood ratio test: $\chi^2(20) = 479.9$, $p <$ **0.000**						

Note: We have used an extended Cox regression framework to investigate dynamic processes in mentoring. *p* Values smaller than 0.05 are marked bold; *, **, *** and **** indicate $p < 0.05$, $p < 0.01$, $p < 0.001$, $p < 0.0001$.

Abbreviations: CI, confidence interval; LL, lower limit; STEM, science, technology, engineering, and mathematics; UL, upper limit.

Likert-type scale decreased the probability of premature match closure by 9%. Variables of the mentees' compliance with program specifications proved again as significant predictors of premature match closure with slight changes within the coefficients (initial program adherence: $\exp(\beta) = 0.96$, $p < 0.000$, longitudinal-averaged platform logins: $\exp(\beta) = 0.90$, $p < 0.000$). Next, we investigated the impact of mentors' previous mentoring experience. With an additional previous matching of the mentor the risk for premature match closure decreased by 10% ($\exp(\beta) = 0.90$, $p = 0.001$). Concerning mentees' current communication with their personal mentors, the number of written emails to their mentors ($\exp(\beta) = 0.79$, $p < 0.000$) and the number of chat sessions with their mentors ($\exp(\beta) = 0.66$, $p = 0.002$), both considered for a specific month, significantly predicted premature match closure. This means, that with an additional email mentees wrote to their mentors their current risk for premature match closure after the month of consideration decreased by 21%, and with an additional chat session mentees had with their mentors their current risk for premature match closure after the month of consideration decreased by 34%. The difference between the number of mentees· emails to the mentor in the month of consideration and the previous month also was a predictor of premature match closure ($\exp(\beta) = 1.14$, $p = 0.001$). An additional email to the mentor, compared to the number of emails in the previous month, increased the risk for premature match closure by 14%. Thus, interestingly, while mentees' risk for premature match closure *decreased* with an additional written email to their mentors by 21%, their risk for premature match closure increased when their number of written emails increased relative to their written emails in the previous month. Both effects taken together indicate that acute changes in communication, and a less steady communication, between mentees and their mentors increased the overall risk for dropout. Furthermore, the amount of mentees' STEM communication in their emails to their mentors also predicted premature match closure ($\exp(\beta) = 0.90$, $p < 0.000$), while the amount of mentees' STEM communication in chat sessions with their mentors did not. Considering mentees' emails, with one additional

STEM word per month on longitudinal average, mentees' risk for premature match closure decreased by 10% after controlling for all other covariates in the model.

In Model 4, we additionally analyzed the predictive power of networking on premature match closure. As in model 3, mentees' age was not a significant predictor, but STEM interest, initial program adherence and longitudinally-averaged platform logins were significant predictors of premature match closure, with a slight change in the coefficient of longitudinally-averaged platform logins ($\exp(\beta) = 0.92$, $p < 0.000$). Furthermore, the mentoring experience of the mentor, the number of mentees' written emails to their mentors, the number of mentees' chat sessions with their mentors, the difference between the number of mentees' emails to their mentors in the month of consideration and the previous month, as well as the amount of mentees' STEM communication in their emails to their mentors and the amount of STEM communication in chat sessions with their mentors remained to be significant predictors of premature match closure, with only slight changes in the coefficients of the number of written emails to their mentors ($\exp(\beta) = 0.83$, $p < 0.000$) and the number of chat session with their mentors ($\exp(\beta) = 0.66$, $p = 0.014$). Regarding mentees' networking behavior, mentees' communication with other mentors did not significantly predict premature match closure, whereas their communication with other mentees did. With an additional email mentees wrote to other mentees in the month of consideration, their risk for premature match closure decreased by 26% ($\exp(\beta) = 0.74$, $p < 0.000$). However, surprisingly if mentees' emails to other mentees contained in longitudinal average more STEM words, their risk for premature match closure increased. On average, for one extra STEM word per month in mentees' emails to other mentees, their risk for premature match closure increased by 21% ($\exp(\beta) = 1.21$, $p = 0.003$). Furthermore, general networking-activity, that is, the number of forum posts mentees wrote in the month of consideration, also significantly predicted the risk for premature match closure. With an additional forum post in the month of consideration, mentees' risk for premature match closure decreased by 19% ($\exp(\beta) = 0.81$, $p = 0.008$), and with an additional STEM word in a forum post, their risk for premature match closure decreased by 31% ($\exp(\beta) = 0.69$, $p = 0.009$). Comparing the four models in their statistics using the Akaike information criterion (AIC) indicated that Model 4 was the most predictive one (Model 1: AIC = 7468.96, Model 2: AIC = 7179.97, Model 3: AIC = 7066.08, Model 4: AIC = 7028.10).

4 | DISCUSSION

In the present study we investigated the dynamically changing risk for premature match closure in an online mentoring program for girls in STEM. For this purpose, we longitudinally observed the development of mentoring relationships as well as mentees' communication and networking behavior, analyzing the role of various potentially influencing factors and their changes over time. First, we investigated whether individual-level characteristics, namely mentees' age and STEM interest, predict premature match closure. Second, we investigated the influence of mentees' compliance with program specifications on premature match closure. As proxy for initial program adherence, we chose mentees' willingness to fill out a questionnaire before entering the program. As another proxy for program adherence, we used the number of logins of mentees on the platform, as all participants committed to communicating on the platform at least once a week when registering for the program. Third, we examined the role of various aspects of the mentoring process for premature match closure. More specifically, we explored the predictive power of the frequency and kind (and here especially the STEM focus) of communication between mentees and their personal mentors for premature match closure. We also investigated the role of mentors' previous mentoring experience. Fourth, we investigated how mentees' networking and STEM-focused networking relate to premature match closure, taking into account platform-wide networking, networking with other mentors and networking among peers.

4.1 | Mentees' Individual-Level characteristics and premature match closure

Our first aim was to investigate the role of mentees' individual characteristics, namely age and STEM interest, for premature match closure. In contrast to previous research (Grossman & Rhodes, 2002; Kupersmidt et al., 2017b; Spencer et al., 2020), we did not find any consistent effect of age on premature match closure. Although age was not a significant predictor of premature match closure in most of our models, our results suggest that if age mattered at all, older mentees were at lower risk for premature match closure than younger mentees. This trend contrasts with previous research, which indicates that older mentees are at higher risk for premature match closure than younger mentees (Grossman & Rhodes, 2002; Kupersmidt et al., 2017b; Spencer et al., 2020). One possible explanation lies in the specific group of mentees and the setting of our study: Unlike previous research that focused mostly on youth mentoring with mentees at risk, we investigated premature match closure in an online mentoring program for girls in STEM. In this setting, two opposing age effects might come into play that cancel each other out: On the one hand, students' — and especially girls' — interest in STEM decreases with age (Frenzel et al., 2010; Kerr & Robinson Kurpius, 2004), which would imply that older mentees are at higher risk for early dropout of a STEM program. On the other hand, since older students use digital tools more frequently than younger students (Medienpädagogischer Forschungsverbund Südwest, 2020), and therefore might be more familiar and experienced with online platforms, older mentees' risk to drop out could be decreased compared to younger ones. In addition, selection effects could come into play. Since STEM interest generally decreases with age (Frenzel et al., 2010; Kerr & Robinson Kurpius, 2004), older students registering for a STEM program might be those who are especially committed to the STEM domain compared to their age group, thus decreasing risk for early drop out. This assumption is supported by a study that showed that CyberMentor participants had higher STEM achievements, STEM interest, STEM activities and higher elective intentions for STEM (e.g., to choose a STEM career) than a same-aged random-sample control group (Stoeger et al., 2016). In contrast, younger mentees might be less committed to STEM and rather register for a STEM program to get to know various STEM areas for the first time, bringing with it a higher risk to drop out of the STEM program early on when compared to older mentees. This interpretation also aligns with our findings concerning the second individual-level characteristic we investigated: mentees' STEM interest. Mentees who rated their STEM interest with a higher score when registering for the program, were less at risk for premature match closure. This finding is in line with previous research on the role of mentees' motivation for premature match closure. For example, extrinsic reasons for program participation as well as mentees' disinterest increase the risk for premature match closure (DeWit et al., 2016; Herrera et al., 2013; Spencer, 2007).

4.2 | Compliance with program specifications and premature match closure

Our second aim was to analyze the role of mentees' compliance with program specifications for premature match closure. As proxies for compliance with program specifications, we used the proportion to which a voluntary questionnaire was filled out by the mentees at the beginning of the mentoring year, and how frequently mentees logged into the online mentoring platform (which should be at least once a week based on program specifications). We found that those mentees who adhered more closely to these program specifications, that is, those who filled out the questionnaire and logged into the online platform more frequently, had a lower risk for premature match closure. This corroborates evidence from previous research (DuBois et al., 2002, 2011; Kupersmidt et al., 2017a) suggesting that mentoring outcomes as well as mentoring relationship durations are critically influenced by participants' adherence to program specifications.

4.3 | Mentoring process and premature match closure

To investigate the role of the mentoring process for premature match closure, we analyzed various characteristics of mentees' general and STEM focused communication with their personal mentors. Furthermore, we took the level

of mentors' previous mentoring experience into account. We found that mentees' risk for premature match closure significantly decreased with the amount of mentee–mentor communication: the more emails mentees wrote to their mentors and the more chat sessions took place with their mentors in the month of consideration, the lower was the mentees' risk for premature match closure in the respective month. In fact, with a further email mentees wrote to their mentors their current risk for premature match closure decreased by 21%. Furthermore, changes in the number of emails mentees wrote to their mentors from one month to another also predicted premature match closure. More concretely, the difference between the number of emails mentees wrote to their mentors in the month of consideration and the previous month predicted premature match closure, with higher positive differences, and therefore abrupt increases in the amount of communication, being associated with a higher risk for premature match closure by 14% for an additional email compared to the previous month. In sum, and taking these two opposing effects together, mentees' risk for premature match closure overall decreased, when they showed a frequent and steady communication with their mentors. Finally, our results showed that the amount of STEM communication with the personal mentor also reduced mentees' risk for premature match closure: the more STEM words in mentees' written emails to their personal mentors, averaged across all mentoring months since matching, the lower mentees' risk for dropping out in the month of consideration.

In sum, our findings indicate that a frequent and steady communication with the personal mentor, with only minor changes over time in terms of contact frequency, can highly curtail mentees' risk for premature match closure, especially when the communication focuses on program content (in our study setting: STEM). Reasons for these results might be that frequently written emails to the mentors not only reflect stable mentoring relationships, but also increase mentees' commitment to the mentoring program (DeWit et al., 2016; DuBois & Neville, 1997; Herrera et al., 2000; Parra et al., 2002). At the same time, an acute change in contact frequency with the personal mentor and losing the STEM focus in mentoring communication seems to increase mentees' risk for premature match closure. Regarding to increased risk for premature match closure related to abrupt increases in the amount of communication, one possible aspect which could come into play might be the emotional coloring of acute increased communication. Previous research points to the impact of communication's emotional context and coloring (Frenzel et al., 2007; Dahl & Waks, 2015). Hence, mentees who are at high risk for premature match closure might increase the amount of communication with their mentors in favor to strengthen or save a troubled mentoring relationship. Furthermore, it could be that they address difficulties or problems with their mentors, or say goodbye. Hence, the context of increased communication needs to be further explored in future research. Moreover, our findings support previous research on the effects of communication characteristics for mentoring effectiveness. Previous studies have shown that both frequency and duration of mentee–mentor contacts as well as the extent in which the participants' communication is focused on program content is related to mentoring effectiveness (Ayoobzadeh, 2019; DuBois et al., 2002, 2011; Parra et al., 2002). In addition, regarding online mentoring for girls in STEM, studies suggest that mentoring effectiveness is related to mentees' STEM communication (Stoeger et al., 2016, 2017, 2021). Going beyond previous research, our findings show the importance of frequent and content-focused mentee–mentor communication not only for mentoring effectiveness but also for preventing premature match closure. Furthermore, our study extends previous research on premature match closure by, for the first time, investigating the dynamically changing risk for premature match closure based on changes in mentees' general and program related (in our case STEM related) communication behavior.

Regarding mentors' previous mentoring experience, we found that with each previous mentoring relationship, mentees' risk for premature match closure decreased. A reason for that might be that mentors who are more experienced in mentoring might have a more realistic assessment of the needs of their mentees or the mentoring process itself and might feel less overwhelmed. This is also consistent with previous research which illustrates that mentors who feel unprepared and overwhelmed, or have too high expectations for mentoring, have a higher risk for premature match closure (Herrera et al., 2013; Kupersmidt et al., 2017b; Shlafer et al., 2009; Spencer, 2007; Spencer et al., 2017; Styles & Morrow, 1992), and contrary, mentors with more expertize due to training have a lower risk for premature match closures (Kupersmidt et al., 2017a; McQuillin & Lyons, 2021).

4.4 | Networking and premature match closure

Finally, our fourth aim was to analyze the role of mentees' networking behavior in premature match closure. Here, we differentiated between platform-wide networking, networking with other mentors, and networking with other mentees. We found that mentees' general networking on the platform (i.e., their platform-wide communication via forum) — and here, especially their STEM-focused networking — decreased the risk for premature match closure. With each further forum activity, the mentees' risk for premature match closure decreased significantly. This finding is well in line with previous research highlighting the positive effects of networking and STEM-focused communication on mentoring success (Higgins & Kram, 2001; Parra et al., 2002; Stoeger et al., 2016, 2017, 2021).

However, premature match closure was not related to networking and STEM communication with other mentors: the number of mentees' written emails and chat sessions with other mentors, besides their own, did not influence mentees' risk for premature match closure, independently of whether the communication did or did not have a STEM focus. To understand these findings, results of previous research might be helpful that show that a less intensive and close relationship between mentees and mentors is related to less positive mentoring outcomes, and that mentees feel more close to their mentors when they communicate regularly (Bayer et al., 2015; DuBois et al., 2002; Lyons & Edwards, 2022; Spencer et al., 2020). As mentees' contacts with other mentors probably are less frequent and therefore their relationship should be less stable and close than the relationships with their personal mentor, this may explain why other mentors have only little influence on premature match closure.

Concerning the impact of mentees' networking and STEM communication with other mentees on premature match closure, our results indicated several competing peer influences. On the one hand, with each further peer-contact, that is with each further email written to another mentee, mentees' risk for premature match closure decreased, highlighting positive effects of networking. On the other hand, we found that the more mentees' communication with other mentees focused on STEM, the *higher* was their risk for premature match closure in the month of consideration. This finding is surprising, as previous research indicates that not only networking with other peers per se, but especially STEM-focused networking increases mentees' mentoring success (Stoeger et al., 2016, 2017, 2021). One possible aspect which could come into play might be the emotional context and coloring of STEM communication (Frenzel et al., 2007; Dahl & Waks, 2015), especially among peers. Hence, mentees who are at high risk for premature match closure might communicate with peers about problems with STEM learning or disinterest in STEM topics. Additional studies that analyze the emotional coloring of communication between the participants are needed. A further explanation could be that mentees who are wishing for a more appropriate mentor could seek out further STEM relationships and compare their experiences to those of other mentees.

To the best of our knowledge, our study was the first one that investigated the dynamics of changing risk for premature match closure. Predicting the changing risk for premature match closure is an important and challenging task. Previous research has only retrospectively examined reasons and risk factors for premature match closure, omitting the fact that dropping out of a mentoring program is not an abrupt event but rather a long-term process. Hence, our study extended previous research on premature match closure by, for the first time, investigating the development of mentoring relationships in a longitudinal analysis, tracking mentoring dyads from the time of matching to their premature closure. For this purpose, we applied a survival analysis framework, more specifically, an extended Cox regression model, which allowed us to simultaneously consider time-independent individual-level characteristics and attributes as well as time-dependent changes and dynamics of mentees' behavior in the mentoring program when predicting premature match closure. In doing so, we explored how the risk for premature match closure changes by the dynamics of mentees' behavior in the mentoring program. Better understanding the role of various potentially influencing factors on the risk for premature match closure could allow practice to identify mentees at high risk for premature match closure early enough to still prevent it.

4.5 | Limitations and future research

Our study replicates findings of earlier studies and broadens research on premature match closure and potentially influencing risk factors and predictors. Particularly, it provides new insights on the dynamically changing risk for premature match closure in mentoring, gained by observing the longitudinal development of mentoring relationships as well as mentees' communication and networking behavior. However, we note several limitations of our study that should be kept in mind when interpreting the results.

First, we have counted mentees as dropouts when they informed the program team that they did not want to participate any longer or when they appeared to be inactive on the online mentoring platform and did not log in anymore. However, in the latter case, it cannot conclusively be assessed whether mentees in fact dropped out of their mentoring relationships. Some of the mentees that were marked as dropouts may have continued their mentoring relationship using communication channels outside the online platform (e.g., regular mailing, video conferencing or chatting systems). Therefore, future research on premature match closure in online mentoring should differentiate between mentoring dropouts and platform dropouts.

Second, we assessed only the amount of STEM communication but not the emotional coloring of (the STEM related) communication. To better understand the negative effect of STEM communication with other mentees on premature match closure, further research is needed. For example, it would be important to find out to what extent STEM communication between mentees focuses on interesting STEM activities and topics compared to problems with STEM learning and how this ratio influences premature match closure.

Third, we did not take the quality of the relationship between mentees and mentors into account, which is a crucial factor for effective mentoring (Bayer et al., 2015; DuBois et al., 2002) and premature match closure in particular (DeWit et al., 2016; Lyons & Edwards, 2022; Spencer et al., 2020). Another important factor might be the fit between mentee and mentor (MENTOR, 2015; Pryce et al., 2014). In the context of our setting, the fit between mentors· STEM domain and mentees· STEM interest might be of particular importance for premature match closure. Future research should therefore consider additional risk factors for premature match closure to broaden the findings of this study.

Since previous research is mostly limited to the identification of reasons and risk factors after match closure has already occurred, we analyzed in our study the dynamics of mentees' changing risk for premature match closure by observing longitudinally the development of mentoring relationships. In a next step, it would be interesting to explore how early and to what extent one can predict mentees' future risk for premature match closure based on mentees' communication and networking behavior during the first few months of mentoring.

Furthermore, since our study focused on premature match closure initiated by mentees, future research should extend the study by investigating the risks, reasons and consequences of premature match closure initiated by mentors.

Finally, our study extended previous research on premature match closure, which mostly focused on youths at risk in on-site mentoring programs, to another mentoring context and target group by investigating for the first time the risk for premature match closure in an online mentoring program for girls in STEM. Future research should corroborate our findings for this target group and mentoring context. Additionally, one should note that it is not clear to what extent our findings of risk factors for premature match closure can be generalized to other target groups (e.g., high-achieving students) and mentoring contexts (e.g., group mentoring), so that further research is needed.

5 | CONCLUSION

If implemented appropriately, mentoring can be a highly effective measure to support individuals in their personal and professional development (Bloom & Sosniak, 1985; Bloom, 1984; Grassinger et al., 2010; Lipsey & Wilson, 1993; National Academies of Sciences Engineering and Medicine, 2019; Roch, 1979; Subotnik et al., 2021). However, premature match closure is one factor that strongly limits positive mentoring outcomes for mentees

(Britner & Kraimer-Rickaby, 2005; Grossman & Rhodes, 2002; Grossman et al., 2012; Herrera et al., 2011; Karcher, 2005; Slicker & Palmer, 1993; Spencer, 2006, 2007). Since one-third to more than half of the mentoring relationships end prematurely (Bernstein et al., 2009; DeWit et al., 2016; Grossman & Rhodes, 2002; Herrera et al., 2013; Keller & Spencer, 2018; Rhodes, 2002; Styles & Morrow, 1992), a better understanding of the underlying reasons and mechanisms leading to premature match closure is essential. Previous research has identified several reasons and risk factors for premature match closure (DeWit et al. 2016; Grossman & Rhodes, 2002; Grossman et al., 2012; Heppe et al., 2019, 2021; Herrera et al., 2013a; Keller & Spencer, 2018; Kupersmidt et al., 2017a, 2017b; Lyons & Edwards, 2022; McQuillin & Lyons, 2021; Raposa et al., 2016; Schwartz et al., 2011; Shlafer et al., 2009; Spencer, 2007; Spencer et al., 2017, 2018, 2020; Stelter et al., 2018) but is limited to a retrospective approach. Since dropping out of a mentoring program is not an abrupt event but rather a long-term process, a longitudinal consideration of the mentoring process and its dynamical changes is crucial to get a better understanding. To fill this research gap, in our study we analyzed mentees' and mentors' communication and networking behavior and their dynamic changes within the context of an online mentoring program for girls in STEM. In doing so, we have broadened previous research, which primarily focused on premature match closure in the context of on-site mentoring programs for youths at risk. Additionally, we analyzed the role of various potentially influencing factors and their changes over time, gaining new insights on the dynamically changing risk for premature match closure during mentoring. We have found that mentees' interest in the program content (in our study setting: STEM) as well as mentees' compliance with program specifications have a significant positive impact on preventing premature match closure. Furthermore, our findings highlight the importance of mentees' frequent and steady communication with their personal mentors, with a focus on the program content (namely STEM) being especially important. Furthermore, mentors' mentoring experience and mentees' networking with other mentees buffered the risk for premature match closure. However, to better understand the role of other mentees in online mentoring in STEM more research is needed, especially when it comes to mentees' STEM-focused networking with peers.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding authors upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

Aalen, O. (1975). *Statistical inference for a family of counting processes*. University of California.

Aalen, O. (1978). Nonparametric inference for a family of counting processes. *The Annals of Statistics*, *6*, 701–726.

Allen, T. D., Eby, L. T., Poteet, M. L., Lentz, E., & Lima, L. (2004). Career benefits associated with mentoring for proteges: A meta-analysis. *Journal of Applied Psychology*, *89*(1), 127–136. https://doi.org/10.1037/0021-9010.89.1.127

Ameri, S., Fard, M. J., Chinnam, R. B., & Reddy, C. K. (2016). Survival analysis based framework for early prediction of student dropouts. In S. Mukhopadhyay (Ed.), *ACM Digital Library, Proceedings of the 25th ACM International on Conference on Information and Knowledge Management* (pp. 903–912). ACM. https://doi.org/10.1145/2983323.2983351

Andersen, P. K., & Gill, R. D. (1982). Cox's regression model for counting processes: A large sample study. *The Annals of Statistics*, *10*(4), 1100–1120. https://doi.org/10.1214/aos/1176345976

Ayoobzadeh, M. (2019). The impact of frequency of contact on protégé mentoring outcomes: The moderating effects of protégé general self-efficacy and face-to-face interaction. *Human Resource Development International*, *22*(4), 385–404. https://doi.org/10.1080/13678868.2019.1615309

Bayer, A., Grossman, J. B., & DuBois, D. L. (2015). Using volunteer mentors to improve the academic outcomes of underserved students: The role of relationships. *Journal of Community Psychology*, *43*(4), 408–429. https://doi.org/10.1002/jcop.21693

Bernstein, L., Rappaport, C. D., Olsho, L., Hunt, D., & Levin, M. (2009). Impact evaluation of the U.S. department of education's student mentoring program (NCEE 2009-4047). National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. https://eric.ed.gov/?id=ed504310

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher*, *13*(6), 4–16. https://doi.org/10.3102/0013189X013006004

Bloom, B. S., & Sosniak, L. A. (1985). *Developing talent in young people*. Ballentine Books.

Breslow, N. E. (1975). Analysis of survival data under the proportional hazards model. *International Statistical Review/Revue Internationale de Statistique*, *43*(1), 45. https://doi.org/10.2307/1402659

Britner, P. A., & Kraimer-Rickaby, L. (2005). Abused and neglected youth. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of Youth Mentoring* (pp. 482–492).

Bundesagentur für Arbeit. (2020). *Berufe auf einen Blick: MINT*. https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Interaktive-Angebote/Berufe-auf-einen-Blick-MINT/Berufe-auf-einen-Blick-MINT-Nav.html

Christensen, K. M., Hagler, M. A., Stams, G. J., Raposa, E. B., Burton, S., & Rhodes, J. E. (2020). Non-specific versus targeted approaches to youth mentoring: A follow-up meta-analysis. *Journal of Youth and Adolescence*, *49*(5), 959–972. https://doi.org/10.1007/s10964-020-01233-x

Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society: Series B (Methodological)*, *34*(2), 187–202. https://doi.org/10.1111/j.2517-6161.1972.tb00899.x

Cox, D. R. (1975). Partial likelihood. *Biometrika*, *62*(2), 269–276. https://doi.org/10.2307/2335362

Darling, N. (2005). Mentoring adolescents. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of Youth Mentoring* (pp. 177–190).

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: the stereotype inoculation model. *Psychological inquiry*, *22*(4), 231–246. https://doi.org/10.1080/1047840X.2011.607313

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 21–29. https://doi.org/10.1177/2372732214549471

DeWit, D. J., DuBois, D., Erdem, G., Larose, S., Lipman, E. L., & Spencer, R. (2016). Mentoring relationship closures in big brothers big sisters community mentoring programs: Patterns and associated risk factors. *American Journal of Community Psychology*, *57*(1–2), 60–72. https://doi.org/10.1002/ajcp.12023

Dickson, J., Kirkpatrick-Husk, K., Kendall, D., Longabaugh, J., Patel, A., & Scielzo, S. (2014). Untangling protégé self-reports of mentoring functions. *Journal of Career Development*, *41*(4), 263–281. https://doi.org/10.1177/0894845313498302

DuBois, D. L., Holloway, B. E., Valentine, J. C., & Cooper, H. (2002). Effectiveness of mentoring programs for youth: A meta-analytic review. *American Journal of Community Psychology*, *30*(2), 157–197. https://doi.org/10.1023/A:1014628810714

DuBois, D. L., & Neville, H. A. (1997). Youth mentoring: investigation of relationship characteristics and perceived benefits. *Journal of Community Psychology*, *25*(3), 227–234. https://doi.org/10.1002/(SICI)1520-6629(199705)25:3<227::AID-JCOP1>3.0.CO;2-T

DuBois, D. L., Portillo, N., Rhodes, J. E., Silverthorn, N., & Valentine, J. C. (2011). How effective are mentoring programs for youth? A systematic assessment of the evidence. *Psychological Science in the Public Interest*, *12*(2), 57–91. https://doi.org/10.1177/1529100611414806

Eby, L. T., Allen, T. D., Evans, S. C., Ng, T., & DuBois, D. L. (2008). Does mentoring matter? A multidisciplinary meta-analysis comparing mentored and non-mentored individuals. *Journal of Vocational Behavior*, *72*(2), 254–267. https://doi.org/10.1016/j.jvb.2007.04.005

Eby, L. T., Allen, T. D., Hoffman, B. J., Baranik, L. E., Sauer, J. B., Baldwin, S., Morrison, M. A., Kinkade, K. M., Maher, C. P., Curtis, S., & Evans, S. C. (2013). An interdisciplinary meta-analysis of the potential antecedents, correlates, and

consequences of protégé perceptions of mentoring. *Psychological Bulletin*, *139*(2), 441–476. https://doi.org/10.1037/a0029279

Fisher, L. D., & Lin, D. Y. (1999). Time-dependent covariates in the Cox proportional-hazards regression model. *Annual Review of Public Health*, *20*, 145–157. https://doi.org/10.1146/annurev.publhealth.20.1.145

Freeman, L. C., Roeder, D., & Mulholland, R. R. (1979). Centrality in social networks: ii. experimental results. *Social Networks*, *2*(2), 119–141. https://doi.org/10.1016/0378-8733(79)90002-9

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. https://doi.org/10.1111/j.1532-7795.2010.00645.x

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Perceived learning environment and students' emotional experiences: A multilevel analysis of mathematics classrooms. *Learning and Instruction*, *17*(5), 478–493. https://doi.org/10.1016/j.learninstruc.2007.09.001

German Federal Bureau of Statistics. (2021). *Students enrolled in STEM courses*. https://www.destatis.de/EN/Themes/Society-Environment/Education-Research-Culture/Institutions-Higher-Education/Tables/students-in-stem-courses.html

Govekar-Okoliš, M. (2018). Mentors' perceptions on effects of their mentoring with higher education students in companies after the adoption of the Bologna process. *European Journal of Higher Education*, *8*(2), 185–200. https://doi.org/10.1080/21568235.2018.1424007

Grassinger, R., Porath, M., & Ziegler, A. (2010). Mentoring the gifted: A conceptual analysis. *High Ability Studies*, *21*(1), 27–46. https://doi.org/10.1080/13598139.2010.488087

Grossman, J. B., Chan, C. S., Schwartz, S. E. O., & Rhodes, J. E. (2012). The test of time in school-based mentoring: The role of relationship duration and re-matching on academic outcomes. *American Journal of Community Psychology*, *49*(1–2), 43–54. https://doi.org/10.1007/s10464-011-9435-0

Grossman, J. B., & Johnson, A. (1999). *In* J. B. Grossman, (Ed.), *Assessing the effectiveness of mentoring programs* (pp. 25–47). Contemporary.

Grossman, J. B., & Rhodes, J. E. (2002). The test of time: Predictors and effects of duration in youth mentoring relationships. *American Journal of Community Psychology*, *30*(2), 199–219. https://doi.org/10.1023/A:1014680827552

Harrell Jr, F. E., Lee, K. L., Matchar, D. B., & Reichert, T. A. (1985). Regression models for prognostic prediction: Advantages, problems, and suggested solutions. *Cancer Treatment Reports*, *69*(10), 1071–1077.

Heilemann, M. (2015). *MINT-Wörterbuch für die diktionärsbasierte Textanalyse mit LIWC*. https://doi.org/10.17605/OSF.IO/3JC9X

Heppe, E. C. M., Kupersmidt, J. B., & Kef, S. (2021). Reasons for premature closure of a mentoring relationship: A qualitative study of mentoring youth with a visual impairment. *Journal of Adolescent Research*. https://doi.org/10.1177/07435584211034874

Heppe, E. C. M., Kupersmidt, J. B., Kef, S., & Schuengel, C. (2019). Does having a similar disability matter for match outcomes? A randomized study of matching mentors and mentees by visual impairment. *Journal of Community Psychology*, *47*(2), 210–226. https://doi.org/10.1002/jcop.22116

Herrera, C., DuBois, D. L., & Grossman, J. B. (2013). The role of risk: Mentoring experiences and outcomes for youth with varying risk profiles. MDRC.

Herrera, C., Grossman, J. B., Kauh, T. J., & McMaken, J. (2011). Mentoring in schools: An impact study of big brothers big sisters school-based mentoring. *Child Development*, *82*(1), 346–361. https://doi.org/10.1111/j.1467-8624.2010.01559.x

Herrera, C., & Karcher, M. J. (2014). *School-based mentoring*. SAGE Publications, Inc. https://doi.org/10.4135/9781412996907

Herrera, C., Sipe, C. L., & McClanahan, W. S. (2000). *Making mentoring relationships better: Program, matching and activity factors that contribute to mentors' positive relationships with youth. Public/Private Ventures*.

Higgins, M. C., & Kram, K. E. (2001). Reconceptualizing mentoring at work: A developmental network perspective. *The Academy of Management Review*, *26*(2), 264–288. https://doi.org/10.5465/amr.2001.4378023

Hopp, M. D. S., Stoeger, H., & Ziegler, A. (2020). The supporting role of mentees· peers in online mentoring: A longitudinal social network analysis of peer influence. *Frontiers in Psychology*, *11*, 1929. https://doi.org/10.3389/fpsyg.2020.01929

Kalbfleisch, J. D. (2002). *The statistical analysis of failure time data* (2nd ed.). *Wiley series in probability and statistics* J. Wiley. http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10444390; https://doi.org/10.1002/9781118032985

Kammeyer-Mueller, J. D., & Judge, T. A. (2008). A quantitative review of mentoring research: Test of a model. *Journal of Vocational Behavior*, *72*(3), 269–283. https://doi.org/10.1016/j.jvb.2007.09.006

Kaplan, E. L., & Meier, P. (1958). Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association*, *53*(282), 457–481. https://doi.org/10.1080/01621459.1958.10501452

Karcher, M. J. (2005). The effects of developmental mentoring and high school mentors· attendance on their younger mentees' self-esteem, social skills, and connectedness. *Psychology in the Schools*, *42*(1), 65–77. https://doi.org/10.1002/pits.20025

Keller, T. E. (2005). The stages and development of mentoring relationships. D. L. DuBois & M. J. Karcher (Eds.), Handbook of Youth Mentoring, 82–99. https://doi.org/10.4135/9781412976664.n6

Keller, T. E., & Spencer, R. (2018). *Prediction and prevention of premature closures of mentoring relationships: The study to analyze relationships. STAR Project*. https://www.ojp.gov/ncjrs/virtual-library/abstracts/prediction-and-prevention-premature-closures-mentoring

Kerr, B., & Robinson Kurpius, S. E. (2004). Encouraging talented girls in math and science: Effects of a guidance intervention. *High Ability Studies*, *15*(1), 85–102. https://doi.org/10.1080/1359813042000225357

Kupersmidt, J. B., Stump, K. N., Stelter, R. L., & Rhodes, J. E. (2017a). Mentoring program practices as predictors of match longevity. *Journal of Community Psychology*, *45*(5), 630–645. https://doi.org/10.1002/jcop.21883

Kupersmidt, J. B., Stump, K. N., Stelter, R. L., & Rhodes, J. E. (2017b). Predictors of premature match closure in youth mentoring relationships. *American Journal of Community Psychology*, *59*(1–2), 25–35. https://doi.org/10.1002/ajcp.12124

Laco, D., & Johnson, W. (2019). "I expect it to be great. but will it be?" an investigation of outcomes, processes, and mediators of a School-Based mentoring program. *Youth & Society*, *51*(7), 934–960. https://doi.org/10.1177/0044118X17711615

Lipsey, M. W., & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment confirmation from meta-analysis. *American Psychologist*, *48*(12), 1181–1209. https://doi.org/10.1037//0003-066x.48.12.1181

Lyons, M. D., & Edwards, K. D. (2022). Strategies for monitoring mentoring relationship quality to predict early program dropout. *American Journal of Community Psychology*, *70*, 127–138. https://doi.org/10.1002/ajcp.12585

McQuillin, S. D., & Lyons, M. D. (2021). A national study of mentoring program characteristics and premature match closure: The role of program training and ongoing support. *Prevention Science*, *22*(3), 334–344. https://doi.org/10.1007/s11121-020-01200-9

Medienpädagogischer Forschungsverbund Südwest. (2020). *JIM-Studie 2020 - Jugend, Information, Medien*. https://www.mpfs.de/studien/jim-studie/2020/

MENTOR (Ed.). (2015). *Elements of effective practice for mentoring* (4th ed). https://www.mentoring.org/new-site/wp-content/uploads/

Miller, A. (2007). Best practices for formal youth mentoring. In T. D. Allen & L. T. Eby (Eds.), *The blackwell handbook on mentoring: A multiple perspectives approach* (pp. 307–324).

Morris, R. C. (2016). Mentoring to improve a child's self-concept: Longitudinal effects of social intervention on identity and negative outcomes. *Current Research in Social Psychology*, *24*(2), 13–30.

Morrow, K. V., & Styles, M. B. (1995). *Building relationships with youth in program settings: A study of Big Brothers/Big Sisters*. Philadelphia, Public/Private Ventures.

National Academies of Sciences, Engineering, and Medicine. (2019). *The science of effective mentorship in STEMM*. https://doi.org/10.17226/25568

Parra, G. R., DuBois, D. L., Neville, H. A., Pugh-Lilly, A. O., & Povinelli, N. (2002). Mentoring relationships for youth: investigation of a process-oriented model. *Journal of Community Psychology*, *30*(4), 367–388. https://doi.org/10.1002/jcop.10016

Peduzzi, P., Concato, J., Feinstein, A. R., & Holford, T. R. (1995). Importance of events per independent variable in proportional hazards regression analysis. *Journal of Clinical Epidemiology*, *48*(12), 1503–1510. https://doi.org/10.1016/0895-4356(95)00048-8

Pennebaker, J. W., Booth, R. L., Boyd, R. L., & Francis, M. E. (2015). *Linguistic inquiry and word count: LIWC2015*. Pennebaker Conglomerates.

Pryce, J., Kelly, M. S. & Guidone, S. R., (Eds.). (2014). *Mentor and youth matching: Handbook of Youth Mentoring* (pp. 427–438). SAGE. https://doi.org/10.4135/9781412996907

Raposa, E. B., Rhodes, J. E., & Herrera, C. (2016). The impact of youth risk on mentoring relationship quality: Do mentor characteristics matter? *American Journal of Community Psychology*, *57*(3–4), 320–329. https://doi.org/10.1002/ajcp.12057

Raposa, E. B., Rhodes, J., Stams, G. J. J. M., Card, N., Burton, S., Schwartz, S., Sykes, L. A. Y., Kanchewa, S., Kupersmidt, J., & Hussain, S. (2019). The effects of youth mentoring programs: A meta-analysis of outcome studies. *Journal of Youth and Adolescence*, *48*(3), 423–443. https://doi.org/10.1007/s10964-019-00982-8

Rhodes, J. E. (2002). *Stand by me: The risks and rewards of mentoring today's youth*. Harvard University Press.

Roch, G. R. (1979). Much ado about mentors. *Harvard Business Review*, *57*(1), 14–20.

Schwartz, S. E. O., Rhodes, J. E., Chan, C. S., & Herrera, C. (2011). The impact of school-based mentoring on youths with different relational profiles. *Developmental Psychology*, *47*(2), 450–462. https://doi.org/10.1037/a0021379

Shlafer, R. J., Poehlmann, J., Coffino, B., & Hanneman, A. (2009). Mentoring children with incarcerated parents: Implications for research, practice, and policy. *Family Relations*, *58*(5), 507–519. https://doi.org/10.1111/j.1741-3729.2009.00571.x

Dahl, A., & Waks, L. (2015). Exploring student persistence in STEM programs: A motivational model. *Canadian Journal of Education/Revue canadienne de l'éducation*, *38*(2), 1. https://doi.org/10.2307/canajeducrevucan.38.2.13

Slicker, E. K., & Palmer, D. J. (1993). Mentoring at-risk high school students: Evaluation of a school-based program. *The School Counselor*, *40*(5), 327–334.

Spencer, R. (2006). Understanding the mentoring process between adolescents and adults. *Youth & Society*, *37*(3), 287–315. https://doi.org/10.1177/0743558405278263

Spencer, R. (2007). "It's not what I expected": A qualitative study of youth mentoring relationship failures. *Journal of Adolescent Research*, *22*(4), 331–354. https://doi.org/10.1177/0743558407301915

Spencer, R., Basualdo-Delmonico, A., Walsh, J., & Drew, A. L. (2017). Breaking up is hard to do. *Youth & Society*, *49*(4), 438–460. https://doi.org/10.1177/0044118X14535416

Spencer, R., Drew, A. L., Walsh, J., & Kanchewa, S. S. (2018). Girls (and boys) just want to have fun: A mixed-methods examination of the role of gender in youth mentoring relationship duration and quality. *The Journal of Primary Prevention*, *39*(1), 17–35. https://doi.org/10.1007/s10935-017-0494-3

Spencer, R., Gowdy, G., Drew, A. L., McCormack, M. J., & Keller, T. E. (2020). It takes a village to break up a match: A systemic analysis of formal youth mentoring relationship endings. *Child & Youth Care Forum*, *49*(1), 97–120. https://doi.org/10.1007/s10566-019-09520-w

Spencer, R., Keller, T. E., Perry, M., Drew, A. L., Clark-Shim, H., Horn, J. P., Miranda-Díaz, M., & McCormack, M. J. (2021). How youth mentoring relationships end and why it matters: A mixed-methods, multi-informant study. *Annals of the New York Academy of Sciences*, *1483*(1), 67–79. https://doi.org/10.1111/nyas.14290

Stelter, R. L., Kupersmidt, J. B., & Stump, K. N. (2018). Supporting mentoring relationships of youth in foster care: Do program practices predict match length. *American Journal of Community Psychology*, *61*(3–4), 398–410. https://doi.org/10.1002/ajcp.12246

Stoeger, H., Debatin, T., Heilemann, M., & Ziegler, A. (2019). Online mentoring for talented girls in STEM: The role of relationship quality and changes in learning environments in explaining mentoring success. *New Directions for Child and Adolescent Development*, *2019*, 75–99. https://doi.org/10.1002/cad.20320

Stoeger, H., Duan, X., Schirner, S., Greindl, T., & Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM. *Computers & Education*, *69*, 408–418. https://doi.org/10.1016/j.compedu.2013.07.032

Stoeger, H., Heilemann, M., Debatin, T., Hopp, M. D. S., Schirner, S., & Ziegler, A. (2021). Nine years of online mentoring for secondary school girls in STEM: An empirical comparison of three mentoring formats. *Annals of the New York Academy of Sciences*, *1483*(1), 153–173. https://doi.org/10.1111/nyas.14476

Stoeger, H., Hopp, M., & Ziegler, A. (2017). Online mentoring as an extracurricular measure to encourage talented girls in STEM (science, technology, engineering, and mathematics): An empirical study of one-on-one versus group mentoring. *Gifted Child Quarterly*, *61*(3), 239–249. https://doi.org/10.1177/0016986217702215

Stoeger, H., Schirner, S., Laemmle, L., Obergriesser, S., Heilemann, M., & Ziegler, A. (2016). A contextual perspective on talented female participants and their development in extracurricular STEM programs. *Annals of the New York Academy of Sciences*, *1377*(1), 53–66. https://doi.org/10.1111/nyas.13116

Stoeger, H., Ziegler, A. & Schimke, D., (Eds.). (2009). Mentoring: Theoretische Hintergründe, empirische Befunde und praktische Anwendungen *(1. Auflage)*. Pabst Science Publishers. https://www.wiso-net.de/document/PBST,APBS__9783899675436340

Styles, M. B. & Morrow, K. V., (Eds.). (1992). *Understanding how youth and elders form relationships: A study of four linking lifetimes programs*. Public/Private Ventures.

Subotnik, R. F., Olszewski-Kubilius, P., Khalid, M., & Finster, H. (2021). A developmental view of mentoring talented students in academic and nonacademic domains. *Annals of the New York Academy of Sciences*, *1483*(1), 199–207. https://doi.org/10.1111/nyas.14286

Therneau, T. M. (2022). *A package for survival analysis in R. R package version, 3, 3-1*. https://CRAN.R-project.org/package=survival

Therneau, T. M., & Grambsch, P. M. (2000). Modelling survival data: Extending the Cox model, *Statistics for biology and health*. Springer.

Tolan, P. H., Henry, D. B., Schoeny, M. S., Lovegrove, P., & Nichols, E. (2014). Mentoring programs to affect delinquency and associated outcomes of youth at-risk: A comprehensive meta-analytic review. *Journal of Experimental Criminology*, *10*(2), 179–206. https://doi.org/10.1007/s11292-013-9181-4

Underhill, C. M. (2006). The effectiveness of mentoring programs in corporate settings: A meta-analytical review of the literature. *Journal of Vocational Behavior*, *68*(2), 292–307. https://doi.org/10.1016/j.jvb.2005.05.003

van Dam, L., Smit, D., Wildschut, B., Branje, S. J. T., Rhodes, J. E., Assink, M., & Stams, G. J. J. M. (2018). Does natural mentoring matter? A multilevel meta-analysis on the association between natural mentoring and youth outcomes. *American Journal of Community Psychology*, *62*(1–2), 203–220. https://doi.org/10.1002/ajcp.12248

Wheeler, M. E., Keller, T. E., & DuBois, D. L. (2010). Review of three recent randomized trials of School-Based mentoring and commentaries. *Social Policy Report*, *24*(3), 1–27. https://doi.org/10.1002/j.2379-3988.2010.tb00064.x

Wood, S., & Mayo-Wilson, E. (2012). School-based mentoring for adolescents. *Research on Social Work Practice*, *22*(3), 257–269. https://doi.org/10.1177/1049731511430836

Ziegler, A., Gryc, K. L., Hopp, M. D. S., & Stoeger, H. (2021). Spaces of possibilities: A theoretical analysis of mentoring from a regulatory perspective. *Annals of the New York Academy of Sciences*, *1483*(1), 174–198. https://doi.org/10.1111/nyas.14419

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