Computers & Education 69 (2013) 408–418

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

# The effectiveness of a one-year online mentoring program for girls in STEM

Heidrun Stoeger [a,*], Xiaoju Duan [b], Sigrun Schirner [a], Teresa Greindl [a], Albert Ziegler [c]

[a] University of Regensburg, Universitätsstr. 31, 93053 Regensburg, Germany
[b] Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Science, Datun Road 4A, Beijing, China
[c] University of Erlangen-Nurenberg, Regensburger Straße 160, 90478 Nuremberg, Germany

A R T I C L E I N F O

*Article history:*
Received 14 November 2012
Received in revised form
26 July 2013
Accepted 29 July 2013

*Keywords:*
Mentoring
Online learning
Gender
STEM
Evaluation

A B S T R A C T

Although the performance of girls in science, technology, engineering, and mathematics (STEM) is continually improving and is no longer below that of boys in most domains, girls' interests in STEM and participation rates are still too low. Online mentoring may help ameliorate this situation. To test this assumption, a one-year personal mentoring program for eleven to eighteen-year-old female college-preparatory students was evaluated. Mentee and mentor communicate with one another and with other program participants via email, online chat, and forums. To measure program effectiveness, we randomly assigned participants ($N = 312$) to either a treatment group ($N = 208$) or a waiting-list control group ($N = 104$). We collected questionnaire data at three points in time. In comparison to the waiting-list group, the treatment-group participants showed greater levels of desirable short-term and long-term developments. Our findings indicate various advantages for online mentoring for promoting girls' interests in STEM.



## 1. Introduction

Mentoring is potentially one of the most effective promotional measures in pedagogy (Bloom, 1984; Lipsey & Wilson, 1993; Walberg, 1984). Some researchers have even deemed it the gold standard of pedagogy and learning (Bloom, 1984). Yet meta-analyses (e.g., Allen, Eby, Poteet, Lentz, & Lima, 2004; DuBois, Holloway, Valentine, & Cooper, 2002; Eby, Allen, Evans, Ng, & DuBois, 2008; Underhill, 2006) indicate that few programs reach such high efficacy levels. Most achieve only low to moderate effect sizes.

Offline mentoring programs face a number of problems that e-mentoring programs can address. Geographical distance, for instance, often restricts the frequency of meetings between mentor and mentee. Domains with few mentors exacerbate geographical constraints. A given region may simply possess too few mentors within a highly specialized domain who are both well qualified and a good fit for prospective mentees. Such exigencies of organization, scheduling, and geography also make involving other social agents within a mentee's environment (e.g., parents and peers) more difficult, and research testifies to the importance of the involvement of such people.

As a means of overcoming these difficulties in mentoring, Web 2.0 is a game-changing development. E-mentoring's lack of geographical centrality and its ability to mitigate the requirement of synchrony during communication mean that it offers solutions to many of the perennial difficulties faced by offline mentoring programs (cf., Miller & Griffiths, 2005). The advantages of computer-mediated communication come at the price of certain disadvantages, however (cf., Kiesler, Siegel, & McGuire, 1984). The exact nature of the trade-offs between offline and online mentoring still needs to be investigated. While various meta-analyses and handbooks (Allen et al., 2004; DuBois et al., 2002; DuBois & Karcher, 2005; Eby et al., 2008; Underhill, 2006) illustrate the depth and breadth of research on offline mentoring programs, studies of online mentoring are just starting to appear (e.g., O'Neill, Asgari, & Dong, 2011; Penny & Bolt, 2009). In both cases, many evaluation studies evince methodological problems. Studies often rely exclusively on satisfaction questionnaires, for example. Longitudinal studies documenting changes in relevant factors over time are the exception. Studies often fail to use control groups; and when they do use

* Corresponding author. Tel.: +49 941 943 1700; fax: +49 941 943 1993.
*E-mail address:* heidrun.stoeger@paedagogik.uni-regensburg.de (H. Stoeger).

0360-1315/$ – see front matter 
http://dx.doi.org/10.1016/j.compedu.2013.07.032

them, serious questions about the comparability of the control and treatment groups often arise (for an overview, cf. Ensher, Heun, & Blanchard, 2003; Stoeger, 2009).

With this contribution we present the results of an evaluation of an e-mentoring program in the area of STEM promotion for girls. Before we describe the hallmarks of both the program and the evaluation study (its design and implementation), we will first briefly discuss the situation of girls in STEM in Germany and the necessity of taking steps to help girls and women move ahead in this area in particular. We will then explain why mentoring is a particularly effective option for promoting STEM interests among girls and list the advantages of e-mentoring in this area.

## 2. Girls and women in STEM

Recent data show that girls and women continue to be underrepresented in STEM in Germany (for an overview cf. Blossfeld et al., 2009). In 2011, for instance, women accounted for less than twenty percent of students in most STEM subjects at German universities (computer science: 19.9%; mechanical and process engineering: 17.2%; electrical engineering: 11.0%). The statistics for other countries are not quite as lopsided but nevertheless comparable (for an overview, cf. Halpern et al., 2007; Papastergiou, 2008; Sáinz & López-Sáez, 2010).

The low rates of participation for girls and women in STEM are problematic both for the individual girls and women and for society as a whole. Women whose career paths reflect these inequitable participation rates suffer considerable drawbacks. They have lower salaries, more limited career and professional development opportunities, and less say in the development of their personal lives and their society (Allmendinger, 2002). Societies in which women are underrepresented in STEM also pay a significant collective economic price in the form of chronic shortages of skilled labor (Ammermüller & Lauer, 2007).

Researchers interested in planning effective intervention methods for confronting this problem started by looking closely at the causes behind these imbalanced participation rates. Early efforts focused on achievement disparities between girls and boys and women and men. More recently, however, the various national and international indicators of academic achievement, which do show that girls' achievements have improved, suggest that achievement disparities are not a sufficient explanation of gender disparities in STEM participation (for an overview cf. Else-Quest, Hyde, & Linn, 2010). The same is true of explanations of gender-related participation discrepancies focusing on personality traits such as giftedness, interest, and motivation (Eccles, 1994; Stoeger, 2007). Accordingly, researchers are now moving away from approaches focused solely on personality traits.

The state of current research reflects simultaneous investigations of three causal networks. First, researchers have examined environmental influences and, in particular, prevailing stereotypes of men being talented in STEM and of women who are inherently ill suited to these fields (e.g., Deaux & Lafrance, 1998). In this context they have described problems such as stereotype threat (Spencer, Steele, & Quinn, 1999; Stelle, 1997); they have also considered socialization influences such as gender-specific toys and activities (e.g., Bussey & Bandura, 1999) and the gender-based division of labor in many Western societies (Eagly, 1987). Second, research has focused on individual goals and interests (Eccles, 1994). And third, studies have examined the role of subjective action spaces, which are defined as the psychological entities that represent the action opportunities available to individuals. Despite possessing all necessary abilities for STEM (for an overview, cf. Blossfeld et al., 2009), the subjective action spaces of girls and women in STEM are often unnecessarily limited, both through exposure to limiting stereotypes (e.g., "math and science just aren't for girls") and on account of the suboptimal implementation of STEM activities (e.g., test anxiety). Effective interventions in STEM are, thus, a complex matter requiring the coordination of various simultaneous efforts. Mentoring is one measure capable of meeting such demands.

## 3. Increasing female STEM participation through mentoring

Mentoring in STEM offers various advantages. It provides girls with appropriate female role models who are experts in STEM fields (Dasgupta, 2011). Girls and women who have chosen courses, programs of study, or careers in STEM stress the importance of role models in their decision processes (Eccles-Parsons, 1984). Studies have shown that the exemplary function of role models effects positive changes in a number of areas: goal setting, success beliefs, self-concept, attitudes and stereotypes (Cheryan, Drury, & Vichayapai, 2012; Deaux & Lewis, 1984; Evans, Whigham, & Wang, 1995; Stout, Dasgupta, Hunsinger, & McManus, 2011), and academic and professional choices in STEM (e.g., Smith & Erb, 1986; Stout et al., 2011).

The influence of mentors goes beyond their effect as role models. Female mentors also help their mentees by counseling, advising, instructing, and sharing knowledge with them (Stoeger, Ziegler, & Schimke, 2009). Mentors help their mentees to, for instance, acquire knowledge and effective action options in STEM which can lead to learning and achievement gains. They help improve their mentees' subjectively perceived action options in STEM by offering suggestions about effective learning strategies, by contributing to a strengthening of their mentees' self-confidence, or by helping mentees deal with setbacks. Mentors also support their mentees in setting appropriate and challenging goals. They motivate mentees for STEM activities and increase their interest in STEM topics through conversations and learning activities. Mentors also effect positive changes in their mentees' learning environments by providing their mentees with learning opportunities, learning materials, and chances to meet other people interested in STEM (e.g., during internships).

When program organizers ensure proper implementation, mentoring thus offers an excellent opportunity for improving the situation of girls and women in STEM. Yet as we indicated above, the implementation of offline programs promoting girls' interests in STEM often proves difficult (Miller & Griffiths, 2005). E-mentoring offers various advantages when it comes to promoting the interests and activities of girls and women in STEM.

## 4. The advantages of E-mentoring for promoting girls and women in STEM

Various authors have discussed disadvantages of e-mentoring compared to offline mentoring (for an overview, cf. Miller & Griffiths, 2005). Early work focused on how inadequate technological infrastructure and poor computer and internet usage skills had negative effects on e-mentoring (cf. Friedman, Zibit, & Coote, 2004; Parks & Roberts, 1998). As internet access and everyday competencies no longer pose problems in many cases, more recent work has focused on specific problems of computer-mediated communication for e-mentoring (for an overview, cf. Döring, 2003) such as the restriction of communication to written expression, resulting difficulties for perceiving social cues (Culnan & Markus, 1987; Kiesler et al., 1984), and the writing competencies required of participants (Segall, 2000). Another area of concern in e-mentoring research is the question of online privacy (Ensher et al., 2003; Wenzel, 2003).

We make the assumption, however, that such problems can be overcome through proper program planning such as ensuring the availability of computers for participants, offering training in effective computer-based communication, and dealing with data security issues. We thus assume that the advantages of e-mentoring will outweigh any disadvantages in the case of promoting girls' STEM interests. Despite the new problems created by online communication, e-mentoring is nevertheless capable of fulfilling various requirements of highly effective mentoring. We will now briefly describe various aspects of successful mentoring and how these can be achieved in e-mentoring. In many cases, their execution can be particularly effective in e-mentoring.

### 4.1. Finding effective role models

Studies have shown same-gender role models to be the more effective option (Bussey & Bandura, 1999; Stout et al., 2011). Thus girl-oriented STEM promotion requires mentors who not only work in a STEM field but who are also female. As the participation rates of women in these fields are low, finding a sufficient number of professional women in STEM is difficult. The task becomes even more difficult when one also considers another empirically substantiated criterion of effective mentoring relationships (DuBois et al., 2002): Successful mentoring dyads must bring individuals together who are well suited to one another. By enabling mentoring relationships across large geographical distances, e-mentoring helps address this problem in a way that a traditional offline program cannot.

### 4.2. Starting interventions early enough

Girls tend to lose interest in STEM around the age of 11, and the rate of interest loss increases as they progress through secondary education (Gardner, 1985; Hoffmann, Lehrke, & Todt, 1985; Kerr, 2004). Accordingly, intervention programs need to start as early as possible for girls, ideally around the time at which their interest levels start to fall. Participation in offline mentoring programs is often logistically difficult for this age-group, however. Meetings with a mentor may require an accompanying adult, who may also need to furnish transportation. The often incompatible schedules of girls and their professional female mentors further exacerbate the situation, with girls having more time during the day and the mentors' free time being limited to evenings and weekends.

### 4.3. Ensuring frequent interaction

Studies indicate that along with the regularity of mentor–mentee interaction, the frequency of this interaction also helps determine the success of mentoring efforts (DuBois et al., 2002). By allowing for asynchronous communication (e.g., via email or in forums) and facilitating geographical and scheduling flexibility, e-mentoring programs can ensure sufficient levels of interaction frequency. A mentee experiencing her first summer science camp, for instance, might exchange a crucial email with her mentor who will find 5 min to respond while waiting for a flight during a business trip. A traditional offline mentoring approach would simply not work in such a case.

### 4.4. Sharing knowledge, counseling, and guidance

Effective interventions promoting girls' interests in STEM need to address a number of related factors. The mentors' role-model function is thus, in and of itself, not sufficient for effecting changes. Mentors also need to share additional knowledge, counsel, and provide guidance. Being effective on so many different fronts simultaneously is no easy task for a mentor. The topics of conversations between mentors and mentees require careful planning. Ideally, such conversations should be supervised (DuBois et al., 2002). E-mentoring is particularly well suited to effective supervision. Messages can be saved and thus examined systematically. Furthermore, the asynchrony of digital communication affords mentors time to be thoughtful when working on answers. Mentors can, for instance, seek the advice of program organizers when preparing a response to a mentee.

### 4.5. Using numerous as well as same-age role models

Studies have confirmed that in addition to role models of a higher status, those mentors who are as similar as possible to their mentees (e.g., with respect to age) are particularly effective (Bussey & Bandura, 1999). E-mentoring programs open up the possibility of creating members-only online community platforms which offer simultaneous access to large numbers of mentors and mentees. Members can discuss STEM topics with one another on such platforms via forums and chat sessions. Such communication structures ensure that mentees have access to a variety of different role models at any given time. E-mentoring's unique ability to ensure a plurality of appropriate role models thus helps each individual mentee to avoid falling into the trap of viewing her respective mentor as a sort of exception to the rule (cf. research on subtyping processes by Richards & Hewstone, 2001). Instead, online role-model variety ensures that a mentee can view her mentor as one of many women who have made it in STEM. And the online mentoring environment allows mentees to see that many of their female peers are also interested in STEM and thus to understand that their STEM interest is neither strange nor unusual, even if their everyday environment might imply as much.

### 4.6. Creating STEM-friendly environments

An additional advantage of e-mentoring programs is that e-mentoring makes the task of creating positive, STEM-friendly learning environments considerably easier than in offline settings. Online forums and chat rooms allow for the sorts of informal, spontaneous discussions on STEM topics which promote informal learning (cf. Cook & Smith, 2004). An online community platform allows participants to collaboratively collect and access STEM-related learning materials and information, and this facilitates group projects such as carrying out experiments or writing articles on STEM topics. Furthermore, the e-learning infrastructure allows for the easy integration of additional, program-external social agents (e.g., teachers, parents, peers) into these sorts of activities. The integration of non-participants has been an important factor in the success of offline programs (DuBois et al., 2002). E-mentoring makes the organization of external collaboration easier.

## 5. The e-mentoring program CyberMentor

The e-mentoring program CyberMentor is systematically applying the advantages described above to the promotion of girls in STEM. CyberMentor combines important aspects of successful girl-oriented STEM promotion with hallmarks of successful mentoring. After an introductory description of the CyberMentor project, we will discuss the project's goals.

### *5.1. Program description*

#### *5.1.1. Participants, duration, and matching*

To ensure that promotional efforts reach girls before the age at which interest in STEM typically decreases, CyberMentor is open to girls as of the age of eleven. Mentees are between the ages of eleven and eighteen. 800 female students from throughout Germany participate in the program every year. The program assigns a personal female mentor to each student for at least one year. As all of the participating students are in college-preparatory secondary schooling, all the mentors are either college students majoring in a STEM subject or college-educated professionals working in STEM. This matching criterion should ensure a maximum amount of similarity between the successful role models and the mentees. The matching algorithm also considers both STEM-related and personal interests as they were recorded for each participant upon registering for the program.

#### *5.1.2. Email contact*

All participants agree to exchange at least one email per week on topics in STEM and to use the members-only community platform (described in more detail below) as often as possible. These guidelines are designed to ensure that mentors and mentees have the highest possible level of contact, as contact frequency is an important factor in mentoring success. Program participants receive a handbook designed to facilitate the initial mentor–mentee contact and to ensure successful mentoring. The ten-member CyberMentor organizational team offers additional support by answering questions submitted via email by mentees about mentoring and by mentors about how best to share knowledge with, to counsel, and to instruct their mentees. The team members, all of whom have university degrees in related fields such as computer science or psychology, also offer weekly online office hours via chat during which they provide information on these topics.

#### *5.1.3. Community platform*

The members-only community platform fulfills two objectives. It facilitates access to as many same-age role models as possible and it ensures that these role models interact within a STEM-friendly environment. We will now briefly describe the platform and what it offers members.

*5.1.3.1. Personal page and guest book.* Each participant can design a personal page with profile information and a picture. The mentors are asked to include information on their personal pages describing their university and professional experiences and highlighting their favorite aspects. That way, girls will have more opportunities to learn about various options for university study and work. Contact buttons on the personal pages and the guest books make it easy for mentors and mentees to contact one another and easier for girls to learn more about their mentors' STEM interests, university work, and careers.

*5.1.3.2. Forum and chat.* Discussions, the sharing of knowledge, and counseling can also take place in the CyberMentor Forum and via CyberMentor Chat. The forum consists of various subforums such as "Speaking of STEM …," "At School," and the "STEM Café." These forum activities give members a chance to discuss both school-related and personal issues. There are also forums dedicated to collaborative work on experiments, projects, and competitions. A decisive advantage of such forum-based interaction is that the mentors with expertise in various fields are easily accessible when questions arise or guidance is needed. Members can use CyberMentor Chat for discussing general topics as well as STEM-related matters. CyberMentor moderators also offer a weekly chat session focusing on a particular topic in STEM. The CyberMentor moderators are either employee members of the professional CyberMentor support team or mentors.

*5.1.3.3. STEM Corner.* The forums for doing experiments, working on projects, and preparing for competitions described above as well as various opportunities to discuss and learn more about STEM topics already constitute STEM-friendly environments. The STEM Corner augments these offerings on the community platform by offering various activities in STEM. There is also a part of the STEM Corner in which mentees are directed to activities in STEM such as interesting STEM-related books, TV programs, and exhibitions. The CyberMentor team manages and continually updates these suggestion lists. The STEM Corner also provides the mentors with detailed information about what the mentees are learning in school by collecting both state curricula for STEM subjects as well as interstate instruction standards for STEM. As both the CyberMentor management team members and all program participants can upload interesting articles and other online materials to the STEM Corner, it is also designed to be participatory.

*5.1.3.4. CyberNew.* The CyberMentor team publishes a monthly online magazine, *CyberNews*, which also contains a wealth of STEM-related information. It contains interviews with experts about university programs, career options, and research projects that mentors are working on as well as descriptions of interesting STEM-related books, programs, and exhibitions. The magazine also includes hands–on activities such as games and problem-solving. Mentors and mentees also have the chance to contribute their own texts to the magazine, which can be written both individually and collaboratively. Other influential individuals—schoolmates, friends, parents, or teachers, for instance—can also collaborate on articles for *CyberNews*.

### 5.2. CyberMentor's goals

The long-term and overarching goal of CyberMentor is to increase the participation rates of girls and women in STEM. As girls start participating in CyberMentor at a relatively young age, their final decisions about university study and careers will only be made years from now. CyberMentor's immediate goal therefore is to positively influence various moderating variables. For example, the program seeks to increase the frequency of girls' activities in STEM (e.g., reading a STEM-related book, watching a television show on a STEM topic, doing an experiment or participating in a discussion in STEM). Another immediate goal is providing offerings which can increase the amount of knowledge the mentees have about topics, programs of study, and careers in STEM. Other goals focus on effecting improvements in STEM interest, confidence in one's own STEM abilities, and the assessment of one's own STEM skills. Another primary concern is increasing the number of participants who intend to study a STEM subject at university later on.

## 6. Aims of the study and expected results

This study seeks to evaluate the effectiveness of the CyberMentor e-mentoring program with regard to the goals described above. We assess changes in the following seven variables: STEM activities, knowledge of STEM topics, knowledge about university studies and jobs in STEM, interest in STEM domains, confidence in one's own STEM abilities, self-assessment of one's own STEM competencies, and academic elective intentions.

We expect to find CyberMentor-related promotion effects for STEM activities, knowledge of STEM topics, knowledge about university studies, and jobs in STEM. In other words, we assume that CyberMentor will effect increases in these variables. We base our assumption on findings regarding the effects of discussing STEM activities, university study options, and careers as well as involvement in group-oriented STEM activities (vgl. Eby et al., 2008).

We only expect to find prevention effects for interest in STEM domains, confidence in one's own STEM abilities, and self-assessment of one's own STEM competencies. In these cases, CyberMentor should help prevent decreases in these variables. We know that girls who register for a program such as CyberMentor already have relatively high levels for STEM interest, confidence in one's own abilities, and self-assessment of knowledge in STEM before they register (Stoeger et al., 2012) and that, therefore, substantial increases in these variables are not probable. But the program should, at the very least, prevent the sort of decline in STEM-related interest, confidence, and self-assessed knowledge which has been documented in various studies for students of this age-group (e.g., Eccles et al., 1989; Gardner, 1985; Hoffmann et al., 1985; Kerr, 2004). The program design also gives reason to expect that the program will contribute to an increase in the academic elective intentions of the participants (DuBois et al., 2002; Stout et al., 2011).

Our evaluation study has three special features. First, we not only asked the participants how satisfied they were in various respects, we also asked them about various aspects pertaining to their future career plans (cf. the concerns about this matter expressed by O'Neill et al., 2011). Second, we collected data on our chosen indicators at three points in time: before participants started the mentoring program, in the middle of the mentoring year, and after the mentoring year. We can thus go beyond merely examining short-term or novelty effects (cf. Ziegler, Schimke, Stoeger, & Merrotsy, 2010) and observe long-term effects. Third, our study goes a step further than many of the studies which have accompanied other mentoring programs (cf. the criticism raised by Allen et al., 2004) by also comparing changes observed in the treatment group with a control group of female students who did not receive mentoring. We stress, furthermore, that we took great care in selecting the participants for our control group. We identified a group of girls with similar interests who had applied for participation in CyberMentor but who were put on a waiting list (after drawing lots) for a later round of mentoring. This means that compared to other studies (for an overview cf. Allen et al., 2004; DuBois et al., 2002; Eby et al., 2008; Underhill, 2006) we not only compared the development of our participants with girls who did not receive mentoring but we had a waiting-list control group of girls with similar STEM interests.

## 7. Method

### 7.1. Procedure and participants

The present study was conducted with the CyberMentor program during the 2010/2011 mentoring year. 1054 girls from across Germany applied for the mentoring program. Through the drawing of lots, 800 of these applicants were selected for participation. The remaining 254 girls constituted the waiting-list control group. All 1054 applicants attended college-preparatory schools in Germany (*Gymnasium*). Their average age was 13.51 years ($SD = 1.95$). 312 of the 1054 applicants (29.4%) filled out the voluntary questionnaire. We collected complete data sets for all 312 members of this group for all three data collection points. Of those who agreed to answer the voluntary questionnaire, 208 girls were in the treatment group (TG) and 104 girls were in the waiting-list control group (WG). The latter group of girls had to wait a year before participating in the program. All 312 of these girls filled out an online questionnaire prior to the beginning of the mentoring year (in April), after the first half of the mentoring year (in October), and after the mentoring year (in March). Completion of the form lasted about 20 min.

### 7.2. Measures

#### 7.2.1. STEM activities

We assessed study participants' levels of STEM activities with six questionnaire items with an identical beginning ("Have you ever …"). Questions included, for instance, "Have you ever read a book on a subject in STEM?" and "Have you ever discussed a STEM topic with your friends?" We used a four-point response format (from *never* to *very often*). The internal consistency score (Cronbach's alpha) for the scale was 0.89 for the first and second measuring point and 0.91 for the third.

#### 7.2.2. Self-assessment of knowledge of STEM topics

We asked respondents to estimate their knowledge of STEM topics. To this end we presented the girls with a line consisting of 100 circles, under which the percentages 0%, 25%, 50%, 75%, and 100% were printed. The statement "very little" was paired with 0% and the statement "a lot" with 100%. The following question and instructions were located above the line: "How much do you know about STEM? Please mark the circle which best represents your knowledge of STEM topics. You can orient this assessment on the percentage rankings provided."

#### 7.2.3. Self-assessment of knowledge about university studies and jobs in STEM

We asked respondents to estimate their knowledge about university studies and jobs in STEM. To this end we presented the girls with the line of circles described above. Above this line respondents found the following question and instructions: "How much do you know about study and job possibilities in STEM? Please mark the circle which best represents your knowledge about study and job possibilities in STEM. You can orient this assessment on the percentage rankings provided."

#### 7.2.4. Self-assessment of interest in STEM domains

We asked respondents to estimate their interest in STEM. To this end we presented the girls with the line of circles described above. Above this line respondents found the following question and instructions: "How interested are you in STEM? Please mark the circle which best represents your interest in STEM. You can orient this assessment on the percentage rankings provided."

#### 7.2.5. Confidence in one's own STEM abilities

We asked respondents to assess their confidence in their own STEM abilities. To this end we used a domain-specific version of the scale "Belief in one's own abilities" (Dweck, 1999; Dweck & Henderson, 1988). This four-item scale measures how confident students are in their (in this case STEM-related) abilities. The end points are formulated as statements, e.g., "I do not have a great deal of confidence in my STEM abilities" vs. "I am confident in my STEM abilities." Each of the statements in an item pair represented one pole on a six-point scale. A low value represented little confidence in one's own abilities. For the present study, the internal consistency (Cronbach's alpha) of the scale sore was 0.88 at the first measuring point and 0.90 at the second and third measuring points.

#### 7.2.6. Self-assessment of STEM competencies

We asked respondents to estimate their competencies in STEM. To this end we presented them with the line of circles described above. The respondents found the following question and instructions above the line: "How good are you in STEM? Please mark the circle which best represents your competence levels in STEM. You can orient this assessment on the percentage rankings provided."

#### 7.2.7. Academic elective intentions

We used four self-constructed items to assess respondents' academic elective intentions. Respondents were to indicate how well they could picture themselves choosing a university major in STEM, a STEM subject for a track or course at school, and pursuing a career in a STEM-related field. All items began with the phrase "I can picture myself …". An example is "I can picture myself majoring in a STEM subject." All items loaded onto the same factor in a factor analysis. Cronbach's alpha was 0.93, 0.92, and 0.94 for the three measuring points respectively.

## 8. Results

We will report our results in two steps. We will first provide descriptive statistics. In a second step we will report on the short- and long-term effectiveness of the CyberMentor program. We based our conclusions regarding the program's short- and long-term effectiveness on an analysis of variance in repeated measurements, using the respondents' group memberships (treatment vs. waiting-list control group) as the independent variables.

### 8.1. Descriptive statistics

Table 1 contains means and standard deviations for each dependent variable analyzed for both the treatment and waiting-list control groups. Both groups were comparable on every variable at the first measuring point ($ts < 1.04$, $ps > 0.05$) with the exception of academic elective intentions ($t(216.83) = 2.48$; $p = < 0.01$). For this variable the waiting-list control group started on a higher level compared to the treatment group. At the second and the third measuring points both groups were comparable on every variable ($ts < 0.90$, $ps > 0.05$) with the exception of STEM activities. The treatment group reported more STEM activities than the waiting-list control group for both measuring points two and three.

### 8.2. Program effectiveness

In order to examine the effectiveness of the mentoring program, we conducted a repeated-measures ANOVA with three measuring points for each dependant variable with group (treatment vs. waiting-list control groups) as the between-subject variable and time as the within-subject variable (measuring points 1, 2, and 3). For all variables a Mauchly's test indicated that the assumption of sphericity had been violated, therefore degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity. The results are shown in Table 2. The differences between the first and the second as well as the first and the third measuring point for every group were analyzed with paired sample *t*-tests (see Table 2).

The data reflect (marginally) significant interactions for the variables STEM activity, self-assessment of knowledge of STEM topics, self-assessment of knowledge about university studies and jobs in STEM, confidence in one's own STEM abilities, self-assessment of STEM competencies, and academic elective intentions (refer to Table 2 and Figs. 1–3). No significant interaction was found for self-assessment of interest in STEM domains.

As expected, the interaction effect for STEM activities reflected the increase in STEM activities in the treatment group. For the treatment group, STEM activities showed a marginally significant increase from the first to the second measuring point; they remained roughly unchanged for all three measuring points for the waiting-list control group (cf. Fig. 1). Contrary to our expectations, the interaction effect for

**Table 1**
Descriptive statistics for the two groups at three measuring points.

| Variable | $t_1$ | | $t_2$ | | $t_3$ | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| STEM activity | | | | | | |
| TG | 2.80 | 0.86 | 2.91 | 0.84 | 2.89 | 0.84 |
| WG | 2.77 | 0.91 | 2.65 | 0.83 | 2.70 | 0.82 |
| Self-assessment of knowledge of STEM topics | | | | | | |
| TG | 65.54 | 16.76 | 66.00 | 16.12 | 67.02 | 17.56 |
| WG | 67.38 | 16.78 | 64.91 | 15.64 | 64.57 | 15.21 |
| Self-assessment of knowledge about university studies and jobs in STEM | | | | | | |
| TG | 34.95 | 26.69 | 39.06 | 27.06 | 39.68 | 27.95 |
| WG | 38.24 | 25.42 | 39.27 | 26.52 | 35.67 | 25.63 |
| Self-assessment of interest in STEM domains | | | | | | |
| TG | 48.61 | 27.24 | 47.96 | 26.84 | 47.02 | 27.79 |
| WG | 53.27 | 26.92 | 50.03 | 27.66 | 46.97 | 27.44 |
| Confidence in one's own STEM abilities | | | | | | |
| TG | 4.51 | 1.04 | 4.49 | 1.15 | 4.55 | 1.08 |
| WG | 4.62 | 0.97 | 4.60 | 0.90 | 4.46 | 1.00 |
| Self-assessment of STEM competencies | | | | | | |
| TG | 74.34 | 15.33 | 74.21 | 14.17 | 74.68 | 15.01 |
| WG | 76.89 | 13.55 | 74.43 | 12.93 | 73.14 | 13.96 |
| Academic elective intentions | | | | | | |
| TG | 3.48 | 1.02 | 3.74 | 1.05 | 3.85 | 1.08 |
| WG | 3.77 | 0.97 | 3.82 | 1.02 | 3.84 | 0.98 |

*Note.* $N = 312$. TG = treatment group, WG = waiting-list control group; STEM activities are based on $min = 1$ and $max = 4$; all self-assessment scales are based on $min = 0$ and $max = 100$; confidence and academic elective intentions are based on $min = 1$ and $max = 6$.

**Table 2**
ANOVA repeated-measures design for the two groups at three measuring point and paired sample *T*-test for the two groups: short- and long-term effect.

| Variable | Main effect group | | | Main effect time | | | Interaction group *x* time | | |
|---|---|---|---|---|---|---|---|---|---|
| | *F* | *p* | $\eta^2$ | *F* | *p* | $\eta^2$ | *F* | *p* | $\eta^2$ |
| STEM activities | | | | | | | | | |
| | 4.18 | 0.04 | 0.01 | 0.02 | 0.98 | 0.00 | 2.46 | 0.09 | 0.01 |
| Self-assessment of knowledge of STEM topics | | | | | | | | | |
| | 0.11 | 0.75 | 0.00 | 0.74 | 0.47 | 0.00 | 3.41 | 0.04 | 0.01 |
| Self-assessment of knowledge about university studies and jobs in STEM | | | | | | | | | |
| | 0.00 | 0.95 | 0.00 | 1.36 | 0.26 | 0.00 | 2.73 | 0.07 | 0.01 |
| Self-assessment of interest in STEM domains | | | | | | | | | |
| | 0.58 | 0.45 | 0.00 | 4.77 | 0.01 | 0.02 | 1.71 | 0.18 | 0.01 |
| Confidence in one's own STEM abilities | | | | | | | | | |
| | 0.11 | 0.74 | 0.00 | 0.82 | 0.44 | 0.00 | 3.24 | 0.04 | 0.01 |
| Self-assessment of STEM competencies | | | | | | | | | |
| | 0.07 | 0.79 | 0.00 | 3.68 | 0.03 | 0.01 | 4.89 | 0.01 | 0.02 |
| Academic elective intentions | | | | | | | | | |
| | 1.22 | 0.27 | 0.00 | 11.42 | 0.00 | 0.04 | 5.38 | 0.01 | 0.02 |

| Variable | | Short-term | | Long-term | |
|---|---|---|---|---|---|
| | | *t*-test | Δ Change | *t*-test | Δ Change |
| STEM activities | | | | | |
| | TG | $t(205) = 1.74, p < .10$ | 0.13 | $t(203) = 1.26, p > .10$ | 0.11 |
| | WG | $t(103) = -1.44, p > .10$ | −0.14 | $t(102) = -0.83, p > .10$ | −0.08 |
| Self-assessment of knowledge of STEM topics | | | | | |
| | TG | $t(207) = 0.51, p > .10$ | 0.03 | $t(207) = 1.34, p > .10$ | 0.09 |
| | WG | $t(103) = -1.97, p < .10$ | −0.15 | $t(103) = -2.02, p < .05$ | −0.18 |
| Self-assessment of knowledge about university studies and jobs in STEM | | | | | |
| | TG | $t(207) = 2.41, p < .05$ | 0.15 | $t(207) = 2.33, p < .05$ | 0.17 |
| | WG | $t(103) = 0.42, p > .10$ | 0.04 | $t(103) = -0.95, p > .10$ | −0.10 |
| Self-assessment of interest in STEM domains | | | | | |
| | TG | $t(207) = 0.44, p > .10$ | −0.02 | $t(207) = 0.91, p > .10$ | −0.06 |
| | WG | $t(103) = 1.69, p < .10$ | −0.12 | $t(103) = 3.13, p < .01$ | −0.23 |
| Confidence in one's own STEM abilities | | | | | |
| | TG | $t(207) = 0.32, p > .10$ | −0.02 | $t(207) = 0.77, p > .10$ | 0.04 |
| | WG | $t(103) = 0.21, p > .10$ | −0.02 | $t(103) = -1.91, p < .10$ | −0.16 |
| Self-assessment of STEM competencies | | | | | |
| | TG | $t(207) = 0.18, p > .10$ | −0.01 | $t(207) = 0.38, p > .10$ | 0.02 |
| | WG | $t(103) = -2.30, p < .05$ | −0.19 | $t(103) = -3.60, p < .001$ | −0.27 |
| Academic elective intentions | | | | | |
| | TG | $t(207) = 4.57, p < .001$ | 0.25 | $t(207) = 5.78, p < .001$ | 0.35 |
| | WG | $t(103) = -0.69, p > .10$ | 0.03 | $t(103) = -0.97, p > .10$ | 0.07 |

Note: TG = treatment group, WG = waiting-list control group.

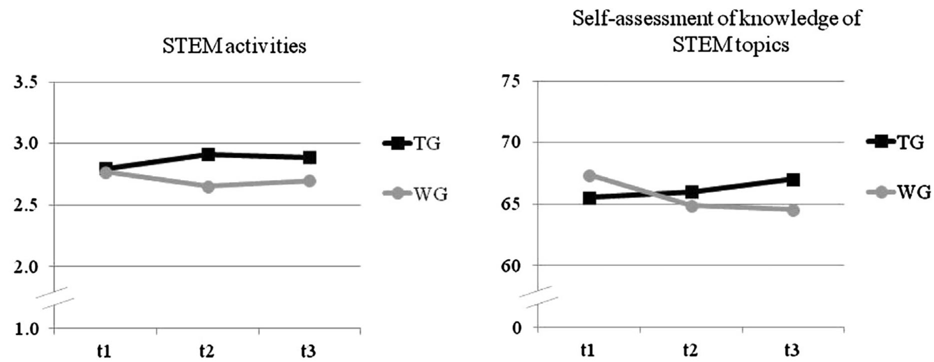


**Fig. 1.** Stem activities and self-assessment of knowledge of STEM topis in the treatment and waiting-list control group.

self-assessment of knowledge of STEM topics was not a result of an increase in the treatment group; instead, it reflected a decrease in self-assessment of knowledge of STEM topics in the waiting-list control group (cf. Fig. 1), which showed a marginally significant decrease from measuring point 1 to 2 and a significant decrease from measuring point 1 to 3.

As expected, the interaction effect for self-assessment of knowledge about university studies and jobs in STEM reflected a significant increase in the treatment group (cf. Fig. 2). Self-assessment of knowledge about university studies and jobs in STEM increased significantly from measuring point 1 to 2 and from measuring point 1 to 3 for the treatment group but remained roughly stable across the three measuring points for the waiting-list control group. The interaction effect for confidence in one's own STEM abilities (cf. Fig. 2) reflected a marginally significant decrease in the waiting-list control group from measuring point 1 to 2. As expected, values for the treatment group remained roughly the same across the three measuring points.

The interaction effect for self-assessment of STEM competencies was also in line with our expectations. It reflected a decrease for the waiting-list control group. Self-assessment of STEM competencies decreased significantly for the waiting-list control group, but it remained roughly the same at each of the three measuring points for the treatment group (cf. Fig. 3). Also as expected, the interaction effect for academic elective intentions resulted from an increase in the treatment group. Academic elective intentions increased in the treatment group over the three measuring points; they remained stable in the waiting-list control group.

## 9. Discussion

Our intention with this study was to evaluate the effectiveness of a one-year e-mentoring program focused on promoting girls' development in STEM. Increasing girls' rates of participation in STEM and fostering positive developments in moderating variables remains crucially important. Girls now perform academically on or even above par with their male peers in STEM (Else-Quest et al., 2010). It is thus all the more problematic that girls continue to choose academic and professional work in STEM less frequently than their male peers do (Blossfeld et al., 2009; Halpern et al., 2007; Papastergiou, 2008; Sáinz & López-Sáez, 2010). A hallmark of CyberMentor – the program examined by this study – is its harnessing of the new possibilities of Web 2.0 (e.g., flexibility in scheduling and bringing together geographically disparate participants) to overcome problems traditionally encountered in offline mentoring programs focusing on encouraging girls in STEM (e.g., only involving girls when they are already too far along in their schooling, an insufficient frequency of mentor–mentee contacts, a lack of appropriate role models).

Our evaluation includes three exceptional features. First, it not only assesses the participants' satisfaction with the program, but it also considers various matters which may be relevant for future career decisions (e.g., STEM activities, knowledge about university studies and jobs in STEM, academic elective intentions; cf. remarks by O'Neill et al., 2011). Second, our evaluation investigates both short- and long-term effects and thereby allows us to identify and discount novelty effects (cf. Ziegler et al., 2010). Third, we compare the development of program participants in the treatment group with that of individuals in a waiting-list control group whose members, it should be stressed, have

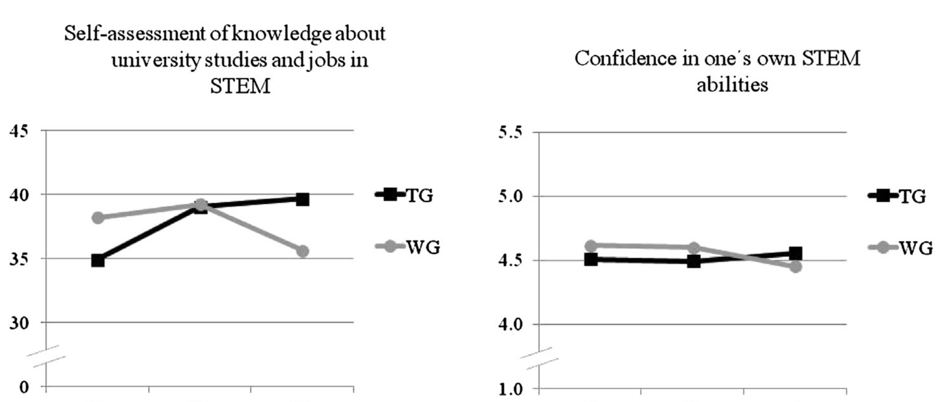


**Fig. 2.** Self-assessment of knowledge about university studies and jobs in STEM and confidence in one's own STEM abilities in the treatment and waiting-list control group.

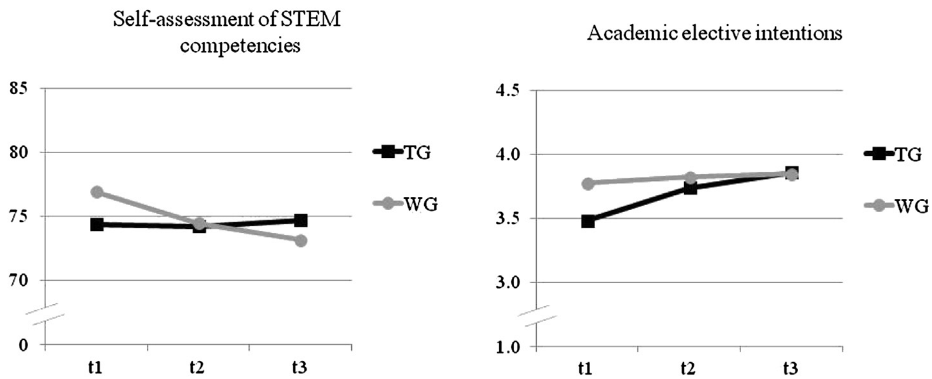


**Fig. 3.** Self-assessment of STEM competencies and academic elective intentions in the treatment and waiting-list control group.

interests very similar to those of the treatment-group members. Therefore our research design distinguishes itself from most earlier studies in two respects. First, we base our comparisons on a control group. This has not yet become standard practice in mentoring research (Allen et al., 2004; DuBois et al., 2002; DuBois & Karcher, 2005; Eby et al., 2008; Underhill, 2006). Second, the fact that our waiting-list control group consists of individuals who, just like the members of the treatment group, actually registered for the program ensures that the waiting-list control group is truly comparable to the treatment group. Most other studies in the field of mentoring research lack this aspect of comparability. These measures allow us to assess the extent to which changes are actually results of the intervention, since they ensure that such changes neither merely reflect other developments extraneous to the program nor only reflect, for instance, treatment-group participants possessing more propitious prerequisites prior to starting the program.

All in all, the results of the evaluation study are promising. We found treatment effects for six of the seven dependent variables we considered. We confirmed expected promotion effects for STEM activities, knowledge about university studies and jobs in STEM, and academic elective intentions. In other words, for these variables we observed increases in the treatment group and stable levels for the waiting-list control group over the course of the mentoring year. We found expected prevention effects for confidence in one's own STEM competencies and self-assessment of one's own STEM competencies. Thus the values in the treatment group remained roughly the same over the course of the mentoring year, while the waiting-list control group showed a decrease. The developments ran contrary to our expectations for the variables interest in STEM domains and knowledge of STEM topics. We did not find the expected training effect for interest in STEM domains. In the case of knowledge of STEM topics, we observed treatment effects, but these were not the promotion effects we expected but rather prevention effects. Girls who participated in the training assessed their knowledge of STEM topics roughly the same at all three measuring points. Self-assessment of knowledge about STEM decreased for the waiting-list control group.

While the effect sizes may seem relatively small, their sizes are typical of those normally found for offline youth mentoring programs. It should be added, that youth mentoring programs tend to reflect average effect sizes that are smaller than those achieved by mentoring programs for adults (Eby et al., 2008). The effect sizes for our study are either comparable to or greater than those reported for the 59 offline youth mentoring programs which DuBois et al. (2002) examined in a meta-analysis. 51 of the 59 effect sizes examined by the authors in their meta-analysis had positive effect sizes, and the $d$ indices of these 51 studies averaged 0.14 with variations ranging from $d = 0.10$ to $d = 0.18$. The remaining $d$ indices included one at 0 and seven with negative values ranging from $d = -0.07$ to $d = -0.25$. We did not find significant negative effects for the treatment group among any of our variables. The effect sizes of the variables for which we found training effects varied for the short-term effects from $d = 0.13$ to $d = 0.25$ and for the long-term effects from $d = 0.17$ to $d = 0.35$. The largest effect sizes were $d = 0.25$ (a short-term effect) and $d = 0.35$ (a long-term effect) for the increase in academic elective intentions.

We are particularly pleased with the increases observed for STEM activities and academic elective intentions. The increase in STEM activities is worth noting because studies show that even when female school students do have high levels of interest in STEM, their environments nevertheless usually fail to offer them better encouragement options than do the environments of girls without particular STEM interests (cf. Stoeger et al., 2012). In other words, even girls showing above-average levels of STEM interest tend to lack opportunities for STEM activities. Unfortunately, however, the initial increase in STEM activities could not be maintained through to the end of the program. One possible reason may be a typical decline in user activity after an initial phase of participation in online programs. This has been documented for online communities in general (for an overview cf. Schimke, Stoeger, & Ziegler, 2009). During an initial phase in which participants are getting to know their online community, participation rates are typically quite high. Thereafter, however, the rates normally fall precipitously. We thus make the assumption that this was also the case for the CyberMentor program. Once participants became acquainted with the program, they started making fewer contacts with mentors and mentees and their participation on the online platform decreased. We assume that these decreases in interactivity levels fostered a situation in which participants were suggesting and jointly organizing fewer STEM activities.

Using visualization tools is one way of, at the very least, lessening this decrease in STEM activities in the future. Studies show that the integration of visualization tools that visually represent the activity level of members of an online community can increase the activity level (Schimke et al, 2009; Ziegler et al., 2010). Future cycles of CyberMentor mentoring should be used to examine whether the use of such tools has a positive effect on participation rates and, via this aspect, on the frequency of STEM activities over time. Another way of increasing and maintaining the STEM activity levels of mentees is to provide the mentors with special training (cf., DuBois et al., 2002). Results from surveys of the CyberMentor mentors indicate that the mentees had trouble finding appropriate STEM topics and activities once the initial phase of getting acquainted was over. We are thus planning on offering training in the future which will help mentors learn to plan their entire mentoring year more effectively. Mentors need to learn how to set appropriate mentoring goals as well as how to choose, organize, and introduce different STEM topics and activities over the course of the mentoring year. Future research should examine whether the introduction of such a training program will succeed in increasing and maintaining the mentees' rates of participation in the online community activities and in STEM activities through to the end of a mentoring year.

Despite the short-lived nature of increases in STEM activities, we were able to confirm long-term effects of mentoring on knowledge of STEM topics, knowledge of university studies and jobs in STEM, as well as on confidence in one's own STEM competencies, on the self-assessment of STEM competencies, and on academic elective intentions. The sizes of the treatment effects for academic elective intentions are a second especially pleasing result of our study. These increased in the treatment group both in the short and long terms, while in the waiting-list control group they remained roughly stable. Academic elective intentions are not the same as actual choices regarding classes, courses of study, or careers. Yet studies indicate that an increase in academic elective intentions has a positive effect on later, real-life choices (Paschal, 2002). In this sense, the increases in academic elective intentions achieved by CyberMentor represent a significant first step towards increasing female participation rates in STEM.

This success does not, of course, avail us of the responsibility of investigating the actual decisions regarding classes and courses of study which mentee participants will go on to make in the future. The age of the mentees in the current study precluded this possibility. In addition to self-assessment scales for various areas, we are also planning on employing tests of knowledge of STEM topics and on assessing real-life choices of university studies and jobs in STEM. We are also preparing log-file analyses of the frequency of STEM discussions in CyberMentor chat rooms and forums as well as of download and upload activity on the CyberMentor site. An additional assessment step will involve analyzing the user input in the forums and chat rooms using corpus linguistic methods to gain a better understanding of just which contents and themes are most beneficial for treatment success.

## 10. Conclusion

This study describes results indicating that e-mentoring is an appropriate measure for promoting girls' development in STEM. This is an agreeable result, as offline programs for this target group are difficult to implement. On the one hand, promotional efforts should start before girls reach the point at which their STEM interests tend to decline (cf. Kerr, 2004). On the other hand, such programs stand and fall with quality of their mentors—in this case they need to be women with track records of success in STEM (Bussey & Bandura, 1999; Stout et al., 2011). Achieving both of these goals simultaneously is very difficult in offline mentoring programs. E-mentoring can surmount both the challenges of time inflexibility and lack of mobility—which, for younger girls, are givens—and thereby offer participants an exceptional chance to find and be inspired by highly appropriate mentors.

In evaluating CyberMentor we followed more rigorous standards than those commonly adhered to in mentoring research (for an overview cf. DuBois et al., 2002; DuBois & Silverthorn, 2005). Even when assessed on the basis of cautious assumptions and interpretations, the program's efficacy is comparable to efficacy levels achieved by other youth mentoring programs and does, in fact, exceed those reported in some cases.

When interpreting our results, it is, furthermore, important to consider evidence that small effects can also lead to large benefits, as Martell, Lane, and Emrich (1996) show in the case of studies of gender stereotypes and their impact on personnel decisions and on the demographic differences present in upper management (also cf. Agars, 2004). Nevertheless, there is still room for improvement. As the aforementioned chances for making improvements illustrate, a lot can still be done to further increase mentoring effectiveness and overall program success levels. In future mentoring cycles, program organizers will need to implement these improvements in the area of accompanying research (e.g., the selection of diagnostic instruments and the monitoring of actual choices). Of crucial importance is the development of more effective programs for training the mentors. Essential are, furthermore, three concerns: increasing contact frequency, setting concrete mentoring goals (in particular in the area of STEM activities), and planning and monitoring the entire mentoring year.

## References


Agars, M. D. (2004). Reconsidering the impact of gender stereotypes on the advancement of women in organizations. *Psychology of Women Quarterly, 28*, 103–111.

Allen, T. D., Eby, L. T., Poteet, M. L., Lentz, E., & Lima, L. (2004). Career benefits associated with mentoring for protégés: a meta-analysis. *Journal of Applied Psychology, 89*, 127–136.

Allmendinger, J. (2002). Abschied von der Männerdominanz? Zur Situation von Nachwuchswissenschaftlerinnen an deutschen Hochschulen [The end of male dominance? The situation of young female researchers at German universities]. In D. Rippl, & E. Ruhnau (Eds.), *Wissen im 21. Jahrhundert: Komplexität und Reduktion [Knowledge in the Twenty-First Century: Complexity and Reproduction* (pp. 105–122). München: Fink.

Ammermüller, A., & Lauer, C. (2007). Bildung und nationale Prosperität [Education and national prosperity]. In K. A. Heller, & A. Ziegler (Eds.), *Begabt sein in Deutschland [Being gifted in Germany]* (pp. 31–48). Münster: LIT.

Bloom, B. S. (1984). The two sigma problem: the search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher, 13*, 4–16.

Blossfeld, H.-P., Bos, W., Hannover, B., Lenzen, D., Müller-Böling, D., Prenzel, M., et al. (2009). *Geschlechterdifferenzen im Bildungssystem: Jahresgutachten 2009* [*Gender discrepancies in education: Annual report 2009*]. Wiesbaden: VS Verl. für Sozialwissenschaften.

Bussey, K., & Bandura, A. (1999). Social cognitive theory of gender development and differentiation. *Psychological Review, 106*, 676–713.

Cheryan, S., Drury, B. J., & Vichayapai, M. (2012). Enduring influences of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly, 37*, 72–79.

Cook, J., & Smith, M. (2004). Beyond formal learning: informal community elearning. *Computers and Education, 43*(1–2), 35–47.

Culnan, M. J., & Markus, M. L. (1987). Information technologies. In F. M. Jablin, L. L. Putnam, K. H. Roberts, & L. W. Porter (Eds.), *Handbook of organizational communication: An interdisciplinary perspective* (pp. 420–443). Newbury Park, CA: Sage.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: the stereotype inoculation model. *Psychological Inquiry, 22*, 231–246.

Deaux, K., & Lafrance, M. (1998). Gender. In (4th ed.)., *The handbook of social psychology* (Vol. 1; pp. 788–827) New York: McGraw-Hill.

Deaux, K., & Lewis, L. L. (1984). Structure of gender stereotypes: interrelationships among components and gender label. *Journal of Personality and Social Psychology, 46*(5), 991–1004.

Döring, N. (2003) (2nd ed.).. *Sozialpsychologie des Internet: Die Bedeutung des Internet für Kommunikationsprozesse, Identitäten, soziale Beziehungen und Gruppen* [*Social psychology and the Internet: The meaning of the internet for communication processes, identities, social relationships, and groups*] (Vol. 2) Göttingen: Hogrefe.

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*, 157–197.

DuBois, D. L., & Karcher, M. J. (2005). *Handbook of youth mentoring*. Thousand Oaks, CA: Sage Publications.

DuBois, D. L., & Silverthorn, N. (2005). Research Methodology. In D. L. DuBois, & M. J. Karcher (Eds.), *Handbook of youth mentoring* (pp. 44–64). Thousand Oaks, CA: Sage Pubications.

Dweck, C. S. (1999). *Self-Theories: Their role in motivation, personality, and development*. Philadelphia, PA: The Psychology Press.

Dweck, C. S., & Henderson, V. L. (1988). *Theories of intelligence: Background and measures* (Unpublished manuscript).

Eagly, A. H. (1987). *Sex differences in social behavior: A social-role interpretation*. Hillsdale, NJ: Erlbaum.

Eby, L. T., Allen, T. D., Evans, S. C., Ng, T., & DuBois, D. (2008). Does mentoring matter? A multidisciplinary meta-analysis comparing mentored and nonmentored individuals. *Journal of Vocational Behavior, 72*, 254–267.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: applying the Eccles et al. model of achievement-related choices. *Psychology of Woman Quarterly, 18*, 585–609.

Eccles-Parsons, J. (1984). Sex differences in mathematics participation. In M. W. Steinkamp, & M. L. Maehr (Eds.), *Advances in motivation and achievement: Women in science* (pp. 93–137). Greenwich, CT: JAI.

Eccles, J. S., Wigfield, A., Flanagan, C. A., Miller, C., Reuman, D. A., & Yee, D. (1989). Self-concepts, domain values, and self-esteem: relations and changes at early adolescence. *Journal of Personality, 57*, 283–310.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological Bulletin, 136*(1), 103–127. http://dx.doi.org/10.1037/a0018053.

Ensher, E., Heun, C., & Blanchard, A. (2003). Online mentoring and computer-mediated communication: new directions in research. *Journal of Vocational Behavior, 63*, 264–288.

Evans, M. A., Whigham, M., & Wang, M. C. (1995). The effect of a role model project upon the attitudes of ninth-grade science students. *Journal of Research in Science Teaching, 32*, 195–204.

Friedman, A. A., Zibit, M., & Coote, M. (2004). Telementoring as a collaborative agent for change. *Journal of Technology, Learning, and Assessment, 3*(1). Retrieved from: http://www.jtla.org.

Gardner, P. L. (1985). Student's interests in sciences and technology: an international overview. In M. Lehrke, L. Hoffmann, & P. L. Gardner (Eds.), *Interests in science and technology education* (pp. 15–34). Kiel: Institut für die Paedagogik der Naturwissenschaften.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in Public Interest, 8*, 1–51.

Hoffmann, L., Lehrke, M., & Todt, E. (1985). Development and change in pupils' interest in physics (grade 5 to 10): design of a longitudinal study. In M. Lehrke, L. Hoffmann, & P. L. Gardner (Eds.), *Interests in science and technology education* (pp. 71–81). Kiel: Institut für die Pädagogik der Naturwissenschaften.

Kerr, B. (2004). Encouraging talented girls in math and science: effects of a guidance intervention. *High Ability Studies, 15*, 85–102.

Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist, 39*(10), 1123–1134.

Lipsey, M. W., & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment. *American Psychologist, 48*, 1181–1201.

Martell, R. F., Lane, D. M., & Emrich, C. (1996). Male-female differences: a computer simulation. *American Psychologist, 51*, 157–158.

Miller, H., & Griffiths, M. (2005). E-mentoring. In D. L. DuBois, & M. J. Karcher (Eds.), *Handbook of youth mentoring* (pp. 300–313). Thousand Oaks, CA: Sage.

O'Neill, D. K., Asgari, M., & Dong, Y. D. (2011). Trade-offs between perceptions of success and planned outcomes in an online mentoring program. *Mentoring & Tutoring: Partnership in Learning, 19*, 45–63.

Papastergiou, M. (2008). Are computer science and information technology still masculine fields? High school students' perceptions and career choices. *Computers and Education, 51*(2), 594–608.

Parks, M. R., & Roberts, L. D. (1998). "Making MOOsic": the development of personal relationships on line and a comparison to their off-line counterparts. *Journal of Social and Personal Relationships, 15*(4), 517–537.

Paschal, S. (2002). Intention-behavior relations: a conceptual and empirical review. *European Review of Social Psychology, 12*, 1–36.

Penny, C., & Bolt, D. (2009). eMentoring: connecting teacher candidates with k–12 students from urban schools. *International Journal of Technology in Teaching and Learning, 5*(2), 169–181.

Richards, Z., & Hewstone, M. (2001). Subtyping and subgrouping: processes for the prevention and promotion of stereotype change. *Personality and Social Psychology Review, 5*, 52–73.

Sáinz, M., & López-Sáez, M. (2010). Gender differences in computer attitudes and the choice of technology-related occupations in a sample of secondary students in Spain. *Computers and Education, 54*, 578–587.

Schimke, D., Stoeger, H., & Ziegler, A. (2009). Evaluating the use of social visualization within virtual communities. In D. Akoumianakis (Ed.), *Virtual community practices and social interactive media: Technology lifecycle and workflow analysis* (pp. 145–163). Hershey, PA: IGI Global.

Segall, R. (2000). Online shrinks: the inside story. *Psychology Today, 32*(3), 38–43.

Smith, W. S., & Erb, T. O. (1986). Effect of women science career role models on early adolescents' attitudes toward scientists and women in science. *Journal of Research in Science Teaching, 23*, 667–676.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Psychology, 35*, 4–28.

Stelle, C. M. (1997). A threat in the air: how stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613–629.

Stoeger, H. (2007). Berufskarrieren begabter Frauen [Careers of gifted women]. In K. A. Heller, & A. Ziegler (Eds.), *Begabt sein in Deutschland [Being gifted in Germany]* (pp. S. 266–290). Berlin, Germany: LIT.

Stoeger, H. (2009). E-Mentoring: Eine spezielle Form des Mentoring [E-mentoring: a special form of mentoring]. In H. Stoeger, A. Ziegler, & D. Schimke (Eds.), *Mentoring: Theoretische Hintergründe, empirische Befunde und praktische Anwendungen [Mentoring: Theoretical background, empirical results, and practical applications]* (pp. S. 227–245). Lengerich: Pabst.

Stoeger, H., Ziegler, A., Greindl, T., Heilemann, M., Neubauer, T., Reutlinger, M., et al. (Eds.). (2012). *Erfolgreich in MINT: Mentoring für Mädchen und Frauen [Succeeding in STEM: Mentoring for girls and women]*. Köln: Häuser.

Stoeger, H., Ziegler, A., & Schimke, D. (Eds.). (2009). *Mentoring: Theoretische Hintergründe, empirische Befunde und praktische Anwendungen [Mentoring: Theoretical background, empirical results, and practical applications]*. Lengerich: Pabst.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics. *Journal of Personality and Social Psychology, 100*, 255–270.

Underhill, C. M. (2006). The effectiveness of mentoring programs in corporate settings: a meta-analytical review of the literature. *Journal of Vocational Behavior, 68*, 292–307.

Walberg, H. J. (1984). Improving productivity of America's schools. *Educational Leadership, 41*(8), 19–27.

Wenzel, J. (2003). Vertraulichkeit und Anonymität im Internet. Problematik von Datensicherheit und Datenschutz mit Lösungsansätzen [Internet privacy and anonymity: the problem of data security and protection as well as solutions]. In E. Etzersdorfer, G. Fiedler, & M. Witte (Eds.), *Neue Medien und Suizidalität – Gefahren und Interventionsmöglichkeiten [New media and suicidal tendencies: Dangers and intervention options]* (pp. 56–70). Göttingen: Vandenhoeck & Ruprecht.

Ziegler, A., Schimke, D., Stoeger, H., & Merrotsy, P. (2010). Standards for field evaluations of modifications to educational settings. *Problems of Evaluation in the 21st Century, 20*(20), 156–169.