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ORIGINAL PAPER

Are students in some college majors more self-determined in their studies than others?

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Abstract
Self-determination theory proposes that the extent to which students' motivation is self-determined is critical to learning outcomes. Based on occasional research evidence and our perceptions, we hypothesize that college students in certain majors have profiles that are higher in self-determined motivation than students in other majors. Specifically, our primary hypothesis is that students in the social sciences and humanities tend to be more self-determined, whereas students in business-related majors tend to be less self-determined. The results from two studies using large samples and advanced analytical methods support the primary hypotheses. Comparison results were also obtained for other majors (e.g., engineering and natural sciences), and supplemental analyses supported the critical role of self-determined motivation in learning outcomes among students in all majors. Study 2 also found support for two mechanisms for such differences, i.e., the majors' learning climates and students' individual differences in autonomous functioning. The current evidence suggests the importance of promoting more humanistic learning environments in certain academic disciplines.

Keywords Academic motivation · Self-determination theory · College majors · Bifactor ESEM

Introduction

Self-determination theory (SDT; Deci and Ryan 2000) is one of the prominent contemporary theories of motivation. It proposes that the extent to which people's motivation is congruent with their sense of self (i.e., is self-determined) is critical to their positive functioning (Deci et al. 1991). Specifically, research in educational settings has consistently shown that self-determined academic motivation is a critical predictor of students' academic performance and well-being (e.g., Ryan and Niemiec 2009).

The current study proposes to compare the self-determined motivation of college students in different academic majors. Such a comparison is important for several reasons. First, SDT proposes that social contexts have a profound impact on the motivational functioning of human beings, but to date, most effort has been focused on immediate interpersonal contexts, and relatively little research has examined the effect of indirect and relatively distal social environments on individuals' motivation (see Ryan and Deci 2017; but see Chirkov et al. 2003; Kasser et al. 2007 for examples of such studies). Therefore, on the conceptual level, the current study provides relatively rare evidence on the effect of indirect higher-level social structures on motivation. Practically speaking, the choice of a college major is one of the most important life decisions for young people. As such, our research will provide deeper insight on students' academic functioning as a consequence of what majors they choose. Our research could point to student sub-populations that may be particularly at risk for low-quality motivation. Subsequently, awareness can be raised so that faculty, administrators, parents and students themselves can aim to improve their motivation. In addition, the identification of the potential mechanisms underlying these differences may provide insight on how people can improve motivation in certain areas.

In the following section, we introduce the notion of self-determined academic motivation and explain why we expect different majors to have different effects on self-determined motivation.

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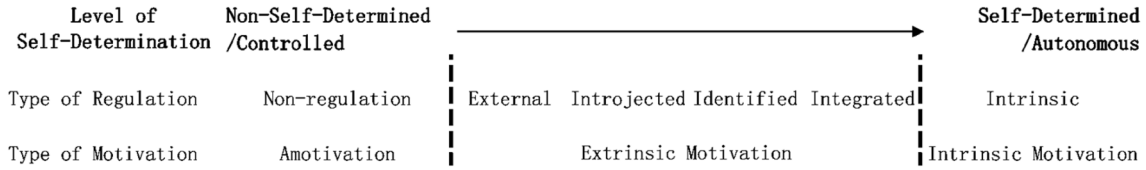

Fig. 1 The self-determination continuum (Modeled after Deci and Ryan 2000)

Self-determined motivation in education

According to SDT, there are multiple types of reasons that people do what they do, based on the extent to which the reason is self-determined (Deci and Ryan 2000). The prototype of self-determined motivation is intrinsic motivation, defined as doing something for its own sake; phenomenologically, this type of motivation translates into a feeling of interest and enjoyment. The opposite of intrinsic motivation is extrinsic motivation, or doing something for an instrumental reason. Different types of extrinsic motivation that have been identified by SDT differ based on the degree to which they are self-determined, depending on how well the instrumental reason is internalized or regulated. When extrinsic motivation is not internalized within the self, that motivation is said to be externally regulated (externally regulated extrinsic motivation, referred to below simply as external extrinsic motivation), in which case people's behavior is aimed at attaining a desired consequence, such as tangible rewards, or avoiding a threatened punishment. A slightly more self-determined form of extrinsic motivation is introjected extrinsic motivation, in which the reason to engage in the behavior is partially internalized so that the behavior is enacted with either a sense of contingent self-worth or a fear of guilt and shame. A still more self-determined type of extrinsic motivation is identified extrinsic motivation, in which people recognize and accept the underlying value of a behavior. The most self-determined type of extrinsic motivation is integrated extrinsic motivation, in which people fully accept the instrumental reasons for the behaviors by bringing them into harmony or coherence with other aspects of their values and identity. Intrinsic motivation and the four types of extrinsic motivation, together with amotivation (i.e., the lack of any motivation), can be placed along a continuum of self-determination (Fig. 1). Self-determined types of motivation are also referred to as autonomous motivation, whereas introjected and external types of extrinsic motivation are referred to as controlled motivation (referring to the experience of doing things in response to pressures and controls that are alienated from the organismic self; Ryan and Deci 2017).

In the educational context, when people study because they are interested in learning (intrinsic motivation), because the learning behavior is part of their identity (integrated extrinsic motivation), or because they identify with the value of the behavior by itself (identified extrinsic motivation), their behavior is self-determined; when people study because they feel guilt, shame, or internal pressure (introjected extrinsic motivation), because of external coercion (external extrinsic motivation), or for no particular reason (amotivation), the learning behavior is alienated from their self, or non-self-determined. Considerable research has supported this conceptualization of self-determined motivation and its impact on student outcomes (for a review, see Ryan and Niemiec 2009; Yu et al. 2018). For example, one of the first studies in this area (Ryan and Connell 1989) supported the conceptualization of types of motivation and the continuum structure in the classroom achievement context. The measurement of self-determined academic motivation was formally established by Vallerand et al. (1993). More recent research has consistently supported the continuum structure of self-determined motivation based on their measurement (e.g., Sheldon et al. 2017).

Research has also confirmed the positive role that self-determined academic motivation plays in a wide variety of outcomes. For example, because self-determined behavior is experienced as "one's own," it is the most harmonious and efficient and is more likely to draw from the energy that emanates from the self, which is experienced as subjective vitality (Ryan and Frederick 1997). In contrast, experiencing activities as being controlled will detract from one's ability to actualize a holistic self, often involving internal pressure and conflict, and therefore both requires and drains psychological energy, a phenomenon that is experienced as depleting (for a review, see Ryan and Deci 2008). In addition to vitality and depletion, numerous studies have shown the effect of self-determined motivation on engagement (e.g., Bao and Lam 2008), educational achievement (e.g., Fortier et al. 1995; Guay and Vallerand 1997), and well-being (e.g., Vansteenkiste et al. 2005), among others.

Major and self-determined academic motivation

Very few studies have examined the differences between fields of academic study from a psychological perspective (e.g., Balsamo et al. 2013; Lipson et al. 2016; Lubinski 2010; Norman and Redlo 1952). Relevant to the current investigation, a handful of studies have shed light on possible differences in self-determined motivation between majors. For example, Sheldon and Krieger showed a decrease in intrinsic motivation and well-being among law students over a 1-year (Sheldon and Krieger 2004) or 3-year (Sheldon and Krieger 2007) period of study in law schools. These researchers attributed this phenomenon to the disciplinary culture of law schools, which encourages students to focus on competition, hierarchy, superficial rewards and image-based values. Similarly, other studies suggested that business school may be another example in which the disciplinary culture tends to foster non-self-determined functioning in students. In an early example, Holland (1985) defined business management as an "enterprising" environment that emphasizes manipulating other people to attain organizational or self-interested goals (also see Sagiv and Schwartz 2000). In SDT, the valuing of materialistic possessions as opposed to relationships is a form of extrinsic value orientation (Kasser and Ryan 1993) that has been shown to be related to less self-determined functioning and to lead to suboptimal outcomes (Sheldon et al. 2004). Subsequently, a few studies reported a higher extrinsic value orientation in business students than in education students (Vansteenkiste et al. 2006), psychology students (Robak et al. 2007), or engineering students (Jiang et al. 2016) and indicated that the extrinsic value orientation explained business students' lower well-being. Given the association between value orientation and self-determined motivation (Sheldon et al. 2004), these studies suggest that business students may be less self-determined in their academic motivation.

Therefore, research so far has shown that law school and business schools tend to harm students' self-determination. However, the existing evidence has some significant limitations. First, a norm-based, between-person comparison has been missing. The research by Sheldon and Krieger (2004, 2007) is focused on within-individual changes, and the research on business school students used relatively arbitrary comparison groups. No research to date can tell us how self-determined students in certain majors are in comparison to the general student population. Second, the few studies on business school students used value orientations. Although we can infer that business students probably have lower levels of self-determined motivation, given the link between value orientations and self-determined motivation, there has been no direct evidence on differences of self-determined motivation per se. In the current study, we propose to provide the first comparison of self-determined motivation across majors that is direct and comprehensive, aiming to support the proposition that students in some majors have lower self-determined motivation. Moreover, no study so far has revealed whether some majors are especially *more* self-determined, whereas based on the theoretical analyses and anecdotal evidence discussed below, we suspect that students in social sciences and humanities majors are higher in self-determination. Our more detailed theorizing follows.

Primary hypotheses: comparison between business-related, social sciences/humanities, and other majors

Our primary propositions are that students majoring in business-related areas score lower in self-determined academic motivation, whereas students majoring in social sciences and humanities score higher in self-determined motivation.

Specifically, business-related majors, such as business, management and finance, are likely to be the most externally regulated among all types of majors because the overarching goal in these fields is to maximize profit (e.g., Kasser and Ahuvia 2002), which from an SDT perspective is the prototype of external extrinsic motivation. For example, Leppel et al. (2001) reported that students who believe that being very well off financially is very important are more likely to major in business. As shown by studies mentioned earlier (Jiang et al. 2016; Robak et al. 2007; Vansteenkiste et al. 2006), these fields also tend to promote the values of self-interest and materialism. Because SDT argues that these values are incongruent with the human organism (e.g., Deci and Ryan 2000; Sheldon et al. 2004) and hence difficult to internalize within the self, we expect business-related majors to also score highly on introjected extrinsic motivation. Also contributing to introjection is the zero-sum competition worldview that permeates these fields (e.g., Imlay and Hamilton 1997). For the same reasons as those for the higher score in introjected extrinsic motivation, we expect these students to score low in integrated extrinsic motivation. In addition, finally, because low levels of autonomous motivation and high levels of controlled motivation are depleting (Moller et al. 2006; Nix et al. 1999; Ryan and Deci 2008) and chronic depletion leads to amotivation, we expect students from business-related majors to be relatively high in amotivation.

In contrast, we expect social sciences and humanities students to score high in intrinsic motivation. Etymologically, "science" derives from the Latin root *scire*, which means "to know." Therefore, we believe that all sciences cater to human curiosity and interest, which is the prototype of

intrinsic motivation (e.g., González-Cutre et al. 2016). The same goes for humanities majors, which are also dedicated to understanding the world. In particular, we expect social sciences and humanities majors (as opposed to other sciences) to be especially self-determined for two main reasons. First, human beings are innately attracted to social life. According to Baumeister and Leary (1995), human beings have a pervasive drive to form and maintain lasting, positive, and significant interpersonal relationships. Part of this fundamental human need translates into our inherent inquisitiveness about the social environment: we are curious what others think and do (e.g., Renner 2006), and we are always trying to understand others (e.g., Watson et al. 1999). In daily life, this inquisitiveness manifests itself as various activities such as gossiping (e.g., Baumeister et al. 2004) and reading stories about others' lives (e.g., László 2008); as a formal academic endeavor, this inquisitiveness manifests itself as the fields of social sciences and humanities. Using SDT terminology, the prosocial characteristic of social sciences and humanities (e.g., Sagiv and Schwartz 2000) is congruent with the tendency for human beings to become integrated into the social matrix (need for relatedness; Deci and Ryan 2000), which may promote the internalization of the learning behavior. In short, motivations for studying social sciences and humanities are likely more self-determined because these majors cater to human beings' inherent curiosity in social life and need for belongingness.

Second, because social sciences and humanities represent holistic approaches to understanding social life, they are usually highly relevant to students' social and personal lives, and they tend both to be informative to students and to provide them with life guidance. Students are likely to study social sciences or humanities not only for the sake of these subjects but also because these majors help them become the people they aim to be and develop into their best selves. For example, learning about the psychology and history of different cultures can help students in making important life decisions, such as choosing a place to live, and in forming friendships, whereas learning about plant biology on different continents is unlikely to contribute as much to students' personal lives. Balsamo et al. (2013) supported the idea that students in social sciences or humanity majors are more likely to be characterized by personal growth and development by showing that humanities majors score highest in self-orientation, defined by dimensions such as personal development. As anecdotal evidence, we are also well aware of the cliché that social scientists study their own problems (e.g., Epstein and Bower 1997). Using SDT terminology, because of the relevance of the social sciences and humanities to students' social lives, these majors contribute to students' ownership and self-organization (need for autonomy; Deci and Ryan 2000), which facilitates the internalization of learning activities.

Overall, we therefore expect students who study social sciences and humanities to be more self-determined in their studies because their subjects of study contribute to the fundamental aspects of their human lives, such as social bonding and self-organization. Because this hypothesis is rather novel in the literature, empirical support for it is rare. Nevertheless, anecdotal evidence is quite abundant. To provide an example in our own field (psychology), if one were to conduct a Google search on the term "why study psychology," one would find that the most frequently cited reasons include those such as to "help you understand yourself and other people," to "help you understand yourself" and "fun and interesting" (e.g., "Why study psychology", n.d.; Cherry 2017). A recent online survey ("What psychology graduates are doing," 2015) also showed that psychology students in China study mostly because of intrinsic motivation (interest).

Secondary comparisons

Apart from the differences hypothesized above for social sciences and business-related majors, we also aim to examine the self-determined motivation of engineering and natural science majors in relation to others. The choice of these majors is driven by their availability at the current university, as well as their numeric majority (in both the current samples and the overall college student population in the US, engineering and natural sciences represent a major body of students; e.g., U.S. Department of Education 2018). We do not have specific directional hypotheses regarding these majors, partly because there are multiple reasons to have different expectations. For example, natural sciences, as forms of science, are supposed to be interesting (because they cater to human curiosity, as explained previously). However, contemporary natural sciences are also known for their problem of being highly compartmentalized such that their research questions do not truly engage holistic real-life phenomena in an intriguing way. To quote the renowned physicist Hideki Yukawa (cited in Prigogine 1998), "It might sound strange, but as a physicist, I am feeling an ever stronger sense of dissociation of modern physics from myself." Similarly, engineering and technology can be highly important and interesting, but because engineering college graduates in the US are also highly paid (e.g., "the Economic Value of College Majors," n.d.), these majors may attract students who study for monetary reasons and therefore also score higher on non-self-determined types of motivation. Therefore, it is meaningful to examine these majors with an exploratory stance.

Supplemental questions

Refuting the match perspective

The importance of the current analysis is based on the assumption that self-determined motivation is associated with positive outcomes for all students. This assumption is consistent with the SDT proposition that self-determined motivation is universally important for all human beings. These premises, however, have been challenged by some researchers with a relativist perspective who propose that self-determination is important only when it matches the values promoted in the social context (i.e., the *match hypothesis*; e.g., Iyengar and Lepper 1999; Sagiv and Schwartz 2000; for a discussion, see Ryan and Deci 2000). To further consolidate our finding that students in some majors function less optimally than others, we examined the moderation effect of major on the impact of self-determination on grades and learning gains. If the match hypothesis is supported (i.e., if the effect of self-determined motivation is important for learning outcomes only for majors that are high in self-determined motivation, such as social sciences and humanities), then the low self-determination that might be found in business-related majors may not be a problem. However, based on an SDT perspective, we hypothesize that self-determined motivation would be a significant positive predictor for learning outcomes for students in all majors.

Possible mechanisms

In addition to detecting differences between majors, the current research also attempts to tap into the possible explanations for such differences. Consistent with the prior literature on individual differences in organizational/vocational research, we consider two possible explanations: *socialization* and *selection* (e.g., Balsamo et al. 2013; Chatman 1989; Grouzet 2014). For example, from an organizational/vocational perspective, Chatman (1989) proposed that socialization and selection are both essential mechanisms that lead to the fit between an individual and organization. Socialization is the process through which members are influenced by the values and regulations of the organization, while selection is bi-directional: The organization assesses a potential member's knowledge, skills and abilities according to its requirements, whereas the individual may choose the organization based on a similarity of values. Similarly, Grouzet (2014) also reviewed previous research that support socialization and selection both as mechanisms underlying the between-major differences in values.

The current study is not concerned with the fit between person and organization or the difference in values. However, it shares the same underlying dynamic: people are matched with certain disciplines, and after some time, they become more or less in line with characteristics of that discipline. As such, the socialization and selection processes can be used to understand why students in some majors are more self-determined than others. First, in terms of socialization, it is possible that students' motivational differences can be explained as a result of studying under the influence of the disciplinary culture in a certain major (e.g., Jiang et al. 2016). SDT proposes that self-determined motivation can be predicted by an autonomy-supportive, student-centered learning environment (e.g., Black and Deci 2000). An autonomy-supportive learning environment is characterized by being attentive to students' inner feelings and perspectives, providing choice and using noncontrolling language, and nurturing students' inner motivational resources (e.g., Jang et al. 2010). Thus, for example, it is possible that social sciences majors provide a learning environment that is more nurturing and student-centered, which predicts students' deeper internalization of the learning material; in contrast, business-relevant majors' course instructors might use language that emphasizes external rewards and competition rather than students' internal regulation and volition, which might feel alienating and undermine intrinsic motivation and internalization. In support, Sénécal et al. (1992) found that psychology students perceived higher autonomy support from their program than business students.

Another possibility is selection, i.e., students are already different at their entry into colleges and majors, even before they are influenced by the disciplinary climate, and their choice of major is based on their individual differences. As previous research suggested (e.g., Leppel et al. 2001), individual differences in students' motivation and values predict what major they choose in the first place. Indeed, SDT proposes that individual differences exist in the general tendencies toward autonomous versus controlled regulations of behavior (Deci and Ryan 2000). For example, research on causality orientations showed that people with an autonomy orientation tend to act in accord with their own emerging interests and self-endorsed values and interpret external events as informational, whereas people with a control orientation tend to act in accord with external or internal demands and interpret external events as pressuring (Vansteenkiste et al. 2010). Subsequently, these general tendencies can also predict domain-specific situational motivation regulation (Vallerand 1997). Therefore, it is possible that young people who function more autonomously appreciate certain majors that are more consistent with autonomy values (e.g., social sciences), whereas those who function less autonomously seek environments replete with extrinsic regulations (e.g., business).

Table 1 Summary of the hypotheses

Research questions and hypotheses	Brief description	Tests in the two studies	
		Study 1	Study 2
Main research question			
Primary hypotheses	Students in business-related majors are less self-determined, whereas students in social sciences or humanities are more self-determined	Examined using ANOVA and Z-tests	Examined using ANOVA, Z-tests, and bifactor ESEM
Secondary comparisons	Comparisons for natural sciences majors and engineering	Examined using ANOVA and Z-tests	Examined using ANOVA and Z-tests
Supplemental research questions			
Refuting the match hypothesis	Self-determined motivation positively predicts learning performance for students in all majors	Examined using regression	Examined using regression
The "socialization" hypothesis	Major → course → learning climate → self-determined motivation → learning outcomes	Not examined	Examined using SEM
The "selection" hypothesis	Students already have different levels of autonomy on a personality level when they first enroll in the different majors	Not examined	Examined using one-way ANOVA (subsample)

The current study

A summary of the research questions and hypotheses examined in the current research is provided in Table 1. To test these hypotheses, we conducted a two-phase study.[1] Study 1 is an initial test, whereas Study 2, which naturally temporally succeeded Study 1, sought to consolidate the findings in Study 1. In Study 1, we aimed to first operationalize and validate the instrumentations involved. We developed and examined the reliability of the coding scheme for majors; we also examined the reliability and validity of the measurements for self-determined academic motivation and self-assessed learning gains. Study 1 also applied traditional mean comparison methods (e.g., ANOVA) to detect differences between majors in motivation and examined the supplemental match hypothesis. Having established the methodology in Study 1, we aimed for a more rigorous investigation in Study 2. Specifically, Study 2 includes a large sample that was collected over 2 years following Study 1; Study 2 also applies a state-of-the-art latent variable modeling method (i.e., bifactor exploratory structure equation modeling or bifactor ESEM) to compare the latent means of the majors. Moreover, in addition to examining the match hypothesis, as in Study 1, in Study 2, we introduced some additional variables to address the mechanisms of the between-major differences in self-determined motivation (i.e., the socialization and selection hypotheses). For the socialization hypotheses, we collected information about the courses in which the students were surveyed and the autonomy support in those courses, among other things. We used structural equation modeling to examine whether the effect of major on self-determined motivation is explained by the differences in the autonomy-supportive learning climate that is present in different types of courses they take. For the selection hypotheses, we collected information from a subsample of students regarding individual differences in the level of autonomous functioning not long after they are enrolled to test whether students who have a general orientation toward autonomy are more likely to study in certain majors and vice versa.

Study 1

Methods

Participants and procedures

Data were collected from courses that were part of a campus-wide course transformation program at a large and comprehensive Midwestern US university. Surveys asking for

[1] It should be noted that it is possible to combine the data from the two studies and run the comparison analyses on the entire sample. However, we perceive this approach as less convincing than the 2-study layout because it is possible for us to overfit this one dataset with an arbitrary model. The two studies, which occurred naturally, can help cross-validate each other and support the generalizability of the findings to other samples.

Table 2 Distribution of the major categories

Study No.	Statistic	Engr/Tech	Nat Sci	Biz/Mgt/Fnc	Soc Sci/ Humanities	Others	Total
Study 1	Frequency	1157	391	774	340	1337	3999
	Percent	28.9	9.8	19.4	8.5	33.4	100
Study 2	Frequency	4962	1217	2039	908	4444	13,570
	Percent	36.6	9.0	15.0	6.7	32.7	100
Study 2 IAF subsample	Frequency	–	–	141	68	1152	1361
	Percent	–	–	10.4	5.0	84.6	100

For the IAF subsample, Engr/Tech and Nat Sci are not examined separately in the analysis, so their sample sizes are not reported here

Engr/Tech Engineering/Technology, *Nat Sci* Natural Science, *Biz/Mgt/Fnc* Business/Management/Finance, *Soc Sci* Social Science

demographic information (including major) and perceptions of the class they were taking, including motivation and self-assessed learning gains, were administered to 4543 undergraduate students (49.6% female, age $M = 20.18$, $SD = 2.61$) enrolled in the participating courses. Course grades were obtained from the registrar after the courses were completed. Of the participants, 1046 (23%) responded to the questionnaire more than once in reference to different courses. To assure that the independent observations assumption was met for the analyses used in the current study, we randomly selected one response for each student providing multiple responses, resulting in a final sample size of $N = 3999$ (88.03% of the total sample).

Measurements

Academic majors In the university where the current study was conducted, students decide on their major before enrollment. When the students responded to the survey, their official majors that are documented at the registrar were automatically recorded in their response data. These majors were then coded in five categories (hereafter capitalized to denote the groups in the current analyses) by the first author: Engineering/Technology, Natural Sciences, Business/Management/Finance, Social Sciences/Humanities, and Others.[2] Notably, The Others group constitutes a large proportion of the current sample (approximately one-third in both Study 1 and Study 2). This category consists of a large number of majors. For example, in Study 1, 96 majors are coded under this category. Majors in this category that include more than 50 participants are explorers, nursing, computer science, pre-pharmacy, general undecided, movement and sport sciences, and health science and pre-professional. Participants from these seven majors constitute a majority (54%) of the sample in the Others group.

The majors were independently coded by a second coder; the initial inter-rater reliability reached satisfactory level (Kappa = .69), and after discussion, the two raters agreed on the final coding categorization for all the majors. The distribution of majors is shown in Table 2. For our primary hypotheses, which focus on Business/Management/Finance and Social Sciences/Humanities, we collapsed Natural Sciences, Engineering/Technology, and Others into one "All Others" group. The subgroups Natural Sciences, Engineering/Technology and Others are used only when exploring specific secondary comparisons.

Academic motivation Academic motivation was measured with an 18-item scale adapted from other scales that tap into the six subtypes of motivation specified in SDT (e.g., the General Motivation Scale: Pelletier et al. 2011; the Situational Motivation Scale: Guay et al. 2000). This scale contains 6 subscales measuring the 6 types of self-determined motivation, with 3 items measuring each subscale. The orienting statements ask students to indicate their "motivation for taking the course". Examples of items include the following: "Because I really enjoy it" (intrinsic motivation); "Because experiencing new things is a part of who I am" (integrated extrinsic motivation); "Because it's a sensible way to get meaningful experience" (identified extrinsic motivation); "Because I would feel bad if I didn't" (introjected extrinsic motivation); "Because that's what I'm supposed to do" (external extrinsic motivation); and "I don't know. I wonder if I should continue" (amotivation). Higher scores on the three self-determined subscales (i.e., intrinsic motivation, integrated and identified external motivation) indicate more self-determined motivation, whereas higher scores on the three non-self-determined subscales (i.e., introjected and external types of extrinsic motivation, and amotivation) indicate less self-determined motivation. In the current sample, the internal consistency was high for all the subscales (Cronbach's alpha ranges from .84 to .96).

[2] We adopted this coding approach because from the raw major data we obtained, there is no existing labeling to determine which major falls under which category for our analysis purposes.

In addition, we calculated an overall score of self-determined motivation, the self-determination index (SDI), following a widely used practice in SDT research (e.g., Pelletier et al. 2002). The following formula is used:

$$\text{SDI} = 3 \times \text{intrinsic} + 2 \times \text{integrated} + \text{identified} - \text{introjected} - 2 \times \text{external} - 3 \times \text{amotivation} \quad (1)$$

The possible range for the SDI is −36 (if the participant scores 1 on all self-determined items and 7 on all non-self-determined items) to 36 (if the participant scores 7 on all self-determined items and 1 on all non-self-determined items).

Self-assessed learning gains This 5-point Likert scale measures participants' self-perceived gains in learning knowledge and in the skills identified by the faculty teaching the class surveyed. The questions were presented in the end-of-semester course evaluation. The questions share the same structure, "This course helped me learn/acquire _____ knowledge/skills," but the specific knowledge/skills that fill in the blank vary by course. For each course, the number of learning gains items used ranged from 3 to 8. In the current study, we are not interested in the specific knowledge or skills demonstrated in each class; rather, we are interested in how students perceived their gains in the knowledge or skills generally considered important by the instructors. Therefore, we averaged all the items and aggregated them into one self-assessed learning gains score to reflect a general level of perceived learning gains. We also calculated Cronbach's alpha, using all the available items and responses on the self-assessed learning gains scale. The overall Cronbach's alpha was .93. This means that if we look beyond the differences of the specific knowledge/skills that the items target and treat them all as items that assess the general perception of learning gains, the items strongly correlate with each other.

Self-assessed learning gains also had a correlation of .19 with course grade ($p < .001$). On the one hand, the high alpha and moderate-to-weak correlation coefficient with course grade validate self-assessed learning gains as an internally consistent measurement that is supported by the more objective learning outcome indicator of course grades; on the other hand, they also indicate that self-assessed learning gains are sufficiently different from course grades to support their incremental value as a more subjective measurement for learning performance.

Data analysis strategy

We used a series of one-way ANOVAs to examine group differences for each of the six motivation dimensions plus the overall SDI. To control for type I error, we used Bonferroni corrections to adjust the alpha levels of the seven omnibus F-tests to .007. If the omnibus one-way ANOVAs were significant, then we followed up with pairwise comparisons for differences between specific majors in a specific dimension (or in the overall SDI). We also conducted a series of Z-tests[3] comparing the group mean of each major with the population mean for the subtypes of motivation and the SDI. All the analyses were completed using the SPSS 22 and Excel 2013 software.

Results

Main analyses

Descriptive statistics supported the normality and constant variance assumptions necessary for the ANOVA.[4] After Bonferroni correction, all one-way ANOVA results were significant except for identified extrinsic motivation (Table 3). Pairwise comparisons generally supported our primary hypotheses: Students in Business/Management/Finance majors were found to be significantly less self-determined than students in the All Others group in introjected, amotivation (i.e., scoring higher), and overall SDI (i.e., scoring lower); students majoring in Social Sciences/Humanities were significantly more self-determined than students in the All Others group, as assessed by their scores in intrinsic motivation, integrated and identified extrinsic motivation, the overall SDI (i.e., scoring higher), and external extrinsic motivation (i.e., scoring lower); and students in the Social Sciences/Humanities were significantly more self-determined than students majoring in Business/Management/Finance, as assessed by their scores in all dimensions of motivation and the overall SDI except introjection (i.e., scoring higher in intrinsic motivation, integrated and identified extrinsic motivation, and the SDI and scoring lower in external extrinsic motivation and amotivation).

We plotted the Z-scores for each dimension of motivation for all the majors in Fig. 2. The figure clearly shows

[3] Z-tests, rather than t-tests, were used because according to the central limit theorem, when the sample size is large enough (as is the case of the current research), the distribution of sample means follow a normal distribution.

[4] Levene's test for homogeneity was significant for all dimensions except integrated extrinsic motivation and the overall SDI. However, an inspection of the standard deviations (SD) revealed that the largest ($SD = 1.74$) was within 1.5 times of the smallest ($SD = 1.25$), and none of the Welch or Brown-Forsythe robustness tests produced a significant result that differed from the ordinary ANOVA. Hence, the ordinary ANOVA results are reported here.

Table 3 ANOVA and Z-test results for the comparisons of self-determined motivation between majors in Study 1

Major	Intrinsic	Integrated	Identified	Introjected	External	Amotivation	SDI
Population	4.36	5.03	4.97	3.20	4.80	2.70	7.81
Soc Sci/Humanities	**$4.59_{a, S}$**	**$5.29_{a, S}$**	**$5.16_{a, S}$**	3.17	**$4.39_{a, S}$**	2.67_{a}	**$10.47_{a, S}$**
All Others	4.35_{c}	5.02_{c}	4.96_{c}	3.15_{a}	4.82_{c}	2.60_{a}	8.01_{b}
Others	4.40	5.03_{c}	5.00	3.12_{a}	4.81_{c}	2.51_{a}	8.64_{a}
Engr/Tech	4.38	5.03_{c}	4.95	3.19	4.73_{b}	2.72_{a}	7.87_{b}
Nat Sci	**$4.07_{c, N}$**	4.96_{c}	4.88_{c}	3.11_{a}	**$5.09_{c, N}$**	2.56_{a}	**$6.31_{c, N}$**
Biz/Mgt/Fnc	4.27_{c}	4.96_{c}	4.91_{c}	**3.39_{N}**	**$4.93_{c, N}$**	**$3.07_{c, N}$**	**$5.85_{c, N}$**
$F(4, 3994)$	5.59*	4.25*	2.61	3.81*	12.58*	17.30*	12.02*
η^2	.006	.004	.003	.004	.012	.017	.013

The pairwise comparisons method is Tukey's HSD (We chose Tukey's HSD because, in contrast to LSD, it corrects for inflation in type I error but is less conservative than the Bonferroni correction. Tukey's HSD is generally considered a good correction method when comparing all possible pairs.). A subscript "a" indicates that the major is significantly more self-determined than Business/Management/Finance in that specific dimension of motivation; a subscript "c" indicates that the major is significantly less self-determined than Social Sciences/Humanities in that specific dimension of motivation; a subscript "b" means that the cell is both significantly more self-determined than Business/Management/Finance and less self-determined than Social Sciences/Humanities; and cells without a subscript mean that the major is not significantly different from Business/Management/Finance or from Social Sciences/Humanities. Boldface type plus a subscript capital "S" mean that the specific major is significantly more self-determined than the population mean, whereas a subscript "N" means that the major is significantly lower in self-determination (N for "non-self-determined") than the population mean in that dimension of motivation. For the latent means, the column headed "SDI/General" refers to the general self-determination factor

Soc Sci Social Sciences, *Engr/Tech* Engineering/Technology, *Nat Sci* Natural Sciences, *Biz/Mgt/Fnc* Business/Management/Finance

*$p < .007$, †$p < .004$

that Business/Management/Finance students tend to score lower in the three autonomous dimensions and higher in the three controlled dimensions; Social Sciences/Humanities students show the opposite pattern, scoring high in the autonomous dimensions and low in the controlled dimensions. The pattern is further supported by the Z-test results (the significance of the Z-tests is indicated by bold font and subscripts in Table 3): Students in Business/Management/Finance majors are significantly less self-determined than the population mean in introjected extrinsic motivation, external extrinsic motivation, and amotivation (i.e., scoring higher in these three dimensions) plus the overall SDI (scoring lower), and students majoring in Social Sciences/Humanities are significantly more self-determined than the population mean in intrinsic motivation, integrated and identified external motivation, and the overall SDI (scoring higher in these dimensions) and external extrinsic motivation (scoring lower).

Our secondary, exploratory comparisons showed that students majoring in the Natural Sciences scored lower than the population average on intrinsic motivation and higher than the population average on external extrinsic motivation. Students majoring in Engineering/Technology did not differ significantly from the population mean.

Supplemental analysis: refuting the match hypothesis

The three-major categorization was dummy coded to create comparisons of Business/Management/Finance versus All Others and Social Sciences/Humanities versus All Others. Five variables were entered into the regression model as predictors of self-assessed learning gains and course grade: the academic SDI, the two dummy variables, and the two interaction terms created by multiplying centered academic SDI and centered dummy variables. The results showed that the academic SDI consistently emerged as a significant predictor for self-assessed learning gains and course grade in all the analyses. None of the interaction terms between SDI and major dummy coding was significant in predicting course grade. However, the interaction between SDI and being a student in Social Sciences/Humanities (as opposed to All Others) significantly predicts self-assessed learning gains (standardized $b = .06$, $t(2170) = 2.09$, $p < .05$). The direction of interaction indicated by the sign of the regression coefficient suggests that being a student in the All Others group is actually associated with a stronger effect of the SDI. Therefore, consistent with the prior literature, we did not find any support for the match hypothesis; rather, our results suggest that students in majors that are not particularly

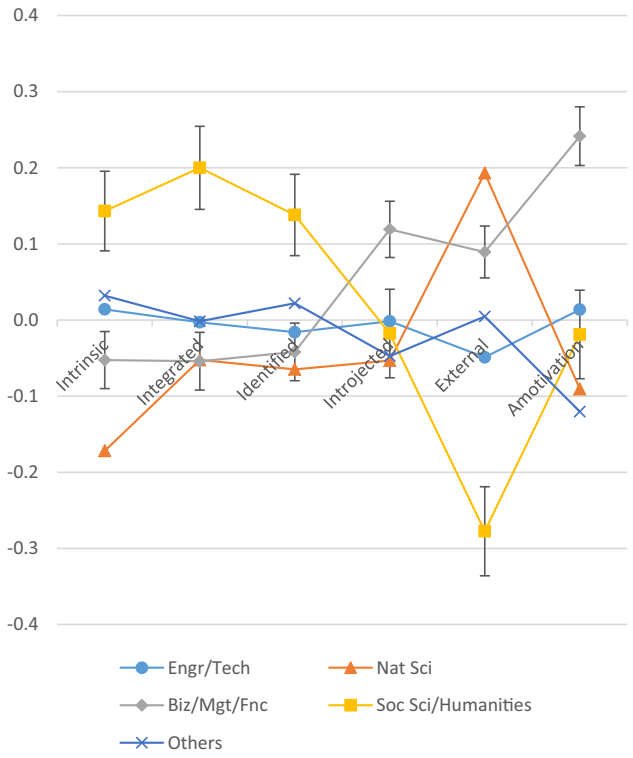

Fig. 2 Self-determination Z-scores by major in Study 1. *Soc Sci* Social Sciences, *Engr/Tech* Engineering/Technology, *Nat Sci* Natural Sciences, *Biz/Mgt/Fnc* Business/Management/Finance. Error bars show standard errors for Social Sciences/Humanities and Business/Management/Finance. Error bars represent standard errors and are displayed only for the Biz/Mgt/Fnc and Soc Sci/Humanities groups

autonomy-supportive are actually more likely to benefit from the positive effect of self-determined motivation on subjective learning gains.

Summary

The results generally supported our primary hypotheses. In terms of our exploratory secondary comparisons, Natural Sciences students scored lower in intrinsic motivation and higher on external extrinsic motivation. Engineering students scored close to the population mean. To further rule out the chance factor in a single sample, we sought to collect a second sample to replicate and further consolidate these findings.

Study 2

During the 2 years following the collection of the sample in Study 1, we collected more data to replicate the findings in Study 1. In addition, we used a recently developed measurement approach, namely, bifactor ESEM, to more accurately capture the construct of self-determined motivation as a latent variable, and we examined our primary propositions by comparing the latent means between Business/Management/Finance and Social Sciences/Humanities majors.[5] We also investigated the two possible explanations for the differences found between majors. For the disciplinary climate (socialization) explanation, we included the Learning Climate Questionnaire to measure the extent to which the classes in which the students were surveyed are perceived to be autonomy-supportive. We also coded the courses students took into different topics. We used structural equation modeling to examine whether the type of major would predict the type of course students take, which would then predict the classroom student-centeredness, which then would predict self-determination and learning outcomes. For the individual difference (selection) explanation, we administered and compared the Index of Autonomous Functioning (IAF; Weinstein et al. 2012) in a subsample composed of first-semester college students. If the IAF is significantly different between majors, then this finding supports the idea that students with varying autonomy at the individual difference level tend to choose different majors because individual difference in autonomous functioning is unlikely to have changed during the short time that they were enrolled in college.

Method

Participants and procedures

As in Study 1, data were collected from the campus-wide course transformation program. Over the 2-year period of data collection, 25,367 students responded to the survey, among whom 16,913 (66.7%) responded more than once. As in Study 1, we randomly selected one response from students who provided multiple responses, thereby resulting in a final sample size of 13,570 (53.49% of the total sample; 48.4% female, age $M = 21.05$, $SD = 2.09$). The distribution of majors is shown in Table 2. Participants were asked to report their academic major, academic motivation, perceived classroom climate, and self-assessed learning gains for the course; course grades were obtained from the registrar after the courses were completed. The IAF was administered to a subsample of students who were in their first semester of college ($N = 1361$; for major composition, see Table 2).

[5] Although latent mean comparison methods are superior to the traditional mean comparison methods used in Study 1, we nonetheless decided to retain the traditional analyses to improve the comparability between the two studies and also as a triangulation for the bifactor ESEM results, which were a recent development.

Measurements

The measurements for self-assessed learning gains were exactly the same as in Study 1. Academic majors were coded using the same protocol used in Study 1. In Study 2, the Others category includes 103 majors, eight of which had more than 100 participants, constituting 63% of the sample size of the Others group. These eight majors are explorers, computer science, pre-pharmacy, nursing, pre-communication, general undecided, health science pre-professional, and movement and sport sciences.

Self-determined motivation The measurement of self-determined motivation and the calculation of the SDI were exactly the same as in Study 1. In Study 2, we also needed to create a latent variable of self-determined motivation for the structural equation model. Because we are not interested in item-level analyses of self-determined motivation, we created three parcels from the 18 items to better represent the latent construct of self-determined motivation, following the suggestions of Little et al. (2002).[6] Each parcel is calculated from six of the 18 items using the SDI formula. For example, parcel 1 is calculated as SDI_parcel1 = 3 × Intrinsic_item1 + 2 × Integrated_item1 + Identified_item1 − Introjected_item1 − 2 × External_item1 − 3 × Amotivation_item1.

[6] According to Little et al. (2002), the benefits of using parcels include the following: they yield more continuous observed variables that are less likely to violate normal distribution assumption; they reduce the chance of type-I error and subsequent model misfit or artificial overfitting, as caused by random spurious correlations (in other words, the parceling approach is more robust against sample characteristics that lead to violations of the local independence assumption); they reduce the unwanted contamination of item relationships by constructs that are irrelevant to the researchers' interest; and they increase the stability of solutions (especially when using just-identified latent constructs, which consists of three parcels). The only drawback that is relevant to the current model is that when the parcels themselves are multidimensional (which is the case for self-determined motivation but not for learning climate), it is difficult to interpret the variance of the latent construct and the structural relations, because parceling obscures the contribution of items. However, Little et al. (2002) also suggested that this limitation on multidimensional parceling is only a problem when the researcher is interested in the items themselves. As they put it, "if the relations among constructs are of focal interest, parceling is more strongly warranted." In our path analysis, we are not interested in the item relations within the academic motivation scale or the Learning Climate Questionnaire. Our focus is to examine how motivation and learning climate play mediating roles between major and learning outcomes. In such cases, the pros of parceling clearly outweigh the cons. This is especially true considering the large number of items in the measurement of academic motivation (18 items), which can cause great potential problems of model misfit and instability if all of them are included under the latent academic motivation construct.

Course coding We coded the names of the courses in which the students were surveyed, using the same protocol we used to code the majors. A categorization with only three main types was used: 1023 (7.5%) of the respondents were surveyed in a business-related course, 6028 (44.4%) in a social sciences or humanities course, and 6519 (48.0%) in courses in other areas.

Learning climate We used the 6-item version of the Learning Climate Questionnaire (Williams and Deci 1996; Yu et al. 2018) to measure autonomy support in the classroom. An example of the item is "I feel that my instructor provides me choices and options." The scale is unidimensional, and its internal consistency is very high in the current sample ($\alpha = .95$). As in our treatment of self-determined motivation, we created three parcels (each an average of two items) to represent the latent construct of learning climate (Little et al. 2002).

IAF We used the IAF (Weinstein et al. 2012) to tap into students' autonomy at the individual difference level. The IAF is a 15-item scale consisting of three five-item subscales, namely, *Authorship/Self-Congruence* (e.g., "My decisions represent my most important values and feelings"), Susceptibility to Control (e.g., "I do things in order to avoid feeling badly about myself"), and Interest Taking (e.g., "I like to investigate my feelings"). In the current study, the internal consistencies for the subscales and the whole scale are $\alpha = .82$, $\alpha = .79$, $\alpha = .87$, and $\alpha = .86$, respectively. For the current analysis, we used only the global IAF score.

Data analysis strategy

First, we replicated the analyses performed in Study 1. A series of one-way ANOVAs and pairwise comparisons was performed on the six subtypes of motivation and SDI. The IAF was also compared using these methods.

Comparisons based on aggregate scale scores do not control for measurement errors, and comparisons based on latent means using structural equation modeling techniques will lead to more accurate results. Moreover, recent research showed the limitations of traditional confirmatory factor analysis (CFA) and recommended bifactor ESEM as a more advanced alternative (Howard et al. 2016; Litalien et al. 2017; Morin et al. 2016). Specifically, in the context of self-determined motivation, the bifactor ESEM takes into account the facts that (1) motivation items rarely tap into only one factor, and (2) there is a higher-order general self-determination factor that contributes to all items. Therefore, in Study 2, we attempted to examine our primary hypotheses (i.e., comparisons between business-related majors, social sciences and humanities, and other majors) using latent mean comparisons in bifactor ESEM.

Our bifactor ESEM analysis follows the procedure specified below. First, we ran a bifactor ESEM model on the entire dataset to examine the fit of data to the general bifactor ESEM structure. In contrast to traditional CFA models, in the bifactor ESEM, all 18 items of the self-determined motivation scale are allowed to freely load on all six subscales, and an additional factor, the general factor, is defined by all the 18 items; for model identification reasons, the six specific factors and one general factor were specified as orthogonal to each other. The bifactor ESEM model was estimated using orthogonal bifactor target rotation (Reise et al. 2011).

The fit of the model is judged by an examination of the fit indices and size of loading estimates. For the fit indices, a combination of the comparative fit index (CFI) and Tucker–Lewis index (TLI) larger than .90 and a root mean square error of approximation (RMSEA) smaller than .08 is considered adequate (Hu and Bentler 1999). For loading strengths, it is expected that items should load relatively strongly (standardized $b > .30$) on their respective factors and relatively weakly (standardized $b < .30$) on the nontarget factors. In addition, Howard et al. (2016) established that the general factor that represents an overall quantity of self-determination is associated with the 18 items following a continuum pattern, in which the least self-determined items (i.e., amotivation items) have the lowest loadings and the most self-determined items (i.e., intrinsic items) have the highest loadings.

As a second step, we examined the invariances of the bifactor ESEM model to ensure that the bifactor ESEM results are comparable between majors. The invariance testing followed the following stepwise sequence: configural, weak, strong, strict and variance–covariance invariance (for details, see Morin et al. 2016). For all the invariance testing, we will follow Cheung and Rensvold's (2002) suggestion and use the change in CFI (ΔCFI) as the criterion; a ΔCFI $< .01$ is considered evidence of invariance. As a last step, once metric invariance is supported with the aforementioned tests, we can conclude that the construct of self-determined motivation is measured comparably between majors and hence proceed to comparing the latent means. Bonferroni corrections were performed on these tests. Because we had 14 comparisons, the alpha level was lowered to .004.

To examine learning climate as a possible explanation of the between-major differences in motivation, we first coded the three types of majors in our primary proposition into two dummy variables: Social Sciences/Humanities versus All Others and Business/Management/Finance versus All Others. The three types of courses were recoded in the same way. Then, we ran a structural equation model in which the major type dummy variables predicted the course type dummy variables; which then predicted the course learning climate as perceived by students; which then predicted SDI; which then predicted learning outcomes, including grades[7] and self-assessed learning gains (see Fig. 4). We also included the direct paths from courses to grades to control for grade inflation (e.g., instructors of social sciences courses may systematically give higher grades than instructors of engineering courses, an effect not necessarily accounted for by learning processes). The bifactor ESEM and structural equation modeling analyses were conducted using *Mplus* software.

Results

Replication of Study 1 analyses

Main analyses The descriptive statistics supported the normality and constant variance assumptions necessary for the ANOVA. The results generally supported the primary hypotheses, consistent with Study 1. One-way ANOVA results were all significant[8] (Table 4). Pairwise comparisons showed that students in Business/Management/Finance majors were significantly less self-determined than students in All Others majors in the intrinsic, introjected, and amotivation dimensions and the overall SDI (i.e., lower in intrinsic motivation and SDI and higher in introjected and amotivation), and students in Social Sciences/Humanities were significantly more self-determined than All Others in all dimensions and the SDI except amotivation (i.e., higher in intrinsic motivation, integrated and identified extrinsic motivation and the SDI and lower in introjected and external extrinsic motivation); in addition, Social Sciences/Humanities students were significantly more self-determined than Business/Management/Finance students in all the dimensions of motivation and the SDI (i.e., higher in intrinsic motivation, integrated and identified extrinsic motivation

[7] Grades are used as an outcome variable in the current research. However, it is possible that grades may function as another socialization mechanism. Some majors may be harsher in grading, hence undermining students' needs satisfaction and motivation. In other words, the predictive effect between grades and motivation may be reciprocal. However, there is no way to test the causal direction between grades and motivation in the current data. Therefore, we simply note this possibility and test only the model in which learning climate is the socialization mechanism and grades are the learning outcome because it is more conceptually established and empirically tested in existing literature (e.g., Guay and Vallerand 1997).

[8] Similar to Study 1, Levene's tests are significant for all dimensions of motivation, except for integration. However, an inspection of standard deviations revealed that the largest ($SD = 1.82$) is within 1.5 times of the smallest ($SD = 1.31$), and none of the robust test results made a difference. Therefore, the standard ANOVA results are reported here.

Table 4 ANOVA, Z-test, and latent comparison results for comparisons of self-determined motivation between majors in Study 2

Major	Intrinsic	Integrated	Identified	Introjected	External	Amotivation	SDI/General
Population	4.18	4.95	4.85	3.08	4.88	2.61	6.62
Soc Sci/Humanities	**$4.36_{a, S}$**	**$5.08_{a, S}$**	**$5.00_{a, S}$**	**$2.88_{a, S}$**	**$4.55_{a, S}$**	**$2.47_{a, S}$**	**$8.84_{a, S}$**
Latent	−.01	.06	.05	−.13†	−.22†	.03	.13†
All Others	4.18_{b}	4.95_{c}	4.85_{c}	3.07_{b}	4.90_{c}	2.58_{a}	6.67_{b}
Latent	.00	.00	.00	.00	.00	.00	.00
Others	4.19_{c}	4.97	4.86	3.04_{b}	4.82_{c}	2.61_{b}	6.83_{b}
Engr/Tech	4.19_{c}	4.92_{c}	4.84_{c}	3.12_{b}	**$4.98_{c, N}$**	2.57_{a}	6.44_{b}
Nat Sci	4.12_{c}	4.99	4.79_{c}	**$2.95_{a, S}$**	4.85_{c}	**$2.47_{a, S}$**	7.07_{b}
Biz/Mgt/Fnc	**$4.07_{c, N}$**	4.93_{c}	**$4.78_{c, N}$**	**$3.24_{c, N}$**	4.92_{c}	**$2.81_{c, N}$**	**$5.36_{c, N}$**
Latent	−.06	.02	−.06	.12†	−.04	.14†	−.05
$F(4, 13565)$	4.94*	3.77*	4.13*	13.33*	19.63*	16.63*	14.21*
η^2	.001	.001	.001	.004	.006	.005	.004

The pairwise comparisons method is Tukey's HSD (We chose Tukey's HSD because, in contrast to LSD, it corrects for inflation in type I error but is less conservative than the Bonferroni correction. Tukey's HSD is generally considered a good correction method when comparing all possible pairs.). A subscript "a" indicates that the major is significantly more self-determined than Business/Management/Finance in that specific dimension of motivation; a subscript "c" indicates that the major is significantly less self-determined than Social Sciences/Humanities in that specific dimension of motivation; a subscript "b" means that the cell is both significantly more self-determined than Business/Management/Finance and less self-determined than Social Sciences/Humanities; and cells without a subscript mean that the major is not significantly different from Business/Management/Finance or from Social Sciences/Humanities. Boldface type plus a subscript capital "S" mean that the specific major is significantly more self-determined than the population mean, whereas a subscript "N" means that the major is significantly lower in self-determination (N for "non-self-determined") than the population mean in that dimension of motivation. For the latent means, the column headed "SDI/General" refers to the general self-determination factor

Soc Sci Social Sciences, *Engr/Tech* Engineering/Technology, *Nat Sci* Natural Sciences, *Biz/Mgt/Fnc* Business/Management/Finance

*$p < .007$, †$p < .004$

and the overall SDI and lower in introjected and external extrinsic motivation and amotivation).

Figure 3 shows that the pattern of results supported our primary hypotheses once again: Students in Business/Management/Finance majors are low on the left side (autonomous dimensions) and high on the right side (controlled dimensions); the opposite pattern was observed for students in Social Sciences/Humanities; students in the other majors tended to display levels of self-determination that were close to the mean level. Z-test significance results (Table 4) showed that students majoring in Business/Management/Finance are significantly less self-determined than the population mean in intrinsic motivation, identified and introjected extrinsic motivation, and amotivation, plus the overall SDI (i.e., lower in intrinsic motivation, identified extrinsic motivation and the overall SDI and higher in introjected extrinsic motivation and amotivation); Social Sciences/Humanities students are significantly more self-determined than the population mean in all dimensions of motivation plus the SDI (i.e., higher in intrinsic motivation, integrated and identified extrinsic motivation, and the overall SDI and lower in introjected and external extrinsic motivation and amotivation).

In our secondary comparisons, Natural Sciences students scored significantly lower on introjected extrinsic

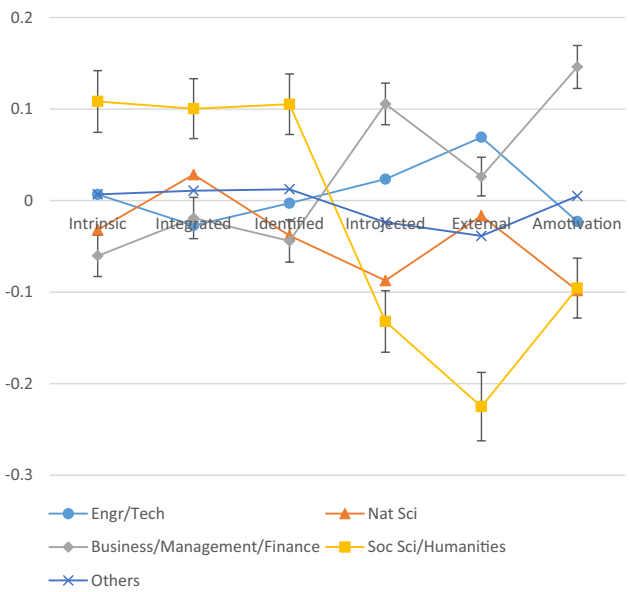

Fig. 3 Self-determination Z-scores by major in Study 2. *Soc Sci* Social Sciences, *Engr/Tech* Engineering/Technology, *Nat Sci* Natural Sciences, *Biz/Mgt/Fnc* Business/Management/Finance. Error bars show standard errors for Social Sciences/Humanities and Business/Management/Finance. Error bars represent standard errors and are displayed only for the Biz/Mgt/Fnc and Soc Sci/Humanities groups

Table 5 Loading results of the bifactor exploratory structural equation modeling analysis in Study 2

Items	General SD	Intrinsic	Integrated	Identified	Introjected	External	Amotivation
Intrinsic							
Item 1	.77	**.47**	< .01	< .01	.06	− .06	.29
Item 2	.84	**.45**	− .03	.03	.03	− .04	.15
Item 3	.83	**.45**	− .04	< .01	.02	− .05	.13
Integrated							
Item 1	.66	.08	**.30**	.10	.05	.03	.03
Item 2	.72	− .05	**.52**	.02	.03	.03	− .03
Item 3	.74	− .08	**.40**	− .10	.14	.02	− .03
Identified							
Item 1	.87	− .05	.04	**.27**	.05	.05	.05
Item 2	.87	.11	< .01	**.15**	.04	.01	.01
Item 3	.84	− .07	.08	**− .14**	.05	− .01	.03
Introjected							
Item 1	.10	.05	.04	.02	**.73**	.14	− .04
Item 2	.09	.03	.01	.12	**.84**	.19	− .01
Item 3	.28	− .01	.07	− .14	**.73**	.14	− .05
External							
Item 1	− .31	− .02	− .02	.04	.10	**.75**	.06
Item 2	− .11	− .03	< .01	− .01	.16	**.79**	< .01
Item 3	− .30	− .04	.07	− .01	.25	**.65**	.05
Amotivation							
Item 1	− .28	< .01	− .01	− .02	.25	.05	**.85**
Item 2	− .32	− .01	− .01	.03	.20	− .01	**.68**
Item 3	− .53	− .02	.10	− .02	.21	.11	**.41**

Bold values indicate the items' loadings on their designated factors

motivation and amotivation. Engineering/Technology students scored the highest on external extrinsic motivation (and are significantly more externally regulated than the population mean).

Supplemental analysis: refuting the match hypothesis Consistent with the results obtained in Study 1, the regression results showed that the SDI is consistently a significant predictor for learning gains and course grade. None of the interaction terms between SDI and major dummy coding was significant in predicting course grade. However, when predicting self-assessed learning gains, the interaction between business-related major (vs. All Others group) and SDI was significant (standardized $b = .04$, $t(13564) = 3.62$, $p < .001$), and the direction of this interaction term suggests that being a Business/Management/Finance student, compared to All Others, actually magnifies the association between SDI and self-perceived learning gains. In other words, although students in business-related majors report lower self-determination, the importance of self-determined motivation is actually greater for them in relation to self-assessed learning gains. The significance is unexpected, but it nevertheless refutes the match hypotheses.

Bifactor ESEM analysis of major differences

The bifactor ESEM fits the data well ($\chi^2(48) = 1549.52$, $p < .001$; CFI = .99, TLI = .97, RMSEA = .05). The loading pattern generally supported the hypothesized structure and replicated previous studies (Howard et al. 2016) so that all the items loaded on their respective factor significantly except for the identified subscale, for which the items did not load adequately ($bs < .30$). All the loadings on nontarget factors are nonsubstantial (all $bs < .30$). The loadings of the 18 items on the general self-determination factor generally followed a continuum in which amotivation has the most negative loadings and intrinsic motivation has the most positive loadings (Table 5). This pattern is again interrupted, however, by the identified items, which loaded most strongly on the general factor. Given that the overall fit and loading pattern are supported, we proceeded to invariance tests, interpreting the identified subscale with caution.

Invariance tests showed that the structure of the scale is invariant between the three large categories of majors up to the variance–covariance level (Table 6). When we imposed the constraints, the change in CFI was within .01 (and the fit actually improved for the TLI and RMSEA). In other words, the proposed configuration of the scale structure, the

Table 6 Fit results of invariance tests in the bifactor ESEM analysis in Study 2

Model	χ^2	df	CFI	TLI	RMSEA
Original bifactor ESEM	1549.52	48	.99	.97	.05
Configural invariance	1874.10	144	.99	.97	.05
Weak invariance	2019.95	298	.99	.99	.04
Strong invariance	2063.03	320	.99	.99	.04
Strict invariance	2178.67	356	.99	.99	.03
Variance–covariance invariance	2402.76	412	.99	.99	.03

loadings of items on latent constructs, the item intercepts, the item uniqueness, and the variance–covariances of the latent constructs are all equivalent across the three types of majors. Given this equivalence or comparability of the scale across majors, we proceeded to compare the latent means. As shown in Table 4, compared to the All Others group, for which the latent means are set to 0 as a reference point, Social Sciences/Humanities students are significantly lower in introjected and external extrinsic motivation, and higher in general self-determination; Business/Management/Finance students are significantly higher in introjected extrinsic motivation and amotivation; and Business/Management/Finance students are also marginally lower in general self-determination ($M = -0.05$, $p = .08$). We also directly compared Social Sciences/Humanities students to Business/Management/Finance students (the latter set as a reference point with latent means of 0; these results are not shown in Table 4), and the results showed that Social Sciences/Humanities students are significantly higher in general self-determination ($M = 4.11$, $p < .001$) and lower in amotivation ($M = -2.49$, $p < .05$), external motivation ($M = -4.10$, $p < .001$) and introjected extrinsic motivation ($M = -5.76$, $p < .001$).

Examination of possible explanations

Examining the role of learning climate: a structural equation modeling analysis The structural equation modeling results supported our hypotheses. The correlations between indicator variables are shown in Table 7, and the structural equation model results are shown in Fig. 4. As shown in Fig. 4, students in Social Sciences/Humanities majors are more likely to take both Social Sciences/Humanities courses and Business/Management/Finance courses, and Business/Management/Finance majors are more likely to take Business/Management/Finance courses but less likely to take Social Sciences/Humanities courses. Social Sciences/Humanities courses are higher in student-centered learning climate than All Others majors, and vice versa for Business/Management/Finance courses. Learning climate then significantly positively predicts SDI, which then positively predicts self-assessed learning gains and grade beyond the grade inflation effects (direct effect from course coding to grade). The overall fit of the model is good: $\chi^2(47) = 1266.79$, $p < .001$; CFI = .96, TLI = .95, RMSEA = .04. Tested using bias-corrected bootstrapping resampling, the indirect effects of Business/Management/Finance majors are significantly negative on SDI (standardized coefficient = −.024, $p < .001$) and self-assessed learning gains (standardized coefficient = −.017, $p < .001$), and the indirect effects of Social Sciences/Humanities majors are significantly positive on SDI (standardized coefficient = .006, $p < .01$), self-assessed

Table 7 Correlations between variables in the structural equation modeling analysis in Study 2

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. SS/H major	.07	.25	–											
2. B/M/F major	.15	.36	−.11***	–										
3. SS/H course	.44	.50	.13***	−.06***	–									
4. B/M/F course	.07	.26	−.01	.32***	−.26***	–								
5. LC parcel 1	5.59	1.34	.00	−.03***	.08***	−.07***	–							
6. LC parcel 2	5.29	1.46	−.01	−.01	.09***	−.06***	.86***	–						
7. LC parcel 3	5.42	1.42	−.00	−.02	.10***	−.06***	.88***	.88***	–					
8. SDI parcel 1	5.35	14.13	.05***	−.04***	−.00	−.04***	.48***	.48***	.47***	–				
9. SDI parcel 2	8.15	11.84	.05***	−.04***	.02*	−.03***	.51***	.50***	.50***	.86***	–			
10. SDI parcel 3	6.37	12.21	.05***	−.04***	.03***	−.04***	.49***	.49***	.49***	.84***	.88***	–		
11. SALG	3.65	1.00	.01	−.03**	.03*	−.03**	.49***	.49***	.49***	.56***	.54***	.53***	–	
12. Grade	3.24	.92	−.01	.04***	.22***	−.00	.17***	.16***	.19***	.17***	.23***	.22***	.14***	–

Variables 1–4 are dummy coded, so the mean for these variables indicates the percentage of responses that fall into the type of major or course

SS/H Social Sciences/Humanities, *B/M/F* Business/Management/Finance, *LC* learning climate, *SALG* self-assessed learning gains

*$p < .05$, **$p < .01$, ***$p < .001$

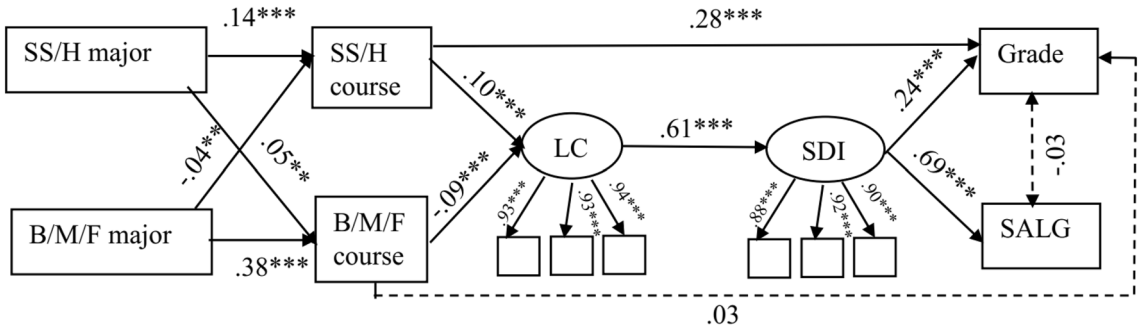

Fig. 4 Structural equation model examining the socialization explanation in Study 2. Residuals are omitted from the diagram. Squares under LC and SDI are their respective parcels (parcel name omitted from the squares due to space constraints). *SS/H* Social Sciences/Humanities; the SS/H course variable is a dummy-coded variable with Social Sciences/Humanities coded as 1 and All Others as 0. *B/M/F* Business/Management/Finance; the B/M/F course variable is a dummy-coded variable with Business/Management/Finance coded as 1 and All Others as 0. *LC* learning climate, *SDI* self-determination index, *SALG* self-assessed learning gains. ***$p < .001$, **$p < .01$

learning gains (standardized coefficient = .004, $p < .01$), and grade (via Social Sciences/Humanities courses: standardized coefficient = .002, $p < .001$; via Business/Management/Finance courses: standardized coefficient = − .001, $p < .05$).

Comparing autonomous functioning among newly enrolled students One-way ANOVA showed significant differences between majors on the IAF ($F(2, 1358) = 4.76$, $p < .01$). Tukey HSD post hoc tests showed that students in Business/Management/Finance majors ($M = 5.62$, $SD = 1.56$) are significantly lower in the IAF compared to either All Others ($M = 6.09$, $SD = 1.81$; $d = -0.26$, $p < .01$) or the Social Sciences/Humanities group ($M = 6.26$, $SD = 1.92$; $d = -0.35$, $p < .05$). Social Sciences students are higher on the IAF than students in All Others, but the difference is not significant ($d = 0.09$, $p > .05$). The results partially supported the difference between newly enrolled students in autonomy at the individual difference level.

Summary

Study 2's primary results using ANOVA and latent mean comparison techniques converged in showing a pattern that is consistent with the results of Study 1, i.e., Business/Management/Finance students are less self-determined and Social Sciences/Humanities students are more self-determined in studying. Notably, though, whereas traditional ANOVA showed that the between-major difference applied across most dimensions of motivation, the bifactor ESEM analysis showed that the differences in latent means were mostly in the general SDI and the controlled motivation dimensions. In Study 2, students majoring in Natural Sciences scored relatively low on introjected and amotivation (i.e., more self-determined). Engineering/Technology students scored high on external extrinsic motivation in Study 2.

The current research includes one of the first attempts to analyze self-determined motivation using a bifactor ESEM approach. The results generally replicated the first study in this area (i.e., Howard et al. 2016): The model with good fit and strong loadings supported the measurement structure of the academic self-determination scale while providing evidence for the validity of the bifactor ESEM methods. Notably, our results departed from Howard et al.'s findings in that external items loaded negatively on the general self-determination factor. Howard et al. (2016) questioned the nature of the "continuum" of self-determination because in their analysis, only amotivation items loaded negatively on the general self-determination factor, and all the other loadings were positive. In contrast, according to SDT, introjected and external extrinsic and amotivation should all load negatively on the general factor because they represent the absence rather than the presence of self-determination. Hence, our finding is more in line with the nature of the continuum conceptualized in SDT. It is possible, though, that our external extrinsic items are "less controlled" than those used by Howard et al. (2016).

However, we did find that the identified items loaded poorly on its subscale; in addition, the identified items loaded most strongly on the general factor, breaking the continuum pattern. In fact, these two anomalies might be related: The identified items might not stick together sufficiently, meaning that they are more a reflection of the general self-determination factor than of the specific qualities of the identified subtype. We reexamined the items "Because it allows me to develop skills that are important to me," "Because it's a sensible way to get a meaningful experience" and "Because it's a practical way to acquire new knowledge." These items do not seem to be different from those used in other self-determination motivation scales (e.g., Gagné et al. 2015; Ntoumanis 2001; Ryan and Connell 1989). The only perceptible difference from previous self-determination

scales used in bifactor ESEM (Howard et al. 2016) is that we asked about more specific facets of the activity (e.g., acquiring knowledge, developing skills) rather than about generally "putting effort" into the activity. More research is needed in the future to explicate this unexpected finding.

The two possible explanations we proposed for the difference between majors both obtained some support. On one hand, the structural equation model results supported the idea that the difference in self-determined motivations is due in part to the different levels of autonomy support provided by classes that students take in different majors. On the other hand, there is also some evidence that students are already different in their autonomous functioning at the individual difference level shortly after they are enrolled in college. Therefore, it seems that the difference develops in a dynamic process in which students who chronically function in an autonomous rather than a controlled way tend to enter certain disciplines, which in turn further shape their motivation toward coursework.

Conclusion and discussion

Main findings

Taken together, the ANOVAs, Z-tests, and bifactor ESEM analyses from the two studies converged to support our primary propositions. That is, students in business-related majors are low in self-determined academic motivation; students in social sciences and humanities majors are high in self-determined motivation; and students in science, technology, engineering and mathematics (STEM) and other majors are somewhere between these two major categories. The current results contribute to previous findings on difference between majors: Whereas past research has noted that college major plays a role in explaining student outcomes such as persistence (Leppel 2001) and well-being (Sheldon and Krieger 2004, 2007), the current study suggests that self-determined motivation is an important explanatory factor underlying these phenomena. The current findings are consistent with recent similar findings (Yu et al. 2018).

Interestingly, the different methodologies also converge on some more detailed aspects of the phenomenon. For example, the bifactor ESEM results showed that business-related majors are less self-determined, mainly because of being lower in general self-determination and higher in controlled motivation. This pattern resonates with the Z-score plots (Figs. 2, 3) in which we observe that the business-related majors are high mainly on the right (non-self-determined) side of the plot. The results acquired from different methodologies diverge in several respects. For example, in Figs. 2 and 3, we see Social Sciences/Humanities as being both high in autonomous and low in controlled types of motivation, but in the bifactor ESEM analysis, we find only Social Sciences/Humanities to be significantly different in the controlled dimensions and general self-determination but not in the autonomous dimensions. Indeed, the bifactor ESEM method is not particularly supportive of our hypothesized difference between majors in the three self-determined types of motivation. It might be that the difference observed for Social Sciences/Humanities in the self-determined dimensions in the Z-plots can be attributed mostly to the general quantity factor of self-determination. More future replications are needed to validate these findings.

Our secondary comparisons showed that the scores of Engineering/Technology students are very close to the population mean. The results for Natural Sciences students show some inconsistency across the two studies. Whereas in Study 1, Natural Sciences students scored as less self-determined on intrinsic and external extrinsic motivation than the population average, in Study 2, they were significantly more self-determined on introjected extrinsic motivation and amotivation dimensions. These inconsistent results point to potentially conflicting dynamics. Future studies could further target Natural Sciences as well as Engineering students' specific motivations.

The current study refutes the match hypothesis, confirming that self-determined motivation is important for all majors. In fact, in both Study 1 and Study 2, we found evidence that students from business-related and other majors that are not as supportive as the social sciences and humanities majors may actually benefit more from a self-determined learning motivation in terms of subjective learning outcomes. As such, our findings are consistent with previous research showing that students who are overall less self-determined tend to be more affected by the situational level of self-determination (e.g., Black and Deci 2000; Tsai et al. 2008; but see Mouratidis et al. 2011, for a counterexample).

The current study also supported the two hypothesized mechanisms for the difference, so that both socialization in the academic disciplines and individual difference in the selection of majors seem to be at play in the phenomenon. Previously, the socialization versus selection framework was used primarily under the framework of the work values tradition of research (e.g., the person-environment fit of work values, or PE-fit; Holland 1958). The current study contributes by extending the selection and socialization mechanisms to another important dimension of vocational psychology, i.e., the self-determined motivation to engage in disciplinary learning. The implications are quite different for socialization versus selection as studied in the PE-fit context and in the current SDT context. In the PE-fit literature, the organization can impact individuals' functioning and attrition via both socialization and selection processes so people should either optimize the individual-organization fit or strengthen the socialization

process. However, in the SDT perspective, given that "not all motives are born equal" or "not all majors are born equal", the focus should not be to promote fit but to improve the self-determined functioning of both the organization and individuals therein. Below, we further discuss the implications of the current findings.

Implications

What do all these results tell us about what we can do? We believe that differences regarding self-determined motivation among majors will essentially remain, although limited improvements can be realized. As we reasoned in the Introduction, business-related majors are less self-determined because their overarching goal is to make money, whereas social sciences and humanities majors are more self-determined because those majors promote social and personal development—these are the inherent and defining characteristics of these majors, and as long as these majors continue to be governed by these overarching features (and we see no reason for this to change), the differences in self-determined motivation will remain. As an analogy, some jobs are inherently more conducive to physical health than are others (e.g., the job of a P.E. teacher may be inherently physically healthier than the job of a software programmer), and these fundamental differences will remain.

However, just as software companies such as Google can improve their employees' physical health by providing indoor climbing walls and exercise classes, there are limited tools that can be applied within certain disciplines to improve the self-determined motivation in their students. As noted in our results on the "socialization effect," the learning environment plays a key mediating role between majors and their students' motivation. Therefore, even though the broader environment (i.e., inherent disciplinary differences) cannot be changed, the proximal micro-climate created by the instructors (along with administrators and campus counselors) can still have a large impact. The recent trend in universities to establish teaching centers to assist faculty in building more supportive learning environments is a timely response to this call.

In terms of the "selection effect," our findings that students' individual differences in autonomous functioning lead to tendencies toward autonomy versus control in college career choice point to the importance of promoting autonomy outside the realm of a college education. In that regard, autonomy support provided by parents (e.g., Soenens et al. 2007) and the value orientation promoted by society overall (e.g., Kasser et al. 2007) are examples of how social contexts can help young people develop more autonomy at the individual level.

Limitations

We should consider that in the current analyses, all the participants are from the same US university, which may limit the generalizability of our conclusions. For example, this university has no medical school, and we thought medicine might be an interesting major to examine. Similarly, our findings do not reveal whether the relationships would also hold for other countries and cultural settings (e.g., tribal colleges). In addition, the highly unequal group sizes in the current samples, especially the relatively small size of some of the majors, may have limited our power to examine certain differences, especially in Study 1 and the comparison of the IAF in Study 2. For example, we had < 70 students in the Social Sciences/Humanities majors in our comparison of the IAF, and we might have detected a significant difference between students in Social Sciences/Humanities and All Others had we had more Social Sciences/Humanities students. However, we should also note that many of the effects detected are rather weak but still significant due to the relatively large overall sample size. For example, the omnibus tests for the differences between majors in motivation is quite weak (all η^2s $< .02$, as shown in Tables 3, 4), and we might not have been able to detect significance in some of the comparisons with a smaller sample. Therefore, although the difference between majors seems reliable, we would caution against the exaggerated interpretation of its practical significance.

Another limitation is that the self-assessed learning gains measurement is a convenient instrument. We decided to include it in the analyses because we found some evidence that it could serve as an acceptable indicator of subjective learning achievement, providing incremental support for the effect of motivation on learning outcome in addition to course grade. In addition, it is involved only in nonprimary analyses, and its results are always examined side by side with course grade. That said, this measure treats self-assessments in all types of knowledge/skills (which differ by course) the same way, which assumes that all the self-assessments contribute similarly to perceived learning performance. This practice is unconventional, and the assumptions may not hold, so the relevant results should be interpreted with caution.

Finally, our analyses of the mechanisms of the differences are quite preliminary. We treated the two mechanisms separately, and future research using more systematic methods (e.g., longitudinal design) is needed to compare their respective effects and further explicate the processes underlying the phenomenon.

Concluding remarks

The idea of the university, or of modern education in general, is deeply rooted in the ancient Greek ideal of liberal arts—an education that prepares the individual to live as a free person who is able to engage fully in civic life. However, this noble ideal has somehow been lost in the modernization process of education. Many modern majors provided in universities have become professionally oriented, compartmentalized from other aspects of the whole person, and/or studied for merely utilitarian reasons. As our supplemental analyses show, self-determination is important for the development of all students, regardless of major. We hope our contribution may raise the awareness of the suboptimal nature of certain academic areas and help promote learning environments that facilitate the optimal development of young people.

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Compliance with ethical standards

Ethical approval The research was approved by the institutional review board at the university at which the data collection took place and was performed in accordance with the ethical standards as described in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

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