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STEM Image Videos as a Means to Increase Students' Interest and Utility Value Perception: Does Goal Congruity Matter?

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ABSTRACT

Given the increasing shortage of STEM professionals and decreasing enrolment numbers in STEM degrees, higher education institutions have been seeking ways to attract more students to STEM subjects, particularly women. In two preregistered studies (N_{Study1} = 292; N_{Study2} = 307), we tested whether STEM image videos can increase (female) students' domain-specific interest in biomedical engineering (Study 1) and geodesy (Study 2), and the perceived utility value of the respective domains. Building on Goal Congruity Theory, we further examined gender differences in participants' agentic and communal goal orientations and the effect of agentic and communal video framings on participants' interest and utility value. Both studies document a positive influence of the videos on students' domain-specific interest and utility value. Further analyses investigating gender differences showed that women reported, after watching the video, higher interest and utility value in biomedical engineering (Study 1) but lower interest in geodesy (Study 2) than men. In Study 2, no gender differences emerged in domain-specific utility value. Consistent with previous research, women valued communal goals more than men in Study 1, yet no gender differences were found regarding agentic goals in both studies. Hardly any effects of the agentic and communal framings on students' domain-specific interest and utility value were found, except for the agentic condition in Study 2, where men expressed higher interest in geodesy than women. We discuss the implications of our findings in the context of attracting students to STEM fields.

KEYWORDS

Image video; STEM; gender gap; goal congruity theory; utility value; interest

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INTRODUCTION

The transformative challenges that societies face in the context of ongoing energy and digital transition processes create a substantial demand for STEM (Science, Technology, Engineering, and Mathematics) professionals in industrialised countries (Anger et al., 2022; Xue & Larson, 2015). At the same time, Europe faces a startling shortage of STEM professionals (Cedefop, 2016). In Germany, the number of STEM study entrants in 2021 was 6.5% lower than in the previous year (Destatis, 2023a), which can only be partially explained by a general decline in student numbers. The general shortage of STEM professionals is accompanied by a persistent underrepresentation of women in these domains. With a share of 34.5%, women are still less likely to choose a STEM study programme compared to men (Destatis, 2023a). Women's share varies greatly in the heterogeneous STEM domains, with gender differences being particularly pronounced in engineering, computer science, and physics, but less so in domains like biology, chemistry, and mathematics (Cimpian et al., 2020; McGuire et al., 2022; Sax & Newhouse, 2018). According to recent European Union enrolment data (tertiary education), 26.9% of the students enrolled in the domains of engineering, manufacturing, and construction in 2021 were female. In natural science, mathematics, and statistics, the share of women was balanced with 50.9% female enrolments (Eurostat, 2024; own calculation). Similarly, in Germany, women were slightly overrepresented in the STEM domain of biology (64.2%), but clearly underrepresented in engineering science (24.5%) and traffic engineering/nautical science (13.2%) in 2021/22 (Destatis, 2023b; own calculation).

To address the drastic shortage of STEM professionals in general and reduce the gender gap in male-dominated STEM domains, it is crucial to understand the mechanisms affecting students' interest in STEM in general and female students' interest in particular. Traditional and current research can contribute insights into how students can be motivated to study STEM. Research grounded in the Expectancy Value Theory (Eccles et al., 1983) has repeatedly demonstrated that the impact of students' domain-specific interest (e.g., Kelly, 2023; Ozulku & Kloser, 2023) and the utility value students ascribe to the domain (e.g., Beier et al., 2019; Ozulku & Kloser, 2023; Wang et al., 2015) contribute to attracting (female) students to STEM. One potential way to draw students' attention to STEM domains and catalyse their interest is the use of videos in which the specific domains are introduced by STEM professionals. Experimental studies have shown that videos of male and female STEM scientists can positively affect students' interest (Pietri et al., 2021; Wyss et al., 2012). Additionally, investigating the effects of different gender gap framings in STEM recruitment interventions, Cowgill and colleagues (2021) found in several experiments that interventions were most effective when they made women feel welcome in the respective discipline and did not overemphasise women's underrepresentation. Moreover, Goal Congruity Theory (Diekman et al., 2010) asserts that personal and particular communal goals (e.g., the aim to work with and help others) must be aligned with the perception of domain-specific characteristics to develop interest (e.g., Boucher et al., 2017; Wolter et al., 2019), decide to pursue (Bonilla et al., 2023), and persist in STEM (Zander & Ertl, 2024). In their recent Belonging Uncertainty as Incongruency of

Communion and Agency Perceptions (BICAP) Process Model, Zander and Ertl (2024) highlight the importance of perceived congruency of individual skills, interests, and values with those perceived in the respective social context (instructors and peers) of the study programme.

In two preregistered studies (Traulsen & Zander, 2023a; Traulsen & Zander, 2023b), we aimed to examine the effectiveness of image videos in arousing students' interest in STEM domains using two videos featuring authentic[1] young engineering scientists. Based on the finding that women feel more welcome in the respective discipline when women's underrepresentation is not overemphasised (Cowgill et al., 2021) and research showing positive effects of female role models on female students' interest and utility value (González-Pérez et al., 2020; Shin et al., 2016), we worked with female scientists in their early research phase to produce one video each in biomedical engineering (Study 1) and geodesy (Study 2).[2]

Our first goal was to examine gender differences in participants' domain-specific interest and utility value and their agentic and communal goal orientation before watching the video. Our second goal was to scrutinise the videos' effects on participants' interest in the domains and the utility value ascribed to them. Our third goal was to investigate the effect of a communal vs. agentic framing on students' interest and perceived utility value. For this purpose, the video was shown to students, subsequent to information regarding the extent to which the domain allows and encourages communal or agentic goals and characteristics, respectively. A neutral condition was also provided. In this way, we could systematically investigate whether a certain description of a domain influences the perception of it. Results are relevant, for instance, for the targeted promotion of degree programmes in order to attract more (female) students to STEM domains and thus narrow the gender gap.

The role of interest in STEM

In educational psychology, high interest is given when a person pays attention to an object or topic which they subjectively value and perceive as useful to fulfil their personal needs (Krapp, 2002). While *individual interest* is a motivational disposition that is personality-specific and relatively stable over time, *situational interest* is not necessarily linked to individual interest and can be stimulated by contextual influences (Krapp, 2002). However, research indicates that, over time, repeatedly triggered situational interest (e.g., by an instructor) can lead to individual interest (Harackiewicz et al., 2016; Hidi & Renninger, 2006).

In STEM gender gap research, individual and situational interest play a key role because they can impact educational attitudes and behaviours (Eccles et al., 1983). According to the Expectancy Value Theory (Eccles et al., 1983), interest is one of four subjective task values of students—along with attainment value, utility value, and relative cost, which affects students' achievement-related choices, engagement, and persistence in STEM. For example, domain-specific individual interest has been found to predict students' major choice goals and STEM career decisions (Lent et al., 2005; Maltese and Tai, 2011). This has important implications as male students frequently report higher individual interest than female students in physics, chemistry, technology, engineering, mathematics, and computer science, whereas female students show higher levels of individual interest in biology (Baram-Tsabari & Yarden, 2008; Frenzel et al., 2010; Jansen et al., 2019; Master et al., 2021; Tellhed et al., 2016; Weber, 2012). Yet, findings are not entirely consistent. For instance, Holstermann and colleagues (2012) found no gender differences in individual biology interest in general and suggested examining gender differences at the topic level.

The stable discrepancy in male and female students' individual STEM interest has spurred the search for psychological explanations. Persistent gender stereotypes regarding men's and women's differential capability to perform well in STEM have been identified as important causes. For instance, Garriott and colleagues (2017) found that STEM stereotypes predicted students' mathematics and science self-efficacy, which, in turn, affected students' mathematics and science interest. Cheryan and colleagues (2009) provided indirect evidence for the effects of stereotypes by showing that women's sense of belonging to and consequently their situational interest in computer science can be improved by creating a non-stereotypically masculine learning environment (e.g., nature poster instead of a Star Trek poster). These results highlight that the stereotype-sensitive representation of a domain can influence personal states like situational interest.

Another means of shaping the representation of STEM domains are image videos. While many studies have examined the influence of specific videos (e.g., expert interviews) on STEM perceptions (Hennes et al., 2018; Moss-Racusin et al., 2018; Pietri et al., 2017; Rosenthal, 2018), only a few have explored the effects of videos on domain-specific interest. Wyss and colleagues (2012) found that a sequence of eight videos featuring female and male STEM scientists increased middle school students' career interest in STEM, though a systematic differentiation of various STEM domains was not given in this study. Pietri and colleagues (2021) used videos of a female Black computer scientist as a role model to study the influence on students' situational computer science interest. However, their focus was the underrepresentation of Black women in STEM, which is why their sample consisted solely of Black women. Nevertheless, both studies document that videos can increase students' situational interest in engaging in STEM.

The importance of utility value in STEM

Another important concept in the investigation of the general shortage in STEM and explanations of gender differences in STEM is the utility value that students associate with a given STEM domain. These can be described as the subjective worth of an activity or subject, driven by its contribution to a person's short- or long-term goals (e.g., a specific career; Eccles, 1983). Similar to interest in the sense of Expectancy Value Theory (Eccles et al., 1983), utility value is part of students' subjective task values and therefore theoretically predictive of students' educational decisions, commitment, and perseverance.

Although utility value has not been consistently found to be connected to individual and situational interest, many studies document the positive correlation between both constructs (Hulleman et al., 2008; Simpkins et al., 2006). Perceiving the value of skills in a particular domain affects learning outcomes, motivation as well as educational and career decisions (Beier et al., 2019; Durik et al., 2015; Wegemer & Eccles, 2019). Moreover, enhancing a person's perception of STEM utility (e.g., through a reflective writing task) can increase situational interest in, higher utility valuation of, and higher intentions to engage in STEM (Curry et al., 2020; Shin et al., 2019).

Results of research investigating gender differences in STEM-related utility value are inconsistent. While some studies document that boys attribute higher utility value to mathematics and mathematics-related domains than girls (Eccles et al., 1998; Updegraff et al., 1996; Wang et al., 2015; Watt et al., 2019), others did not. For example, Simpkins and colleagues (2006) found no differences in the utility assessment of boys and girls in science and mathematics. Aschbacher and colleagues (2014) found that students who valued the importance and usefulness of science had greater individual interest in STE-M (M = Medicine) careers—irrespective of their gender. Given these results, it seems nonetheless important to consider perceived utility value in the examination of students' interest in different STEM domains.

From our perspective, there have been no studies to date that systematically investigated how and under what conditions videos can impact STEM-related utility value. However, based on the repeatedly demonstrated connections between interest and utility value (Hulleman et al., 2008; Simpkins et al., 2006), it can be assumed that domain-specific utility value can also be influenced by videos that provide insights and objectives of STEM domains.

Different STEM domains lead to different images

A powerful explanation for the lack of (women's) interest in STEM fields is the image associated with each domain. Even if STEM domains are mostly based on communal ideals (e.g., helping others), they are usually linked to and perceived as having agentic characteristics (e.g., working alone; Brown, Smith et al., 2015). Based on a literature review, Cheryan and colleagues (2017) argued that the "masculine culture" of STEM, defined as "a social and structural environment that confers a greater sense of belonging and ability to succeed to men than women" (p. 8), differs between subjects. For instance, fields like computer science, engineering, and physics are seen as more stereotypically male than biology, chemistry, and mathematics (Cheryan et al., 2015; Degner et al., 2019). Moreover, Joshi and colleagues (2022) conducted domain-specific analyses and found that subjects like engineering/physical science offered, in fact, fewer communal work opportunities (e.g., collaborative assignments) and emphasised agentic aspects more strongly compared to earth science/biology, where agentic and communal characteristics were more balanced.

Cheryan and colleagues (2017) differentiate three superordinate STEM stereotypes: The first relates to whether the content of work is primarily people- or thing-orientated, the second refers to the attainment of goals like power and status through work, and the third applies to innate talents and brilliance required for success. At the subject level, Cheryan and colleagues (2017) refer to research that has shown that (1) meeting people-orientated goals seems to be best afforded in biology and least in mathematics, while engineering and computer science lie in between (Masnick et al., 2010; Matskewich & Cheryan, 2016; Weisgram & Bigler, 2006), (2) achieving career goals like power and status appears to be more feasible in engineering and computer science than in mathematics, while biology is located in between (Matskewich & Cheryan, 2016), and (3) success in engineering, computer science, and physics seems to require more innate talent compared to biology and chemistry (Leslie et al., 2015).

Consequences of (in)congruences between the self and STEM domains

Based on the Self-to-Prototype Matching Theory (Niedenthal et al., 1985), researchers argue that stereotypes and prototypes, which can largely be used synonymously (Hannover & Kessels, 2002), influence individual educational choices. They assume that individuals who have to decide between different options (e.g., study programme or vocational career), choose the option that promises the best fit between their imagined prototypes (e.g., about the typical student of a study programme) and their own self-views (Hannover & Kessels, 2004). Concerning STEM, several studies showed that students' discrepancy between their STEM prototypes and their self-views can relate to less interest in STEM pathways (McPherson et al., 2018; Ryan, 2014) and less value beliefs about STEM (Starr & Leaper, 2019). Following this, STEM fields that are strongly masculine stereotyped (e.g., due to its seeming thing-orientation) and/or characterised (e.g., due to the numerical representation of male students) could be perceived as less interesting and valuable by people who do not perceive themselves as masculine. Complementing this reasoning, Diekman and colleagues (2010) proposed within Goal Congruity Theory that individuals turn to a STEM domain when they perceive this domain as likely to fulfil their own goals. The Goal Congruity Theory builds on Bakan's (1966) distinction between agency (related to dominance, status, and power) and communion (related to social caring, cooperation, and the need for harmonious relationships) as fundamental dimensions of human personality (Abele & Wojciszke, 2014; Bakan, 1966).

Similarly, Zander and Ertl (2024) provide a theoretical framework for understanding how incongruency of perceived skills, interests, and goals contribute to female students' perceptions of belonging uncertainty in STEM domains (Belonging Uncertainty as Incongruency of Communion and Agency Perceptions, BICAP model). Building on previous analyses and findings by Schmader and Sedikides (2018) as well as Höhne and Zander (2019), and partially against the background of Goal Congruity Theory (Diekman et al., 2010), they argue that contextual cues signalling social hierarchies will cause students to scrutinise the congruency in skills, goals, and interests between themselves and their social environment along the dimensions of agency and communion. High levels of assessed incongruency between own characteristics and those perceived in the respective context are proposed to result in perceptions of belonging uncertainty, which, in turn, can trigger behaviour and cognitions resulting in avoidance and disengagement or approach and engagement.

A lot of research focusing on gender differences in agentic and communal goal orientations showed strong differences favouring women in communal goals (Diekman et al., 2011; Lippa, 1998; Morgan et al., 2001; Pöhlmann, 2001; Tellhed et al., 2018). Concerning agentic goal orientations, some studies found gender differences favouring men compared to women (Lippa, 1998; Morgan et al., 2001), while others demonstrated less distinct findings (Diekman et al., 2011; Tellhed et al., 2018). For example, Tellhed and colleagues (2018) could not demonstrate any gender differences in agentic goal orientation using the measurement by Diekman and colleagues (2011). By applying an ipsative goal choice scale which asked to decide between an agentic and a communal career, they showed that boys chose agentic careers more than girls, while the opposite was the case for communal careers. Joshi and colleagues (2022) found no gender differences in agentic and communal goal foci among STEM students. Folberg and colleagues (2020) argued that inconsistent findings originate through different components of agentic goals, with women having weaker *agentic dominance goals* than men, but no gender differences occurred for *global* or *self-directed agentic goals*. They also found that women had higher communal goals compared to men and stated that communal goal orientation is single-factorial. Knekta and colleagues (2019) also exposed different factors of agentic, but additionally of communal goals. They proposed a subdivision into *prestige*, *autonomy*, and *competency* for the agency scale, and *service* and *connection* for the communal scale.

Following the Goal Congruity Theory (Diekman et al., 2010), many STEM domains are seen as preventing the achievement of communal goals, leading people with strong communal goals to lose their interest and subjective values (e.g., utility value) attached to these STEM domains (Diekman et al., 2010; Diekman et al., 2011; Diekman & Steinberg, 2013). In a longitudinal study, Stout and colleagues (2016) found that the numerical underrepresentation of women in pSTEM courses (pS = physical science) compared to men dissolved when women perceived high communal goal affordances in pSTEM. Analogously, men's underrepresentation in behavioural science courses dissolved when they recognized strong agentic goal opportunities (Stout et al., 2016). Henderson and colleagues (2022) conducted a longitudinal study focusing on U.S. college women's persistence and demonstrated that college women who perceived opportunities for both communal and agentic goals in STEM were more inclined to persist in STEM fields. They also showed that women's higher perceptions of agentic, but not communal, goal affordances in STEM reduced the loss of interest over time (Henderson et al., 2022). A meta-analysis reported gender differences in individual vocational interest, with higher levels for men compared to women in engineering, science, and mathematics (Su et al., 2009). Also, there was evidence for gender differences on the people-things-dimension with women showing a higher preference to work with people and men a higher preference to work with things. Other studies have highlighted the importance of other communal aspects for women's individual study interest, for example, belonging (Veldman et al., 2021) and group support (Robnett & Leaper, 2013). Somewhat contradictory, Brown, Thoman, and colleagues (2015) and Boucher and colleagues (2017) provided support for the communal affordance hypothesis indicating that regardless of gender, individuals develop greater STEM motivation and interest when they have stronger communal affordance beliefs about STEM. The authors stressed the importance of highlighting communal opportunities in general when designing interventions to promote STEM interest.

Given the robust evidence for women's stronger focus on communal goals compared to men (Diekman et al., 2011; Pöhlmann, 2001; Su et al., 2009; Tellhed et al., 2018), it seems nonetheless plausible that women develop a greater interest in STEM domains when communal (versus agentic and neutral) aspects and goals are emphasised (Diekman et al., 2015). Analogously, agentic STEM descriptions highlighting personal achievement and status as well as a strong task orientation should be somewhat more likely to appeal men compared to communal and neutral descriptions, even if evidence for gender differences in agentic goal orientations was in the past inconsistent (Diekman et al., 2011; Tellhed et al., 2018). This can be assumed because research demonstrated repeatedly that men tend to have stronger agentic characteristics than women (Hsu et al., 2021; Rucker et al., 2018) and that individual traits lead to personal goals (Reisz et al., 2013). Furthermore, studies demonstrated that men as compared to women are more interested in agentic-related goals like vocational advancement (Betz et al., 1989), task orientation (Anderson & Blanchard, 1982), and pragmatic and egocentric negotiation (Kray & Haselhuhn, 2012).

Regarding domain-specific STEM utility value, to our knowledge, there are no studies that systematically prove its relationship to agentic and/or communal goals. However, due to the multiple shown relations between utility value and interest (Curry et al., 2020; Hulleman et al., 2008; Shin et al., 2019; Simpkins et al., 2006), similar effects as for interest can be expected. This is for example supported by Diekman and colleagues (2015) who argue that the clearness of how others benefit from STEM domain activities can positively influence values such as importance and utility value, especially for people with pronounced communal goals.

Several experimental studies investigating the influences of agentic and communal STEM framings on student attitudes support these predictions—directly regarding students' interest and indirectly regarding students' utility value. For example, based on the Self-to-Prototype Theory, Neuhaus and Borowski (2018) demonstrated that middle school girls were more interested in participating in a coding course when a framing (course title, course goals, and a picture) highlighted communal goals, while boys were more interested in the course when it was combined with an agentic framing. Diekman and colleagues (2011) found that a written collaborative (versus an independent) scenario of a typical workday in STEM resulted in a higher positivity toward science careers among women and those with strong communal goals, while both conditions had no effect on men's attitudes. Brown and colleagues (2017) replicated this study with U.S. and Asian college students showing that men generally expressed more interest in science careers than women, but gender did not interact with the framing in this study.

Overview of the present research

The primary purpose of our research was to examine whether image videos portraying young female STEM scientists can catalyse (female) students' situational interest in STEM domains and the utility value ascribed to them. We further aimed to systematically explore the potential effect of video framings grounded in the predictions of Goal Congruity Theory (Diekman et al., 2010). Specifically, we expected that female students' interest and utility value would be increased when the domain was described as affording communal compared to agentic or no specific characteristics and goals and that the agentic framing would heighten male students' interest and utility value in comparison to the communal or neutral framing. In addition to our hypotheses recorded in the preregistrations, we expected that students' utility value would mediate the effect between the framing and students' interest, while the framing would interact with students' gender.

Furthermore, we expected female students to report higher communal career goals than male students and that male students would state higher agentic career goals than female students in the pretest. To consider potential confounding variables and interactions, we also assessed students' prior knowledge as well as their current field of study in both studies.

To identify potential variations of distinct STEM domains, we selected two engineering domains. As a seemingly more female and communal connoted domain compared to other STEM domains and because of its interdisciplinary character, we chose biomedical engineering (Study 1) which develops technologies that promote human health and healing. The field combines engineering work in the laboratory with biological and medical components aimed at developing advances in medical technology. As a seemingly more male and agentic connoted domain, we chose geodesy. This subject is characterised by technical capabilities (e.g., certain measurement techniques) that can be used to get accurate spatial data about the earth and understand the earth's geometric shape, its orientation in space, and its gravitational field (National Ocean Service, 2023).

Both videos portray a young female scientist at her workplace explaining her current research project. In the biomedical engineering video (DIG1T Studio, 2024a; Study 1), the researcher demonstrates in a laboratory how vascular prostheses for humans can be produced from pig blood. The researcher also explains how these blood prostheses can be used in medicine (e.g., to prevent vein thrombosis or replace damaged vessels) and what future research steps need to be taken to realise their use in practice. In the geodesy video (DIGT1T Studio, 2024b; Study 2), the researcher presents various methods (e.g., optical levelling) for measuring urban objects. Then, the function of a real-time kinematic system is explained and used to determine the height of a building. In the end, the researcher explains that precise measurements like these are essential to improve digital navigation systems.

STUDY 1: BIOMEDICAL ENGINEERING

METHODS

Statistical power considerations

The sample size was calculated with different a priori power analyses (G*Power 3.1.9.7; Faul et al., 2007) for each statistical test. Considering the reviewed literature, we chose medium effect sizes for the calculation, indicated a statistical power of 95%, and an alpha level of $\alpha = .05$. The exact values of the calculations are shown in our preregistration (Traulsen & Zander, 2023a). Anticipating students' dropout, we decided to survey at least 10% more participants.

Sample of analyses

Overall, 305 students participated in the study. Thirteen students were excluded from the analyses due to various reasons (e.g., identified as outliers or no student status). Among these thirteen students, three students stated their gender as diverse and two chose the answer "not specified". As these groups were too small to compare them with male and female students, they could not be included in the analyses. Consequently, the total sample comprised 292 students with an average age of 24.57 years ($SD = 4.37$). The gender distribution of the sample was almost balanced with 54.1% female and 45.9% male participants. The majority of the students (66.8%) were located in Germany, 28.4% in other countries of the European Union (e.g., Austria), and 4.8% stated countries which do not belong to the European Union (e.g., Switzerland) as their place of residence.

Data collection took place via Prolific (www.prolific.com) in 2023. Students from all disciplines were invited to take part in the study. The only requirement was that the students had to be fluent in German. Therefore, the academic levels (e.g., Bachelor and Master) and study programmes were very heterogeneous with computer science (12.6%) and psychology (7.8%) as the most frequent study programmes. Participants' fields of study were categorised into STEM-related ($n = 129$) and non-STEM-related ($n = 193$) subjects.

Study design and data collection

At the beginning of the study, a pretest was conducted to assess students' agentic and communal goal orientation as well as their interest in biomedical engineering and the perceived utility value of the respective domain. After completing the pretest, students edited a short writing task regarding their knowledge of biomedical engineering which served the purpose of not directly associating the content of the previously completed items with the following treatment. Then, students were randomly assigned to one of three conditions in which they watched a video (approx. 3 minutes) about a female biomedical engineering researcher. The conditions differed in terms of the framing (agentic, communal, and neutral), provided as a written introduction directly before the video. The entire framing material can be found in Appendix A. The neutral framing (96 words) provided general instructions, while the agentic framing (174 words) included additional information about biomedical engineering that underscored the importance of agentic characteristics (e.g., independent work and assertiveness) and goals (e.g., achieving excellent performance and thereby finding solutions to particularly challenging problems). In the communal framing (175 words), participants received information emphasising communal characteristics (e.g., collaborative work and connection to the research community) and goals (e.g., helping other people and thereby supporting them in certain areas of life). In the posttest, the focal variables, along with a manipulation check and collecting sociodemographic characteristics were assessed.

The experiment was conducted with the survey programme LimeSurvey (www.limesurvey.org) in German language. Participation was voluntary, anonymous, and paid with £1.65.

Measures
All measurements had the form of a 5-point Likert scale with response options from 1 = *strongly disagree* to 5 = *strongly agree.*

Agentic and communal career goal orientation (pretest)
To capture students' career goal orientation, items of the Goal Endorsement Scales provided by Diekman and colleagues (2011) were used. We selected eight items from the agentic goal scale (e.g., "It is important to me to be very successful in my future career"; α = .76) and seven items from the communal goal scale (e.g., "It is important to me to help others in my future career"; α = .85). Diekman and colleagues (2011) found the Goal Endorsement Scale to be two-factorial (agentic and communal factor), while other researchers (Folberg et al., 2020; Knekta et al., 2019) identified deeper-level factor structures within the agentic and the communal goal scale (see section Consequences of (in)congruences between the self and STEM domains). For a precise examination of the structure of the used agentic and the communal goal scale constructs, we conducted exploratory factor analyses. Following this, the agentic goal scale consists of a dominance and a self-directed factor, and the communal goal scale of a service and a connection factor.

Domain-specific prior knowledge (pretest)
Domain-specific prior knowledge was ascertained with one self-developed item ("I already know a lot about biomedical engineering").

Domain-specific interest (pre- and posttest)
For the assessment of students' domain-specific interest, we adapted two items (e.g., "I am interested in the research field of biomedical engineering"; α_{pre} = .87, α_{post} = .85) by Jansen and colleagues (2019).

Domain-specific utility value (pre- and posttest)
The domain-specific utility value was measured with three adapted items of the subscale *task value* (e.g., "The examination of topics in biomedical engineering seems useful for me"; α_{pre} = .77, α_{post} = .79) of the *Motivation in Science Learning* scale by Velayutham and colleagues (2011).

Manipulation checks
After completion of the questionnaire, we performed two manipulation checks. Firstly, we inquired if participants could guess the study's purpose, and secondly, participants of the agentic and communal framing were asked if they remembered the content of the pre-video text. No participant guessed the concern of the study correctly, but some participants were not able to answer the second question correctly. To take this into account in our analyses, we coded participants' responses with the following system: 1 = *no memory* (*n* = 42), 2 = *description of unrelated content* (*n* = 53), 3 = *description of related content of the framing but incorrect answer to question* (*n* = 21), and 4 = *correct answer* (*n* = 76).

Data analyses
Data analyses were conducted using SPSS Statistics (Version 28). The statistical tests are reported in the section Results. All means and standard deviations can be seen in Table 1.

Table 1
Means and standard deviations of the measures in Study 1

Measure	Total (*N*=292)	Male (*n*=134)			Female (*n*=158)		
		Total	STEM (*n*=83)	Non-STEM (*n*=51)	Total	STEM (*n*=46)	Non-STEM (*n*=112)
Agentic goal orientation	3.78 (0.59)	3.81 (0.58)	3.81 (0.56)	3,84 (0.62)	3.75 (0.61)	3.64 (0.61)	3.81 (0.59)
Communal goal orientation	3.87 (0.67)	3.75 (0.68)	3.78 (0.67)	3.71 (0.71)	3.96 (0.66)	3.86 (0.61)	4.01 (0.67)
Interest (pretest)	2.85 (1.09)	2.84 (1.06)	3.02 (1.07)	2.55 (1.01)	2.86 (1.12)	3.37 (1.05)	2.66 (1.08)
Utility value (pretest)	3.62 (0.81)	3.59 (0.86)	3.72 (0.81)	3.41 (0.92)	3.64 (0.76)	3.89 (0.69)	3.52 (0.76)
Prior knowledge	2.03 (1.06)	2.11 (1.04)	2.28 (1.12)	1.84 (.86)	1.96 (1.08)	2.76 (1.23)	1.63 (0.82)
Interest (posttest)	3.52 (1.01)	3.43 (0.98)	3.58 (0.98)	3.17 (0.94)	3.61 (1.02)	4.04 (0.78)	3.42 (1.06)
Utility value (posttest)	4.19 (.76)	4.09 (0.82)	4.13 (0.76)	4.03 (0.93)	4.29 (0.69)	4.43 (0.63)	4.23 (0.71)

Note. Standard deviations are indicated in parentheses after the mean values.

RESULTS
To test the general effect of the video on the variables interest and utility value, we conducted one independent paired samples *t*-test each to compare the pretest and posttest measures. Both students' interest, $t(291) = 12.39$, $p < .001$, $d = 0.725$,

and students' utility value, $t(291) = 14.51$, $p < .001$, $d = 0.849$, were significantly higher after watching the video than before.

The analyses of the assumed gender differences in the pretest revealed no differences regarding agentic goal orientation, $t(290) = -0.899$, $p = .369$, students' interest, $t(290) = 0.160$, $p = .873$, and students' utility value, $t(290) = .347$, $p = .694$, but a significant gender difference with higher values for women than for men was shown regarding students' communal career orientation, $t(290) = 2.676$, $p = .008$, $d = 0.314$. Exploratory comparisons of students' different study backgrounds showed that the difference only emerged among non-STEM students, $t(161) = 2.595$, $p = .010$, $d = 0.438$, and not among STEM students, $t(127) = 0.632$, $p = .534$. Further analyses of this difference within the non-STEM group showed that this finding was mainly driven by the factor of service, $t(161) = 2.263$, $p = .025$, $d = 0.382$, and not by the factor of connection, t(161) = 1.305, $p = .194$.

The conducted two-way ANCOVA (2 (gender) x 3 (framing)) with prior knowledge as the covariate and interest as the dependent variable showed a significant relation of the covariate, $F(1, 285) = 61.934$, $p < .001$, $\eta^2_p = 0.179$, and a significant main effect of participants' gender, $F(1, 285) = 4.456$, $p = .036$, $\eta^2_p = 0.015$. Post hoc testing using Bonferroni correction indicated that interest was higher for female students in comparison to male students across all video framing groups ($p = .036$). No main effects were observed for the framing, $F(2, 285) = 0.289$, $p = .751$, or an interaction between participants' gender and the framing, $F(2, 285) = 0.057$, $p = .945$.

Variations in utility value were examined with the identical 2 x 3 procedure. The analysis showed significant associations of the covariate, $F(1, 285) = 6.445$, $p = .012$, $\eta^2_p = 0.022$, and participants' gender, $F(1, 285) = 5.607$, $p = .019$, $\eta^2_p = .019$. Post hoc testing using Bonferroni correction showed that male students reported a lower utility value score than female students ($p = 0.19$). There was no main effect of the video framing, $F(2, 285) = 0.372$, $p = .690$, nor a significant interaction between participants' gender and the video framing, $F(2, 285) = 0.063$, $p = .939$.

The pattern of the results of both ANCOVAs was robust after adding the subject of study (STEM/non-STEM) as another covariate and when only including participants with a manipulation check code > 2 (2 = *description of unrelated content*, 1 = *no memory*) in the calculations (see Appendix C).

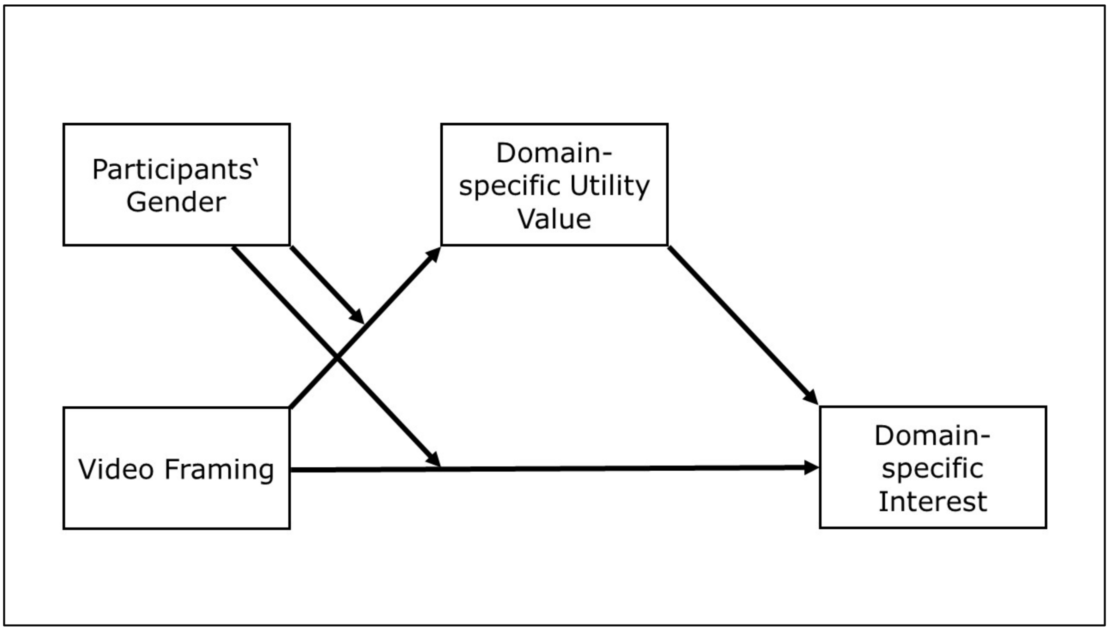
Explorative analyses

Exploratory factor analyses: Students' agentic and communal goal orientation

A principal component analysis (PCA) was performed following Field (2020) for both the eight agentic and the seven communal items. The Kaiser-Meyer-Olkin measure confirmed the sample appropriateness for further analyses, $KMO_{agentic} = .782$; $KMO_{communal} = .825$. All KMO values for individual agentic items were > .74, and for individual communal items > .69, which is both more than acceptable (Field, 2020). Bartlett's test of sphericity for agentic items, χ^2 (28) = 565.347, p < .001, and for communal items, χ^2 (21) = 928.411, p < .001, showed that correlations among items were large enough for the PCA. Two initial analyses were conducted. Regarding the agentic items, two components had eigenvalues above Kaiser's criterion of 1 and explained together 55.46% of the variance. Concerning the communal items, two components had eigenvalues over 1, they explained in sum 70.16%. Given further analyses of the scree plots and Kaiser's criterion, two components for agency and communion each are apparent. All factor loadings after varimax rotation are shown in Appendix B. The items which loaded on the same components propose in line with Folberg and colleagues (2020) a *dominance/ competence* and a *self-directed* dimension of agentic goal orientation, and in line with Knekza and colleagues (2019) a *serving* and *connection* dimension for communal goals. We created all factors as new variables using the Anderson-Rubin method in order to maximize validity (DiStefano et al., 2009) and to conduct further exploratory analyses regarding the different factors.

Moderated mediation analyses
We used PROCESS v4.2 by Hayes (2022) with bias-corrected bootstrapping with 5,000 iterations (95%-*CI*) for the analysis of the moderated mediation effect of the framing (independent variable) on students' interest (dependent variable) through students' utility value (mediator) with gender as a moderator of the a- and the c'-path (model 8 in the PROCESS macro; see Figure 1). There was no significant interaction between the framing and participants' gender for the a-path, b = -0.015, p = .895, but a significant b-path from utility value to students' interest, b = 0.664, $p < .001$. Also, the c'-path was not moderated by a significant interaction of gender and the framing, b = 0.48, p = .669. The index of the moderated mediation was not significant, b = -0.013, 95% percentile *CI* [-.181, .152]. Thus, there was no evidence for a moderated mediation. All results were controlled for prior knowledge.

Figure 1
Moderated mediation model



Note. Model 8 in the PROCESS macro by Hayes (2022) was used.

STUDY 2: GEODESY

METHODS
The analytical procedure was identical for Study 1 and Study 2. The treatment video, however, targeted the domain of geodesy. Instructional framing and all assessed variables were also identical, except that we replaced *biomedical engineering* with *geodesy*.

Sample of analyses

Three hundred and thirteen students participated in the survey. Six participants were excluded for various reasons (e.g., identified as outliers). Among these six students, only two students stated their gender as diverse so that a separate analysis of this group was not feasible. The final sample consisted of 307 students with an average age of 25.19 years (*SD* = 5.28). Fifty-seven percent of the participants were female and 43% male. The majority of the students (67.4%) were located in Germany, 26.7% lived in other countries of the European Union, and 5.9% stated their country of residence as not belonging to the European Union. The most common study programmes were psychology (10.4%) and computer science (8.8%). We coded students as STEM-related (*n* = 119) or non-STEM-related (*n* = 188) to be able to account for their study programme in the analyses.

Data collection was conducted via Prolific (www.prolific.com) ensuring that participants could not participate in both experiments.

Measures

As in Study 1, reliabilities for all measures were moderate to good: $\alpha_{agentic}$ = .76, $\alpha_{communal}$ = .84, $\alpha_{pre\text{-}interest}$ = .85, $\alpha_{pre\text{-}value}$ = .73, $\alpha_{post\text{-}interest}$ = .89, and $\alpha_{post\text{-}value}$ = .74.

Manipulation checks

As in Study 1, no participant guessed the study purpose correctly (manipulation check 1). However, some participants in the agentic and communal framing conditions were not able to answer the second manipulation check question properly. We coded their answers as in Study 1: 1 = *no memory* (*n* = 54), 2 = *description of unrelated content* (*n* = 47), 3 = *description of related content of the framing but incorrect answer to question* (*n* = 38), and 4 = *correct answer* (*n* = 63).

Data analyses

As in Study 1, all analyses were conducted using SPSS Statistics (Version 28) and statistical tests are reported in the section Results. All means and standard deviations are depicted in Table 2.

Table 2
Means and standard deviations of the measures in Study 2

Measure	Total (*N*=307)	Male (*n*=132)			Female (*n*=175)		
		Total	STEM (*n*=72)	Non-STEM (*n*=60)	Total	STEM (*n*=47)	Non-STEM (*n*=128)
Agentic goal orientation	3.79 (0.58)	3.82 (0.61)	3.84 (0.59)	3.81 (0.61)	3.77 (0.56)	3.69 (0.61)	3.79 (0.55)
Communal goal orientation	3.93 (0.66)	3.87 (0.71)	3.88 (0.74)	3.86 (0.68)	3.97 (0.62)	3.98 (0.61)	3.97 (0.63)
Interest (pretest)	2.48 (1.01)	2.64 (1.03)	2.65 (1.09)	2.63 (0.96)	2.37 (0.98)	2.64 (0.91)	2.27 (0.98)
Utility value (pretest)	3.15 (0.82)	3.18 (0.84)	3.12 (0.95)	3.26 (0.69)	3.13 (0.81)	3.01 (0.88)	3.17 (0.78)
Prior knowledge	1.85 (1.08)	2.07 (1.14)	2.13 (1.21)	1.98 (1.06)	1.69 (1.01)	2.06 (1.24)	1.56 (.88)
Interest (posttest)	3.14 (1.08)	3.41 (0.97)	3.46 (0.97)	3.34 (0.96)	2.95 (1.12)	3.29 (1.03)	2.83 (1.14)
Utility value (posttest)	3.68 (0.82)	3.73 (0.76)	3.63 (0.82)	3.85 (0.66)	3.64 (0.86)	3.67 (0.95)	3.63 (0.95)

Note. Standard deviations are indicated in parentheses after the mean values.

RESULTS

We performed independent *t*-tests for paired samples to compare pre- and posttest measures to investigate the general effects of the video. Both students' interest, $t(306) = 10.56$, $p < .001$, $d = 0.603$, and students' utility value, $t(306) = 10.515$, $p < .001$, $d = 0.601$, were significantly higher after watching the video than before.

No differences between female and male students in the pretest with regard to agentic goal orientation, $t(305) = -0.805$, $p = .421$, communal goal orientation, $t(305) = 1.308$, $p = .192$, and students' utility value, $t(305) = -0.563$, $p = .287$, were found. A significant gender difference in students' interest with higher values for male students than for female students occurred, $t(305) = -2.323$, $p = .021$, $d = -0.268$. Exploratory comparisons of students' study backgrounds showed the difference only among non-STEM students, $t(186) = -2.324$, $p = .021$, $d = -0.364$, and not among STEM students, $t(117) = -0.039$, $p = .969$.

A 2 (gender) x 3 (framing) ANOCVA with prior knowledge as covariate and interest as dependent variable showed a significant association of the covariate, $F(1, 300) = 31.197$, $p < .001$, $\eta^2_p = 0.094$, and a significant main effect of participants' gender, $F(1, 300) = 8.225$, $p = .004$, $\eta^2_p = 0.027$. Post hoc testing with Bonferroni correction showed that interest was higher for male students than among female students (p = .004). There was no main effect of the framing, $F(2, 300) = 0.957$, p = .385, and no interaction between participants' gender and the framing, $F(2, 300)$ = 0.524, p = .593. Pairwise comparisons with Bonferroni correction showed a significant gender difference favouring men compared to women in the agentic framing condition (p = .030), but not in the neutral (p = .054) or communal (p = .383) framing indicating that men reported higher interest in geodesy after watching the video in which scientific work in the field was described as requiring independent work and assertiveness.

The 2 x 3 ANCOVA with prior knowledge as the covariate and utility value as the dependent variable indicated no significant effect of the covariate, $F(1, 300)$ = 2.953, p = .087, no significant main effects of participants' gender, $F(1, 300)$ = .387, p = .535, and the framing, $F(2, 300) = 0.050$, p = .951. Furthermore, there was no interaction between participants gender and the framing, $F(2, 300)$ = 0.677, p = .509.

The pattern of results of both ANCOVAs was replicated when the subject of study (STEM/non-STEM) was added as another covariate. Even when only participants with a manipulation check code > 2 (2 = *description of unrelated content*, 1 = *no memory*) were included, results were similar, although the difference between the interest of men and women in the agentic framing condition did no longer reach the level of statistical significance given the smaller sample size (p = .055). The results of the additionally conducted ANCOVAs are provided in Appendix D.

Explorative analyses

Exploratory factor analyses: Students' agentic and communal goal orientation

A PCA was conducted for the agentic and the communal items. The KMO measure verified the sample suitability for further analyses, $KMO_{agentic}$ = .782; $KMO_{communal}$ = .819. All KMO values for individual agentic items were > .73, and for individual communal items > .71, which is both good (Field, 2020). Bartlett's test of sphericity for agentic items, χ^2 (28) = 562.408 p < .001, and for communal items, χ^2 (21) = 872.874, p < .001, indicated that the correlations between items were large enough to conduct a PCA. Two initial analyses were performed. Regarding the agentic items, two components had eigenvalues above Kaiser's criterion of 1 and explained together 53.54% of the variance. Concerning the communal items, two components had eigenvalues over 1, they explained in sum 68.19%. Given further analyses of the scree plots and Kaiser's criterion, two components for agency and communion each are identifiable. All factor loadings after varimax rotation are shown in Appendix B. The loaded items indicate the same factor pattern for agentic (*dominance/competence* and *self-directed*) and communal goals (*service* and *connection*) as in Study 1. New variables were created following the Anderson-Rubin method.

Moderated mediation analyses

For the moderated mediation analysis, we used the same analytical procedure as in Study 1 (see Figure 1). Again, there was no significant interaction between the framing and participants' gender for the a-path, b = 0.130, p = .253, but a significant b-path from utility value to students' interest, b = 0.767, p < .001. Also, the c'-path was not moderated by a significant interaction of gender and the framing, b = 0.009, p = .935. The index of the moderated mediation was not significant, b = -0.099, 95% percentile *CI* [-.074, .266]. There was no indication for a moderated mediation in the data. All results were controlled for prior knowledge.

DISCUSSION

Primary goal of the two presented studies was to examine the potential use of STEM image videos as a means to increase (female) students' domain-specific interest and utility value in two STEM domains: the more female and communal connoted domain of biomedical engineering (Study 1) and the more male and agentic connoted domain of geodesy (Study 2). Both studies demonstrate the beneficial role of the videos: Irrespective of the portrayed domain as well as students' gender and study major, participants perceived the STEM field as more interesting and useful after watching the video. Another goal was to investigate whether an agentic vs. communal framing could affect students' interest and utility value based on the theoretical framework of Goal Congruity Theory (Diekman et al., 2010). Our analyses indicated that describing the domain as either affording agentic goals (importance of independent work and assertiveness) or communal goals (importance of collaborative work and connection to the research community) did not have a main effect on participants' domain-specific interest and utility value per se. In addition, there were no interaction effects of the framing and participants' gender. Yet, through pairwise comparisons, we found that female participants reported lower interest than male participants in the more male-connoted domain of geodesy (Study 2) when the domain was portrayed as agentic. Although this finding certainly requires replication, it further substantiates the idea that a specific affordance perception of a STEM field can affect men's and women's interest in, and, ultimately, their decision to enrol in a study programme (Diekman et al., 2010).

Our study further strengthened and extended the body of existing empirical findings regarding gender and domain-specific differences. Importantly, in Study 1, women displayed higher post-interest than men across all conditions, whereas in Study 2, men had higher pre- and post-interest than women across all conditions. In addition, we found that women rated the utility value of biomedical engineering in the posttest higher than men (Study 1), while we did not find any gender differences for geodesy (Study 2). In illustrating what could be described as a gender-stereotypic preparedness with female participants being more responsive to information about more female-connoted and male participants being more responsive to information about male-connoted STEM domains, this substantiates the need for a domain-specific STEM research. Furthermore, our findings converge with previous research indicating that women tend to favour STEM fields featuring elements of biology, while men prefer domains in which technical elements are predominant (Baram-Tsabari & Yarden, 2008; Frenzel et al., 2010; Jansen et al., 2019; Master et al., 2021; Tellhed et al., 2016; Weber, 2012), which could also explain the gender differences found in the utility value of biomedical engineering after watching the video. The reason why we found gender differences in the pre-test in Study 2 (geodesy), but not in Study 1 (biomedical engineering), cannot be explained unambiguosly. However, in line with the presented findings of previous research on gender differences in STEM interest, it could be argued that biomedical engineering appeals—due to its interdisciplinary composition consisting of biological, medical, and technical components—to people of all genders, whereas geodesy, which could mainly be perceived as a technical domain, might rather arouse men's interest.

Taken together, the results support the idea that image videos showing authentic young (female) scientists who describe specific applications of their own work are not only a meaningful tool to lure out students' interest, but also help to elucidate the fields' practical use as apparent in the increase of the domains' perceived utility value. The boundary conditions of agentic and communal framing effects need to be further scrutinised in future studies.

Complementary analyses revealed further findings worth noting. Firstly, exploratory factor analyses regarding the agentic and the communal goal orientation scale (Diekman et al., 2011) identified two-factorial structures of both scales.[3] In line with Folberg and colleagues (2020), in both studies, students' agentic goal orientation consisted of a *dominance/competence* and a *self-directed* dimension; communal goals loaded, in accordance with Knekza et al. (2019), on a *serving* and *connection* dimension. Secondly, in the moderated mediation analyses of the framing (independent variable) on students' interest (dependent variable) through students' utility value (mediator) with gender as a moderator of the a- and the c'-path (model 8 in the PROCESS macro; see Figure 1), only the already well-established b-path was significant showing that students' utility value affects students' interest in the respective domain (Beier et al., 2019; Curry et al., 2020; Durik et al., 2015; Shin et al., 2019).

Practical implications

Our studies underscore that videos can be an effective means to influence students' domain-specific STEM interest and utility value which are both, according to the Expectancy Value Theory (Eccles et al., 1983) and supported by a body of empirical evidence (Beier et al., 2019; Lent et al., 2005; Maltese and Tai, 2011; Wegemer & Eccles, 2019), crucial for students' educational and career-related choices. Given the imperative to counter the shortage of STEM professionals in industrialised countries (Anger et al., 2022; Xue & Larson, 2015), it could therefore be worthwhile to use the potential of videos to attract more (young) people to STEM domains. In translating these findings into practice, three critical considerations emerge.

Firstly, scientists and research institutions must be willing to present their research work in videos. Regarding this, it should be noted that scientific content often has to be reduced and/or simplified so that it is suitable for discourse contexts outside the scientific community (Bromme & Kienhues, 2014). Furthermore, producers of science communication videos need to consider the form (e.g., interview or laboratory presentation) in which they want to provide insights into their work. Overall, the conception and production of high-quality videos often requires a high degree of work capacity and media expertise (Stein et al., 2022), so that the realisation is usually not possible for individual scientists without further ado. For this reason, consideration must be given to how scientific institutions and scientific funding organisations can establish structures and provide resources to support scientists in the creation of videos.

Secondly, producers should think carefully about how they want to represent their discipline. Even though our studies showed hardly any influences of the agentic and communal framings on students' perceptions of STEM domains, based on other research (Brown et al., 2017; Diekman et al., 2011; Neuhaus & Borowski, 2018), it can be assumed that agentic and communal STEM descriptions contribute to the assessment of STEM domains and students' attraction to it. However, care should be taken to ensure that the presentation of the STEM domain in the video does not create a false image that cannot be confirmed in reality (e.g., showing only communal-connoted images in which people work in groups, although the work primarily requires agentic-connoted individual work in the laboratory) to avoid students turning away from STEM due to disappointed expectations.

Thirdly, it is important to think about how produced videos that provide insights into STEM domains can be deployed to reach (young) people. Regarding this, several formal (e.g., integration in school lessons) and informal (e.g., presentation via social media) contexts of science communication are conceivable. Depending on the context, it may be worth considering whether and how didactic support could enhance the impact of videos on students' interest and utility value perceptions. The integration of videos into school lessons, for instance, offers opportunities for additional information, discussions, and tailored answers to students' questions. A further step could be to coordinate the development of teaching concepts with the production of the videos together with scientists/scientific institutions and educational practitioners/institutions to be able to respond to specific needs (e.g., specific topics demanded by the school curriculum).

Limitations and future directions

Consistent with previous research, our analyses showed that both videos had a positive effect on students' interest and utility value in general. These results suggest that videos can be an effective tool for promoting STEM fields. However, the current study design does not allow yet to pinpoint specific characteristics of the videos responsible for these effects which should be systematically examined in future research. One such aspect pertains to the gender of the scientist portrayed in the video. In the present studies, we decided to work with young female scientists who authentically report about a specific and central topic of their current work. Nonetheless, the positive impact of the videos extended to both men and women. Our results, once again, confirm that female role models can spur interest in male and female perceivers (e.g., Lockwood, 2006). However, research on the effects of the similarity of instructors and perceivers is ambiguous. While some studies suggest that an instructor's gender does not influence students' interest and learning (Hoogerheide et al., 2018; Schrader et al., 2021), other research showed that gender differences in STEM interest can be reduced by a female instructor (Solanki & Xu, 2018), that gender similarity of video instructors and perceivers can influence affective components (e.g., enjoyment; Hoogerheide et al., 2016), and that gender similarity with an animated pedagogical agent led to higher programme ratings (e.g., interest) of female students, whereas the opposite was the case for male students (Ozogul et al., 2013). Based on this, future research should systematically investigate the effect of instructor-perceiver gender similarity in various STEM domains.

In two studies, we found only negligible effects of the agentic and communal framing. Specifically, male participants were more affected by the agentic framing in the male-connoted domain of geodesy than female participants. We can think of at least two features of the framing that could explain the absence of stronger effects. The first feature pertains to the way in which the information was presented. The framing was provided in written form preceding the video. Stated by the scientist, the framing could have been perceived as more authentic, and thus, be more persuasive than the written information. A second feature relates to the information in which agentic and communal characteristics and goals were addressed. While our framing addressed the core characteristics of agentic and communal goals, we did not systematically vary between proximal and distal characteristics of agency and communion within the framing. Steinberg and Diekman (2018) showed that distal communal opportunities (e.g., helping society) in STEM lead to higher interest compared to proximal communal opportunities (e.g., direct help to others). Given that agentic and communal goals can be fulfilled in various ways in different contexts, a systematic exploration of the persuasiveness of specific examples can further help to create effective image videos more suitable to catalyse female and male students' interest in STEM domains.

Another limitation is that our sample consisted of mostly Western participants (Rad et al., 2018). The language of the experimental instructions was German, thus attracting only German-speaking participants. Replicating the study in other countries could further qualify our findings. For example, Stoet and Geary (2018) provided evidence for what they call the Gender-equality Paradox, which describes that more women graduate in STEM in countries with lower levels of gender-equality compared to countries with higher levels of gender-equality. This effect has been explained by the proportionally higher impact of socioeconomic considerations in students' choices, resulting in choices of majors that likely improve the socioeconomic situation of students and their families (e.g., through a high payment in STEM professions). We believe that it would be important to study the impact of image videos in countries with varying levels of gender equality to find out to which degree the effects identified in our studies are valid across different societal conditions, further exploring the interplay of perceived opportunities, perceived stereotypes, and individual strengths.

Finally, we would like to note that a more comprehensive measurement of utility value could have potentially yielded different results. In our study, we applied a measure assessing general utility value without specifying it in more detail or in a certain direction (e.g., personal use vs. societal relevance). Gaspard and colleagues (2015), for instance, divided mathematics utility value into five facets and found that male students had higher values regarding the utility for *future life* and *job* than female students, whereas no gender differences could be observed regarding short-term oriented facets, namely utility for *school*, *daily life*, and *social utility*. This differentiated assessment enables the investigation of students' utility value regarding different aspects which would be necessary to get a comprehensive picture of students' STEM utility value. Future studies may benefit from measuring utility value in such a differentiated way to better understand which aspects should be underscored and addressed in image videos in various STEM domains.

Conclusion

In the current research, we reported the results of two preregistered studies examining the effects of STEM image videos on students' interest and perceived utility of the domains of biomedical engineering and geodesy. Our findings document the high potential of videos to positively influence students' interest and their perceived utility value in the respective domain, which may cause them to consider the STEM domain as a field of study or future career opportunity. As such, they can be a valuable tool for orientation in secondary education right before students decide which subject to study at university. In light of this, it seems fruitful to investigate the videos' effects on male and female adolescents where STEM attitudes are already established (Master, 2021) and influence educational decisions and career aspirations (Lauermann et al., 2017).

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ENDNOTES

[1] In both studies, we assessed perceptions regarding *scientificity* and *credibility of the content* with two self-developed single-item measures on a 5-point Likert scale. For the biomedical engineering video, scientificity was rated with M = 4.26, SD = 0.75, and credibility with M = 4.42, SD = 0.71. The geodesy video was scored with M = 4.12, SD = .74 on scientificity, and M = 4.48, SD = 0.63 on credibility. These relatively high scores suggest that participants perceived both videos as authentic.

[2] Women are underrepresented in both fields (39.5% female enrolments in biomedical engineering and 28.5% in geodesy for the winter semester 2021/22 at the university where this research has been conducted; Leibniz Universität Hannover, 2021).

[3] It should be noted that we did not use all items of the original scale by Diekman and colleagues (2011), for a complete listing of the used items see Appendix B.

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APPENDIX

Appendix A

Specification of the experimental framing treatment

Original neutral framing in German
Im Folgenden sehen Sie ein Video, in dem eine Person aus dem Forschungsfeld [der Erdmessung/der Biomedizintechnik] Einblicke in ihren Forschungsalltag gibt. Das Forschungsfeld der [Erdmessung/Biomedizintechnik] beschäftigt sich unter anderem mit der Entwicklung von spezifischen Verfahren, [die eine exakte Vermessung der Erde/die die Herstellung von Gefäßimplantaten] ermöglichen.

Bitte nutzen Sie Kopfhörer, um den Ton des Videos abzuspielen. Schauen Sie das Video für sich und in Ruhe an. Wichtig ist, dass Sie das Video bis zum Ende anschauen und nicht vorher abbrechen. Sobald Sie das Video zu Ende geschaut haben, klicken Sie auf "Weiter". Beantworten Sie dann bitte die Fragen zu dem Video.

English translation of the neutral framing
The video that follows shows a person from the research field of [geodesy/biomedical engineering] giving insights into their daily research routine. The research field of [geodesy/biomedical engineering] deals, for example, with the development of specific procedures [that enable the exact measurement of the earth/the production of vascular implants].

Please use headphones to play the sound of the video. Watch the video alone and in a quiet environment. It is important that you watch the video to the end and do not stop before. Once you have finished watching the video, click "Continue". Then please answer the questions about the video.

Original agentic framing in German
Im Folgenden sehen Sie ein Video, in dem eine Person aus dem Forschungsfeld [der Erdmessung/der Biomedizintechnik] Einblicke in ihren Forschungsalltag gibt. Das Forschungsfeld der [Erdmessung/Biomedizintechnik] beschäftigt sich unter anderem mit der Entwicklung von spezifischen Verfahren, [die eine exakte Vermessung der Erde/die die Herstellung von Gefäßimplantaten] ermöglichen.

Forschung in diesem Bereich verfolgt also das Ziel, exzellente Leistungen zu erbringen und so Lösungen für besonders anspruchsvolle Probleme zu finden.

Auf diese Weise erlangt das Forschungsfeld [der Erdmessung/der Biomedizintechnik] einen hohen Status in der Gesellschaft.

In verschiedenen Befragungen haben Forschende berichtet, dass ein besonders wichtiger Teil ihrer Tätigkeit in [der Erdmessung/der Biomedizintechnik] die eigenständige Arbeit und die Durchsetzungsfähigkeit in ihrer Forschungsgemeinschaft ist.

Die Unabhängigkeit von anderen Forschenden ist also entscheidend für gute Ergebnisse und Innovationen im Bereich der [der Erdmessung/der Biomedizintechnik].

Bitte nutzen Sie Kopfhörer, um den Ton des Videos abzuspielen. Schauen Sie das Video für sich und in Ruhe an. Wichtig ist, dass Sie das Video bis zum Ende anschauen und nicht vorher abbrechen. Sobald Sie das Video zu Ende geschaut haben, klicken Sie auf "Weiter". Beantworten Sie dann bitte die Fragen zu dem Video.

English translation of the agentic framing
The video that follows shows a person from the research field of [geodesy /biomedical engineering] giving insights into their daily research routine. The research field of [geodesy/biomedical engineering] deals, for example, with the development of specific procedures [that enable the exact measurement of the earth/the production of vascular implants].

Research in this field thus pursues the goal of achieving excellent performance and thereby finding solutions to particularly challenging problems.

In this way, the research field of [geodesy/biomedical engineering] attains a high status in society.

In various interviews, researchers have reported that a particularly important part of of their work in [geodesy/biomedical engineering] is working independently and being assertive in their research community.

Thus, independence from other researchers is critical to good results and innovation in [geodesy/biomedical engineering].

Please use headphones to play the sound of the video. Watch the video alone and in a quiet environment. It is important that you watch the video to the end and do not stop before. Once you have finished watching the video, click "Continue". Then please answer the questions about the video.

Original communal framing in German
Im Folgenden sehen Sie ein Video, in dem eine Person aus dem Forschungsfeld [der Erdmessung/der Biomedizintechnik] Einblicke in ihren Forschungsalltag gibt. Das Forschungsfeld der [Erdmessung/Biomedizintechnik] beschäftigt sich unter anderem mit der Entwicklung von spezifischen Verfahren, [die eine exakte Vermessung der Erde/die die Herstellung von Gefäßimplantaten] ermöglichen.

Forschung in diesem Bereich verfolgt also das Ziel, anderen Menschen zu helfen und sie so in bestimmten Lebensbereichen zu unterstützen.

Auf diese Weise leistet das Forschungsfeld [der Erdmessung/der Biomedizintechnik] einen relevanten Beitrag zum gesellschaftlichen Wohlergehen.

In verschiedenen Befragungen haben Forschende berichtet, dass ein besonders wichtiger Teil ihrer Tätigkeit in [der Erdmessung/der Biomedizintechnik] die kooperative Zusammenarbeit in Teams und die Eingebundenheit in eine Forschungsgemeinschaft ist.

Die Zusammenarbeit mit anderen Forschenden ist also entscheidend für gute Ergebnisse und Innovationen im Bereich der [der Erdmessung/der Biomedizintechnik].

Bitte nutzen Sie Kopfhörer, um den Ton des Videos abzuspielen. Schauen Sie das Video für sich und in Ruhe an. Wichtig ist, dass Sie das Video bis zum Ende anschauen und nicht vorher abbrechen. Sobald Sie das Video zu Ende geschaut haben, klicken Sie auf "Weiter". Beantworten Sie dann bitte die Fragen zu dem Video.

English translation of the communal framing
The video that follows shows a person from the research field of [geodesy /biomedical engineering] giving insights into their daily research routine. The research field of [geodesy/biomedical engineering] deals, for example, with the development of specific procedures [that enable the exact measurement of the earth/the production of vascular implants].

Research in this field thus pursues the goal of helping other people and thereby supporting them in certain areas of life.

In this way, the research field of [geodesy/biomedical engineering] makes a relevant contribution to societal well-being.

In various interviews, researchers have reported that a particularly important part of their work in [geodesy/biomedical engineering] is working cooperatively in teams and being part of a research community.

Thus, collaboration with other researchers is critical to good results and innovation in [geodesy/biomedical engineering].

Please use headphones to play the sound of the video. Watch the video alone and in a quiet environment. It is important that you watch the video to the end and do not stop before. Once you have finished watching the video, click "Continue". Then please answer the questions about the video.

Appendix B

Table B1
Summary of exploratory factor analysis results for agentic goal orientation in Study 1 (biomedical engineering; N = 292) and Study 2 (geodesy; N = 307)

	Rotated factor loadings			
Item: Für meine spätere berufliche Tätigkeit ist es mir wichtig, … [It is important to me...]	Factor 1: Agentic dominance goal orientation		Factor 2: Agentic self-directed goal orientation	
	Study 1	Study 2	Study 1	Study 2
… Einfluss auf andere ausüben zu können. [… to be able to exert a powerful influence on others in my future career.]	**.71**	**.70**	-.01	-.04
… gute Leistung zu erbringen. [… to achieve good performance in my future career.]	.16	**.37**	**.65**	.28
… unabhängig von anderen zu sein. [… to be independent of others in my future career.]	.11	.12	**.72**	**.79**
… einen hohen Status zu haben. [… to have a high status in my future career.]	**.78**	**.81**	.24	.20
… sehr erfolgreich zu sein. [… to be very successful in my future career.]	**.69**	**.75**	**.39**	.30
… selbstverantwortlich handeln zu können. [… to be able to act self-directly in my future career.]	.18	.15	**.77**	**.72**
… viel Anerkennung zu bekommen. [… to get a lot of recognition in my future career.]	**.80**	**.70**	.08	.15
… mich auf mich selbst fokussieren zu können. [… to be able to focus on myself in my future career.]	.04	.14	**.63**	**.74**

Note. The procedure of factor analysis is described in the text. Factor loadings above .30 are in bold. Items are adapted and translated based on the Agentic Goal Endorsement scale by Diekman et al. (2011). Only the German translation was used in the survey. The English translation is given in parentheses.

Table B2
Summary of exploratory factor analysis results for communal goal orientation in Study 1 (biomedical engineering; N = 292) and Study 2 (geodesy; N = 307)

	Rotated factor loadings			
Item: Für meine spätere berufliche Tätigkeit ist es mir wichtig, … [It is important to me…]	Factor 1: Communal service goal orientation		Factor 2: Communal connection goal orientation	
	Study 1	Study 2	Study 1	Study 2
… für andere da sein zu können. [… to be there for others in my future career.]	**.76**	**.76**	.28	.33
… etwas für Menschen tun zu können. [… to be able to do something for people in my future career.]	**.82**	**.81**	.16	.16
… für andere sorgen zu können. [… to be able to serve/care for others in my future career.]	**.68**	**.65**	.21	.21
… anderen helfen zu können. [… to be able to help others in my future career.]	**.86**	**.86**	.17	.12
… etwas für die Gemeinschaft tun zu können. [… to be able to do something for the community in my future career.]	**.70**	**.76**	.14	.13
… mit anderen Menschen zusammenarbeiten zu können. [… to be able to work together with other people in my future career.]	.21	.15	**.91**	**.88**
… mit anderen Menschen in Kontakt sein zu können. [… to be able to be in contact with other people in my future career.]	.23	.25	**.91**	**.86**

Note. The procedure of factor analysis is described in the text. Factor loadings above .30 are in bold. Items are adapted and translated based on the Communal Goal Endorsement scale by Diekman et al. (2011). Only the German translation was used in the survey. The English translation is given in parentheses.

Appendix C

Table C1
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and interest as the dependent variable in Study 1

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	45.900	<.001	0.139
Subject of study (STEM/non-STEM; covariate)	1	3.681	.056	0.013
Participants' gender	1	6.992	.009	0.024
Video framing	2	0.222	.801	0.002
Participants' gender x video framing	2	0.042	.959	0.000

Note. N = 292 ($n_{\text{agentic framing}}$ = 93; $n_{\text{communal framing}}$ = 99; $n_{\text{neutral framing}}$ = 100).

Table C2
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and interest as the dependent variable in Study 1 when including only participants with the manipulation check code > 2 (2 = description of unrelated content, 1 = no memory) in the calculations

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	32.572	<.001	0.147
Subject of study (STEM/non-STEM; covariate)	1	4.260	.040	0.022
Participants' gender	1	11.516	<.001	0.057
Video framing	2	0.319	.727	0.003
Participants' gender x video framing	2	1.265	.285	0.013

Note. N = 197 ($n_{\text{agentic framing}}$ = 46; $n_{\text{communal framing}}$ = 51; $n_{\text{neutral framing}}$ = 100).

Table C3
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and utility value as the dependent variable in Study 1

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	4.556	.034	0.016
Subject of study (STEM/non-STEM; covariate)	1	0.541	.463	0.002
Participants' gender	1	6.133	.014	0.021
Video framing	2	0.380	.684	0.003
Participants' gender x video framing	2	0.045	.956	0.000

Note. N = 292 ($n_{\text{agentic framing}}$ = 93; $n_{\text{communal framing}}$ = 99; $n_{\text{neutral framing}}$ = 100).

Table C4
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and utility value as the dependent variable in Study 1 when including only participants with the manipulation check code > 2 (2 = description of unrelated content, 1 = no memory) in the calculations

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	2.627	.107	0.014
Subject of study (STEM/non-STEM; covariate)	1	0.090	.764	0.000
Participants' gender	1	7.237	.008	0.037
Video framing	2	1.306	.273	0.014
Participants' gender x video framing	2	0.249	.780	0.003

Note. N = 197 ($n_{\text{agentic framing}}$ = 46; $n_{\text{communal framing}}$ = 51; $n_{\text{neutral framing}}$ = 100).

Appendix D

Table D1

Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and interest as the dependent variable in Study 2

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	28.201	<.001	0.086
Subject of study (STEM/non-STEM; covariate)	1	2.377	.124	0.008
Participants' gender	1	5.712	.017	0.019
Video framing	2	0.785	.457	0.005
Participants' gender x video framing	2	0.727	.484	0.005

Note. N = 307 ($n_{\text{agentic framing}}$ = 96; $n_{\text{communal framing}}$ = 106; $n_{\text{neutral framing}}$ = 105).

Table D2

Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and interest as the dependent variable in Study 2 when including only participants with the manipulation check code > 2 (2 = description of unrelated content, 1 = no memory) in the calculations

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	13.657	<.001	0.065
Subject of study (STEM/non-STEM; covariate)	1	2.167	.143	0.011
Participants' gender	1	7.456	.007	0.036
Video framing	2	2.311	.102	0.023
Participants' gender x video framing	2	0.257	.774	0.003

Note. N = 206 ($n_{\text{agentic framing}}$ = 45; $n_{\text{communal framing}}$ = 56; $n_{\text{neutral framing}}$ = 105).

Table D3
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and utility value as the dependent variable in Study 2

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	3.521	.062	0.012
Subject of study (STEM/non-STEM; covariate)	1	1.422	.234	0.005
Participants' gender	1	0.818	.367	0.003
Video framing	2	0.087	.917	0.001
Participants' gender x video framing	2	0.660	.518	0.004

Note. N = 307 ($n_{\text{agentic framing}}$ = 96; $n_{\text{communal framing}}$ = 106; $n_{\text{neutral framing}}$ = 105).

Table D4
Results of the two-way ANCOVA with prior knowledge and subject of study (STEM/non-STEM) as covariates, and utility value as the dependent variable in Study 2 when including only participants with the manipulation check code > 2 (2 = description of unrelated content, 1 = no memory) in the calculations

Source	df	*F*	*p*	η^2_p
Prior knowledge (covariate)	1	1.334	.249	0.007
Subject of study (STEM/non-STEM; covariate)	1	0.020	.887	0.000
Participants' gender	1	0.395	.531	0.002
Video framing	2	0.061	.941	0.001
Participants' gender x video framing	2	0.320	.726	0.003

Note. N = 206 ($n_{\text{agentic framing}}$ = 45; $n_{\text{communal framing}}$ = 56; $n_{\text{neutral framing}}$ = 105).