Learning and Motivation 90 (2025) 102118

Contents lists available at ScienceDirect

Learning and Motivation

journal homepage: www.elsevier.com/locate/l&m

Fostering autonomous motivation in first-year college students: A self-determination theory-based online intervention

Yurou Wang [a,1], Yadan Zhao [b,*,2], Jihong Zhang [c,3], Kaiwen Man [a,4], Junfei Lu [a,5]

[a] University of Alabama, USA
[b] Dalian University of Foreign Languages, China
[c] University of Arkansas, USA

ARTICLE INFO

Keywords:
Self-determination Theory
Achievement motivation
Intervention
First-year college students
Autonomous motivation

ABSTRACT

Achievement motivation plays a crucial role in shaping college students' academic success and future prospects. This study developed and evaluated a self-determination theory (SDT)-based online intervention designed to enhance first-year college students' optimal types of achievement motivation (i.e., autonomous motivation). The research was conducted in two phases: a pilot study (Study 1) to test the initial intervention and a full-scale randomized controlled trial (Study 2) to assess its effectiveness. In Study 1, 128 students participated in the intervention, and feedback from students and educators was used to refine the program. Study 2 implemented the improved intervention with 125 first-year college students in an experimental group, while 199 students served as a control group. We examined whether the intervention increased students' identified regulation, integrated regulation, and intrinsic motivation. Path analysis and ANOVA revealed significant increases in all three types of autonomous motivation for students in the experimental group compared to the control group. Although academic performance (final exam scores) was also measured, no significant differences were found between the groups. Additionally, qualitative responses indicated greater self-awareness of motivation, improved future planning, and reduced anxiety among students who received the intervention. These findings suggest that SDT-based interventions can effectively foster autonomous motivation and provide a framework for designing future motivational interventions in higher education.

1. Introduction

Motivation refers to the drive that fuels our actions, while achievement motivation specifically relates to the drive to perform in situations where standards of excellence are applied (Eccles et al., 1998). First-year college students face numerous challenges, including academic transitions, social and emotional adjustments, and financial pressures (Chemers et al., 2001; Kantanis, 2000; Zhang, 2021). These challenges frequently lead to a decline in achievement motivation (Haynes et al., 2006; Kowalski, 2007). Yet,

* Correspondence to: 407 Chongde Building, Dalian University of Foreign Languages, Dalian, Liaoning, China.
E-mail address: vickyzhao123@126.com (Y. Zhao).
[1] ORCID: https://orcid.org/0000-0002-2176-2069
[2] ORCID: https://orcid.org/0009-0003-6180-8847
[3] ORCID: https://orcid.org/0000-0003-2820-3734
[4] ORCID: https://orcid.org/0000-0002-9696-9726
[5] ORCID: https://orcid.org/0000-0002-7369-8417

https://doi.org/10.1016/j.lmot.2025.102118
Received 30 December 2024; Received in revised form 26 February 2025; Accepted 26 February 2025
Available online 14 March 2025

sustaining achievement motivation is critical, as it significantly influences academic performance (Alhadabi & Karpiniski, 2020; Friedman & Mandel, 2011), retention (Demetriou & Schmitz-Sciborski, 2011), student engagement (Zepke & Leach, 2010), career planning (Clements & Kamau, 2018), and mitigating academic dishonesty (Anderman & Koenka, 2017). Given this context, there is an increasing need for interventions to bolster the motivation of first-year college students.

This study is grounded in self-determination theory (SDT), a framework well-suited for understanding student motivation dynamics (Deci & Ryan, 2000). SDT is rooted in the organismic perspective, and it has been widely applied to achievement settings. Although SDT extends beyond traditional achievement motivation theories, its insights into intrinsic and extrinsic motivation make it a relevant framework within this domain. Intrinsic motivation, where students find learning enjoyable and interesting (Black & Deci, 2000), is the most self-determined form of motivation. However, fostering intrinsic motivation in first-year college students is challenging due to the internal and external pressures they face (Girelli et al., 2018). Organismic Integration Theory (OIT), a key mini-theory within SDT, provides insights into addressing this challenge (Pelletier & Rocchi, 2023)

OIT conceptualizes motivation as a continuum, ranging from controlled to autonomous forms (Table 1; Ryan & Deci, 2020). Understanding this continuum is essential for designing interventions that promote optimal types of motivation. Autonomous extrinsic motivation includes *identified regulation*, where individuals recognize the value of an activity, and *integrated regulation*, where external motivations align with personal values, allowing engagement without internal conflict. Unlike intrinsic motivation, autonomous extrinsic motivation is driven by value rather than enjoyment (Filgona et al., 2020). In contrast, controlled motivation consists of *external regulation*, driven by rewards or punishments, and *introjected regulation*, which involves behavior motivated by ego (introjected-ego) or guilt avoidance (introjected-guilt; Wang & Wind, 2020b). Collectively, identified regulation, integrated regulation, and intrinsic motivation form autonomous motivation, while external and introjected regulation constitute controlled motivation. While students may experience multiple motivation types simultaneously, interventions should focus on shifting controlled motivation toward more autonomous forms to support long-term academic success (Sobral, 2004; Soom & Donche, 2014).

Given the importance of fostering autonomous motivation, various interventions have been developed to enhance college students' autonomous motivation through classroom discussions (Butz & Stupnisky, 2017), medical bedside teaching (Moll-Khosrawi et al., 2021), satisfying students' basic psychological needs (i.e., autonomy, competence, and relatedness; e.g, Behzadnia & FatahModares, 2023, Niemiec & Muñoz, 2019, van den Boogaard et al., 2024), and counseling services (Law & Liu, 2021). Recent research continues to explore effective ways of fostering need-supportive learning environments in online settings. For example, Paap et al. (2025) conducted a web-based need-supportive intervention for physical education teachers, demonstrating significant positive effects on students' perceived autonomy, competence, and relatedness satisfaction. This study underscores the potential of digital interventions in promoting students' autonomy and engagement.

While considerable progress has been made in designing and implementing SDT-based interventions, two key limitations remain. First, the majority of research on SDT interventions has been concentrated at the K-12 level, with fewer studies focusing on higher education (Wang et al., 2024). Given that university students face distinct challenges related to autonomy and motivation, this lack of targeted interventions represents a gap in the literature (Butz & Stupnisky, 2017). Second, most SDT-based interventions are designed to improve student motivation indirectly by training teachers or manipulating external factors, rather than addressing students' internal needs and mindset directly. While these interventions have shown promise, they rely heavily on teachers' willingness and ability to implement autonomy-supportive practices effectively, which may vary widely across educational contexts (Hospel & Galand, 2016). This focus on teachers limits the potential reach of SDT interventions by overlooking the direct role that students themselves can play in developing their motivation and autonomy.

Notably, Patall et al. (2022) introduced a student-centered intervention involving SDT, demonstrating that fostering an agentic mindset at the start of the semester led to higher engagement, need satisfaction, personal interest, and retention in the field. This suggests that directly involving students in SDT-based interventions can be a powerful strategy. However, such student-focused interventions remain scarce.

Table 1
Motivation and Regulation Styles.

Motivation	Extrinsic Motivation					Intrinsic Motivation
	Controlled Motivation			Autonomous Motivation		
Regulation Styles	External Regulation	Introjected-Ego Regulation	Introjected-Guilt Regulation	Identified Regulation	Integrated Regulation	Not Applicable
Motivational force	• External rewards or punishment • Compliance • Reactance	• ego-involvement • focus on approval from self and others	• Guilt • Shame	• Personal Importance • Conscious valuing activity • Self-endorsement of goals	• Congruence • Synthesis and consistency of identifications	• Interest • Enjoyment • Inherent satisfaction

Note. Adopted and adjusted according to Ryan & Deci, 2020; Wang & Wind, 2020b.

2. The current intervention

To address these limitations, this study develops and tests *an online student-centered SDT-based intervention* designed to enhance first-year college students' autonomous motivation. To ensure the effectiveness of our intervention, we carefully followed several Social-Psychological Intervention (SPI) principles, as outlined in prior research (i.e., understanding students' needs, conceal intervention intention, and at educational transitions; Walton, 2014; Cohen et al., 2009; Yeager & Walton, 2011). Additionally, the intervention video was designed to align with SDT principles, ensuring that it satisfies students' three basic psychological needs of autonomy, competence, and relatedness (Deci & Ryan, 2008; Niemiec & Ryan, 2009; Reeve, 2009).

Our research question is whether this intervention could effectively shift first-year college students' motivation toward more autonomous forms and ultimately enhance their academic performance. To address this research question, we employed a randomized controlled trial (RCT) design, randomly assigning first-year college students to either an experimental group, which received the intervention, or a control group, which did not. This approach allows us to examine causal relationships between the intervention and shifts in students' motivational orientations and academic outcomes while controlling for potential confounding variables and ensuring internal validity.

Based on SDT, we hypothesize that students in the experimental group will exhibit a significant increase in autonomous motivation types, while displaying a decrease in controlled motivation types. Furthermore, we anticipate that these motivational shifts will correlate with enhanced academic performance, as evidenced by higher exam averages for students in the experimental group compared to those in the control group. This study thus makes a meaningful contribution to SDT-based intervention research, demonstrating how directly targeting students' internal thinking process can foster autonomous motivation and positively impact academic outcomes in first-year college students.

We conducted two phases of research. In Study 1, we implemented a pilot study to assess the feasibility and initial impact of the intervention with a smaller sample of first-year college students, allowing us to refine both the intervention content and research procedures. Insights from Study 1 informed the development of Study 2, our full-scale, randomized controlled trial, designed to rigorously test the intervention's effectiveness on a broader scale. Together, these studies provide a comprehensive examination of how SDT-based interventions can enhance students' autonomous motivation and academic outcomes. The following sections detail the design, methodology, and findings of each study.

3. Study 1

In Study 1, we aimed to test a newly developed SDT-based intervention to determine whether it effectively improved students' achievement motivation. The main purpose of the intervention was to help students understand why some types of motivation can lead to negative effects and help them adopt a healthier form of motivation. Moreover, we hope the intervention could help them understand their own motivation better, and ultimately decrease their external and introjected motivation, and increase their identified and integrated motivation. We recruited 144 first-year college students from Finance majors at a university in northeastern China. Sixteen students did not complete the entire intervention (missing rate = 11.1 %). Therefore, the final sample consisted of 128 students who had completed the pretest, the intervention session, and the posttest. 22.6 % of participants were men. The average age of the participants was 19.6 (SD = 1.67) years old.

3.1. Procedure

The intervention was designed according to the social-psychological intervention design rules discussed above. The 40-minute intervention session consisted of four parts: the pre-video ordering activity, video, discussion, and post-video ordering activity. The instructor started her online teaching session via DingTalk (online meeting software similar to Zoom) and said they were doing something different that day. We did not disclose the purpose of the intervention to the participants (Yeager & Walton, 2011). Instead, the participants were told they were helping the university develop a new program for freshmen. The instructor first sent out the pre-video ordering activity (See Appendix B) link and gave students 10 minutes to finish the activity. Such activity proved to promote the intervention's effectiveness, as it asked students' perspectives but did not directly push them to think in a certain way (Hulleman & Harackiewicz, 2009).

After students confirmed they had finished the activity, the teacher played a 7-minute psychoeducation video about SDT (specified below). The video is warm and welcoming, instead of simply pushing ideas on students. Following the video presentation, students were asked to talk about the video freely, and after a short discussion, the instructor picked five students to share their thoughts. After students finished sharing, the instructor sent out the post-video activity for students to complete which had the same questions as the pre-video activity, except two open-ended questions that asked about students' feelings towards and suggestions for this newly developed program for freshmen. The pre and post video activities were designed to engage students only, so the ordering activities data were not analyzed. Only the two open-ended questions were analyzed. The post-video activity took students about 15 minutes. The intervention session ended after students completed the post-video activity.

3.2. The psychoeducation video

The development of the 7-minute psychoeducation video followed a structured, theory-informed process to ensure alignment with Self-Determination Theory (SDT) and to rigorously support students' psychological needs for autonomy, competence, and relatedness.

The first and fifth authors, as the design team, both experts in motivation, led the design process and were supported by five graduate students, who contributed through interviews that provided real-world perspectives on different motivational types. This methodological process was inspired by multimedia learning design principles and qualitative methods used in intervention research, where iterative feedback and real-world examples enhance the intervention's relatability and effectiveness (Mayer, 2014; Hulleman & Harackiewicz, 2009).

The design process consisted of multiple stages. Initially, the first and fifth authors collaborated in **conceptual alignment sessions** to determine key SDT principles—specifically different types of motivation and three basic psychological needs—that would guide the video content. They established an outline that included essential motivational concepts (e.g., types of motivation, intrinsic motivation's role in well-being) and structured the video to facilitate open, reflective engagement with these ideas.

In the **content development phase**, the authors drafted a script that included an expert's explanation of extrinsic and intrinsic motivations, along with their impacts on academic performance and well-being. To enrich the video with authentic perspectives, the authors interviewed five graduate students, all Chinese graduates from U.S. universities who wore masks during recording to maintain anonymity. These students' responses were de-identified and integrated into the video to illustrate various motivations, creating a relatable narrative for viewers. This approach not only enhances relevance and relatability but also supports relatedness by normalizing diverse motivational experiences among students (Ryan & Deci, 2017). We also include content about how students can actively seek environments that enhance their autonomous motivation.

The **storyboard and feedback phase** allowed the design team to map visual and narrative elements, reviewing clarity and engagement through pilot feedback from other team members (i.e., the second, third, and fourth authors, as well as the five graduate students we interviewed). Guided by feedback, the design team made adjustments to ensure an autonomy-supportive tone, promoting open-ended reflection rather than directive statements (Reeve, 2009).

In the **production and finalization phase**, the first and fifth authors supervised production to ensure the video's pacing, tone, and structure supported students' feelings of competence, with practical strategies that students could implement independently. The expert explanations were kept concise and were structured to progressively build students' understanding, supporting competence by fostering clear and achievable learning goals (Hulleman et al., 2010).

The **review and validation phase** provided an opportunity to confirm the video's alignment with SDT. The team conducted a final evaluation to ensure that the video supported autonomy through non-prescriptive language, competence by providing actionable insights on managing motivation, and relatedness through relatable peer examples. By including authentic, de-identified interviews with graduate students, the intervention created a sense of community among participants, grounding theoretical concepts in real experiences. See Appendix C for the transcript of the intervention video.

3.3. Surveys

We adopted the internalization of learning motivation (ILM) scale (Wang & Wind, 2020b) to measure regulation styles. It is a 7-point Likert scale with 24 items including five subscales that measure different regulation styles with great internal consistency and reliability (external regulation (α =.841), introjected-ego regulation (α =.895), introjected-guilt regulation (α =.864), identified regulation (α =.874), integrated regulation (α =.913); see Appendix A for the complete survey). Because the ILM scale's English and Chinese versions were already validated in the original survey development study, there was no need to translate the ILM into Chinese. A careless-checking item (i.e., "*For this item, please choose disagree*") was also added to the survey to identify careless responses.

As shown in Fig. 1, we gathered students' responses months before the intervention as the pretest (S1T1). One month after the intervention, we administered the ILM scale again to assess the impact of the intervention on students' motivation (posttest; S1T2).

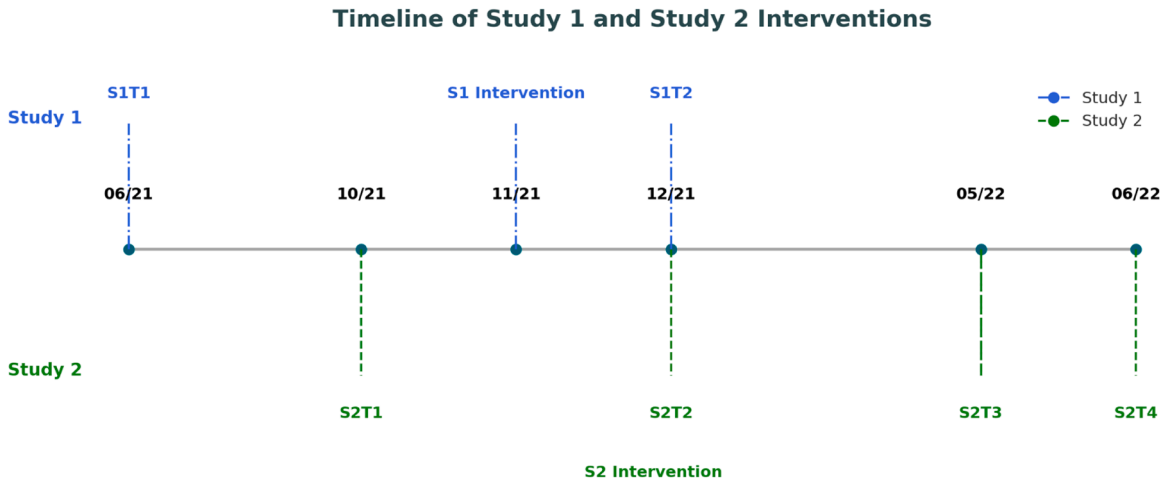

Fig. 1. Study Timeline. *Note. All time points are presented in the format Month/Year (e.g., 06/21 represents June 2021). S1 refers to Study 1, and S2 refers to Study 2. T1, T2, T3, and T4 indicate Time Points 1, 2, 3, and 4, respectively.*

3.4. Data analysis

We took a convergent parallel mixed-method design, in which the qualitative and quantitative data were collected simultaneously, analyzed separately, and then merged to draw conclusions (Creswell & Clark, 2018). For the quantitative data, we first calculated Pearson correlations among motivation subscales as a preliminary analysis. Then, we conducted a path analysis to examine the effects of time (0: pretest; 1: posttest) on the five motivation sum scores. In this analysis, the time variable was treated as a predictor, and each motivation subscale served as an outcome variable. Path analysis has become a widely used methodological tool for evaluating intervention programs with a pretest–posttest design in education and psychology (e.g., Alessandri et al., 2017; Russell et al., 1998). Because we estimated separate regression paths rather than a full structural equation model (SEM) with latent variables and covariances, traditional model fit indices (e.g., CFI, TLI, RMSEA) were not applicable. The time variable was dummy coded so that its effect on each motivation variable represents the change in students' motivation levels from pretest to posttest. We assessed the statistical significance of these time effects using the Wald-z test, with a significance threshold of $p < .05$ (Gonzalez & Griffin, 2001).

In addition to quantitative data, we synthesized the qualitative data we obtained from students through the survey question: "*how do you feel after watching this video?*" and "*do you have any suggestions for the program?*". Because students typed their answers into the survey, their responses did not require transcription. We synthesized the information from these two questions through the thematic method (Braun & Clake, 2006). The initial coding process commenced with open coding, during which segments of data were assigned codes based on their significance and relevance to the research objectives. Codes were continually refined, and an evolving codebook was established to provide structure to the analysis. In addition, the first and fifth authors held meetings regularly to review and refine the coding process, enhancing the rigor and consistency of the analysis. After the initial coding phase, codes were grouped into higher-order themes, following a process of comparison and contrast. Themes emerged through discussions among the research team, with a particular focus on identifying patterns, connections, and relationships within the data. This iterative process led to identifying key themes and subthemes, which were subsequently reviewed for relevance and validity.

3.5. Results

3.5.1. Preliminary analyses

The results of Pearson correlations among sum scores of motivation subscales at time 1 (labelled as S1T1) and time 2 (labelled as S1T2) were presented in Appendix D. Consistent with previous studies about motivation (Wang & Wind, 2020b), external regulation was negatively correlated with two types of autonomously enacted extrinsic motivation (identified regulation: $r_{t1} = -0.273$, $p < .001, r_{t2} = -0.365, p < .001$; integrated regulation: $r_{t1} = -0.239$, $p < .001$, $r_{t2} = -0.287, p < .001$). Identified regulation was positively correlated with integrated motivation ($r_{t1} = 0.895$, $r_{t2} = 0.902$). At both time 1 and time 2, introjected ego regulation had significantly positive associations with introjected guilt regulation ($r_{t1} = 0.624, p < .001; r_{t2} = 0.515, p < .001$). Overall, the results revealed that most motivation variables were moderately correlated with each other except for the pair external regulation and introjected guilt regulation ($r_{t1} = -0.039, p = 0.66; r_{t2} = 0.118, p = 0.19$), which was not statistically significant. We also computed the test–retest reliability of each motivation sum score. All motivation had moderate reliability with values from 0.389 to 0.667.

3.5.2. Path analysis results

Table 2 shows the standardized regression coefficients of time effects on sum scores of motivations from the path analysis. As shown in Table 2, only integrated regulation (*InR*) had a significantly positive time effect between S1T2 and S1T2 ($\beta = 0.36$, $p = 0.008$), which suggested the mean score of integrated regulation increased over time. However, other motivation scores showed non-significantly positive time effects ($\beta_{ER} = .055, p = .375; \beta_{IER} = .097, p = .117; \beta_{IGR} = .070, p = .257; \beta_{IdR} = .118, p = .054$).

3.5.3. Students' feedback

For the first question, "*how do you feel after watching this video?*" we identified three themes among the 128 participants. Thirty students did not provide valuable information to this question, so we excluded them from the analysis.

Theme 1: change in attitude toward learning

Sixty-three students stated this video changed their attitude toward learning. Some students discussed how this video made them

Table 2
The Effect of Time on Motivation in Study 1.

Subscales	*B*	*SE*	*z*	*p*
External Regulation	0.06	0.06	0.89	0.38
Introjected Ego Regulation	0.10	0.06	1.57	0.12
Introjected Guilt Regulation	0.07	0.06	1.13	0.25
Identified Regulation	0.12	0.06	1.92	0.05
Integrated Regulation	**0.16** * *	0.06	2.63	0.01

Note. * : p < .05, * *: p < .01, * ** : p < .001; time = 0 (S1T2) or 1 (S1T2); *B* = Standardized time effect; *SE* = standard error; *z* = z-test value. Significant time effects are boldfaced.

realize the importance of learning. For example, one student said, "*Learning is very important for our life and development, so we cannot ignore the importance of lifelong learning.* Another said, "*I realized that there are so many people in our society who play all the time without learning new things. I think we need to cherish our time and study harder to contribute to society.*" Some students said that after watching this video, they could feel the joy of learning: "*I found this video [to be] very meaningful and useful at the same time. It made me realize that learning would bring me happiness*." Participants also reported the video provided them with a deeper understanding of learning. One student wrote, "*I think learning can make us more resistant towards challenges in our life. We should fall in love with learning, achieve meaningful knowledge, but not be forced to learn.*" Another student mentioned, "*I am enlightened by this video in many ways. I regained the courage to keep learning new things and understand that there are so many reasons for us to learn. We are changing every day, and we can motivate ourselves to use different strategies.*" In general, after watching this video, students realized the importance of learning, understood that learning can be joyful, and reflected on why and how people should keep learning.

Theme 2: understanding of motivation

Fifty-four students mentioned that they have a new understanding of motivation. Specifically, some students talked about their new understanding of intrinsic motivation for learning: "*Having intrinsic motivation is important for learning.*" "*Learning should be driven by internal forces. We should have a specific goal so we can learn better and be more resistant to external temptations.*" Other students discussed their understanding of extrinsic motivation toward learning: "*Learning is for our own good. We do not need to look at others and compare ourselves to other students*." Above all, the students' answers demonstrated they understood achievement motivation.

Theme 3: reflection on current emotion status

Surprisingly, students opened up and shared their current emotional status with the research team when answering this question. Ten students expressed this video helped them process their anxiety, guilt, and pressure. Regarding anxiety, students said: "*Everyone can feel anxious towards learning and academic performance. It is important to change the current mindset and change anxiety into motivation so I can perform in school.*" Regarding guilt, one student said: "*When I did not study hard enough, feeling guilty [made] me study harder for a short [amount] of time, but now I know, for long term, it is not a good strategy. So, the solution is finding a better way to motivate myself, such as setting learning goals and finding my own interest. I should not feel guilty anymore.*" Regarding pressure, a participant stated, "*Learning is necessary and will help us gain new knowledge. I feel lots of pressure from my parents and other aspects of my life. I think if I find a proper way to learn, even though I will still feel tired, my pressure will be released.*" These answers show the video helped students understand the importance of learning and motivation while finding a new way to understand their anxiety, guilt, and the pressure they were experiencing.

For the second question, "*Do you have any suggestions for the program?*" most students ($n = 124$) did not provide any suggestions. However, four valuable answers gave the research team meaningful suggestions. First, students can become distracted during the video, so two students suggested the research team make the video more interactive. Second, one student said the video should have better resolution to be more professional. Third, one student asked for more time to reflect on the video and more interventions like the current one.

3.6. Study 1 Discussion

The intervention demonstrated effectiveness through a combination of quantitative and qualitative analyses. Path analysis results revealed an improvement in students' integrated regulation, highlighting the intervention's success in conveying the importance of learning for personal and professional goals. Qualitative data indicated that students gained insights into achievement motivation and learned to manage negative emotions, find relatedness with the graduate students in the intervention video.

However, this initial pilot run revealed some limitations. It did not reduce students' controlled motivations, such as external and introjected regulation, nor did it promote identified motivation. The video's interactivity and resolution could be enhanced to increase student engagement. Methodologically, the pilot lacked a control group, and intrinsic motivation was not measured, limiting the ability to draw definitive conclusions about the intervention's effectiveness. In Study 2, the full-scale study, these issues were addressed.

4. Study 2

Study 2 implemented the revised intervention with first-year college students to decrease their external, introjected-ego, and introjected-guilt motivation, and increase their identified, integrated, and intrinsic motivation. Our research kept track of students' motivation for the entire year, and we conducted an intervention 2 weeks before the students' final exam week to increase students' achievement motivation and ultimately improve there academic performance.

4.1. Participants

With permission from the university, the research team conducted the intervention in a typical online class setting. First, we generated a random number list using a random number generator (https://www.random.org/sequences/). Then, we assigned these numbers to students as their research IDs. When all first-year students (Finance major) had their own research ID, these IDs were randomized again by using the generator (https://www.random.org/lists/). We assigned the first half of the participants on the list to a control group and the rest of the students to an intervention group. This design helped increase the statistical power and provide a

better estimate of the intervention effects (Efird, 2011). In total, we collected 390 students' responses, of which 56.4 % ($n = 220$) were measured four consecutive times from October 2021 to June 2022, and 43.5 % ($n = 170$) were measured two times in May and June 2022. For each time point, we dropped participants with the wrong format of student IDs, participants who did not pass the checking item (e.g., *For this item, please select disagree*), and participants who had duplicated records. Careless and insufficient effort responding (C/IER) can pose a major threat to data quality (Ulitzsch et al., 2022; Wind & Wang, 2022). To further improve the quality of data, we also dropped 5 % of our sample for rapid responding. These students completed the survey in rush with only a few seconds. For example, at Time 1, 20 respondents (5 % of the participants) with shortest total response time were removed from the further analysis. Eventually, we had 199 students in the control group and 125 students in the intervention group ($n = 324$). According to the power analysis for linear regression with the experiment group and the dummy variables of time as predictors and motivation scores as outcomes, a sample size larger than 100 will lead to a test power larger than.909 with an alpha level of.05, so our data meets the requirement of minimum sample size.

The sample consisted of 24.7 % male ($n = 80$) and 62.0 % female ($n = 201$) participants, and 13.3 % ($n = 43$) refused to answer the question. The missing rates of motivation scale responses across four time points are 52.2 %, 57.7 %, 36.4 %, and 40.4 %. The details of missingness handling will be illustrated in the Plan of Analysis section. Participants' age ranged from 17 to 22 (mean = 18.52, $SD = 0.82$). Additionally, 86.73 % ($n = 281$) identified their race as Han (i.e., the majority in China), and 12.6 % ($n = 43$) identified as an ethnic minority.

4.2. Procedure

We collected students' motivation data at four time points (See Fig. 1). Specifically, Time 1 served as a baseline, Time 2 was used to monitor pre-intervention motivation trends, and Time 3 and Time 4 served as the true pretest and posttest, respectively. The intervention took place in the 13th week of the second semester in the 2021–2022 academic year. The rationale for collecting data at more than four time points was based on an understanding that students' motivation fluctuates because of internal and environmental changes (Gonida & Lemos, 2019). Two time points (pre-intervention and post-intervention) were insufficient to observe the effectiveness of the intervention because other factors may have caused the change between pre-intervention and post-intervention. However, if we had collected students' motivation data from multiple time points, and students' motivation changed significantly only after the intervention, it could be concluded with confidence that our intervention was effective. Therefore, our primary analysis focused on the pretest (Time 3) and posttest (Time 4) changes to evaluate intervention effectiveness.

During a regular online mandatory class, the instructor used DingTalk (same as Zoom) to put students into intervention and control groups based on their research ID. Students in the control group attended a self-study session, while students in the intervention group worked on the intervention activities. We did not explain the purpose of the intervention to students. We only told them it was a new program developed for other students that needed their feedback. We also concealed the real information we wanted to collect. Study 1 showed a certain level of intervention effectiveness, so we followed the same procedure it used. We also added two components to the procedure from Study 1 according to students' feedback.

4.3. Interactive Video

To have a high-quality and interactive intervention video, we used *TechSmith Camtasia Version 2021.0.17* to edit the intervention video. We adopted the same psychoeducation video in Study 2, but to make the video more interactive, we inserted three questions to the video to retain students' attention. To watch the complete video, students must answer these three questions. These three questions were 1) *Why do you study* (00:40:00)*?* 2) *Have you ever felt anxious or guilty when you study? Yes or No* (03:04:00)*?* 3) *Do you agree with these students? Agree or Disagree* (06:10:00)*?* These questions were related to the video content, which reinforced students' memory of the video content. We used the *TechSmith Camtasia Version* because it can email participants' answers to researchers and indicate whether they finished watching the video. The results showed that each student in the intervention group answered these three questions and finished watching the video. This was an effective way to ensure the fidelity of the online intervention because it allowed us to assess whether students watched the intervention video carefully. The video content was further validated by two motivation researchers and they both agreed that the content in the video is clear and valid.

4.4. Peer discussion

Unlike Study 1, in which the instructor selected five students to discuss their feelings directly after the video, the research team provided more time for students to process the information in the video. Students were prompted to engage in a structured discussion addressing three key questions: (1) What is your understanding of your own motivation? (2) What have you learned about actively seeking a supportive environment? (3) Which strategies discussed in the video do you intend to implement immediately? The purpose of this activity was twofold: to provide students with an opportunity for self-expression and to facilitate reflective engagement with the material. This reflective process aimed to enhance students' comprehension of the content and reinforce memory retention through active cognitive processing. It is a way to satisfy students' needs for autonomy (Ryan & Deci, 2020).

Moreover, to avoid reporting biases (i.e., students reproducing what they were told in the video), we did not tell students they are in an intervention, and instead we ask them to provide opinions on a program designed for future students. We also named the surveys "Understanding your learning conditions", instead "motivation survey". We administrated the survey one month after they watched the video, so they might not remember what exactly the video said, but they still have the awareness of what kind of motivation they

are holding.

4.5. Measures

The motivation measure used in Study 2 is still the ILM scale (Wang & Wind, 2020a). We added the measure of intrinsic motivation by using the Intrinsic Motivation Inventory (IMI), which several researchers have developed and improved (e.g., Deci et al., 1999; Ryan, 1982; Whitehead & Corbin, 1991). IMI measures an individual's experience with certain activities. In our context, the activity refers to general learning activities. The IMI has 45 items, but only the interest/enjoyment dimension assesses intrinsic motivation. Therefore, we adopted only seven items in interest/enjoyment dimensions.

We adjusted the original IMI items to fit the study context by replacing the word "activity" with "learning." For example, the item *I thought this activity was quite enjoyable* was modified to *I think learning is quite enjoyable.* Although previous studies have translated and validated the IMI (e.g., Siu & Lopez, 2010; Wu et al., 2014), we conducted an independent translation and back-translation process to ensure contextual accuracy. One bilingual researcher translated the seven items into Chinese, and another bilingual researcher back translated them into English. A third researcher reviewed both versions to resolve discrepancies through discussion. The final survey and its Chinese translation are available in Appendix A.

4.6. Academic performance

We also gathered data on students' academic performance to determine whether there were significant differences between the experimental and control groups. Academic performance was measured using students' average final exam scores across all courses taken during the semester in which the intervention was implemented. This approach provided a comprehensive assessment of overall academic achievement during the intervention period.

4.7. Intervention fidelity

To ensure the effectiveness and validity of the intervention, we closely monitored intervention fidelity throughout the implementation process. Intervention fidelity refers to the degree to which the program was delivered as intended according to its design (Dusenbury et al., 2003). In this study, fidelity was assessed through multiple approaches, including detailed training for the instructor (the second author), strict adherence to the intervention protocol, and consistent delivery of the key components across all intervention sessions. The first author conducted observations during the implementation to verify compliance, while the instructor maintained detailed logs documenting the process. Furthermore, participant engagement and understanding of the intervention activities were confirmed through the background data of the TechSmith software (e.g., whether they watch the video or answer the embedded questions in the video). These measures ensured that any observed variations in outcomes could be confidently attributed to the intervention itself, rather than inconsistencies in its delivery (O'Donnell, 2008).

4.8. Plan of analysis

As in Study 1, we adopted a convergent parallel mixed method design. First, we conducted descriptive and correlational analyses of the bivariate associations among the continuous regulation variables. Second, to examine differences in regulation at baseline by demographical conditions, for those missing data versus not, males versus females, and racial minority versus majority, we conducted multiple one-way ANOVAs with demographic variables or missing status as an independent variable and regulation scores as outcomes using R (R Core Team, 2019). One-way ANOVA is frequently used to examine group differences in social science research (i.e., Patall et al., 2022). Third, we used a one-way ANOVA with the group variable as the independent variable (0 = control group and 1 = experiment group) and Time 1 regulation scores as the outcome to examine group differences in regulation levels at baseline. Fourth, according to the results of Little's Missing Completely at Random (MCAR) test ($\chi^2 = 5.75, p = .016$), we concluded that the data are missing completely at random (MCAR). Thus, 114 individuals with missing math scores were imputed by mean values (Zhang, 2016). Finally, we adopted a piecewise regression analysis to investigate the change of different types of internalizations and intrinsic motivation. Piecewise linear regression (also known as segmented regression) is frequently used when a potential outcome changes at a specific time. In a piecewise linear regression, the change in intercept or slope from pre-intervention to post-intervention is estimated and used to test causal hypotheses about the intervention (Taljaard et al., 2014; Valsamis et al., 2019).

The most basic structure of a piecewise regression consists of repeated measures on the samples has two phases: Continuous measurements occur before the start of the intervention (phase A: time 1/2/3), and a follow-up measurement occurs after the intervention (phase B: time 4). This design has numerous variations in terms of the number and order of phases (e.g., ABAB or AB1B2B3) based on specific research questions and assumptions about the nature of the behavior and the resulting data (Nock et al., 2007). In this study, we restricted our attention to the A1A2A3B design. The data for phase A served as a reference or baseline for what would have happened in phase B if no intervention had occurred in phase A (e.g., a linear decrease of motivation with time). Next, to test the intervention effect on the experiment group, each group's level and development in phase B were compared to the level and development in phase A. If the invention effect was pronounced, we predicted the experiment group would have a significant change in phase B compared to phase A. In contrast, the control group would be consistent between phase A and phase B. The formula of the piecewise regression model is as follows:

$$Score_i = \beta_0 + \beta_1 time_{t1} + \beta_2 * step_{t2} + \beta_3 * group_i * step_{t2}$$

in which $Score_i$ is the regulation or motivation scores for person i; $time_{t1}$ is an ordinal time variable (0 = Time 0, 1 = Time 1, 2 = Time 2, 3 = Time 3) representing the slope of growth in phase A; $group_i = [0, 1]$ are dichotomous indicator variables representing whether person i belongs to one group with value zero as the control group and value one as the experiment group; and $step_{t2} = [0, 0, 0, 1]$ represents the change of slope in phase B compared to phase A (0 = Time 0/1/2, 1 = Time 3). The effects in the model can be interpreted as follows:

1. β_0 is the intercept, the number of mean scores for the whole samples at Time 1.
2. β_1 is the time effect, the growth of scores without intervention.
3. β_2 is the nonintervention effect, the change of scores in phase B compared to phase A for the control group. The nonintervention effect may have had numerous sources, such as the pandemic or online learning.
4. β_3 is the intervention effect, the change of scores in phase B compared to phase A for the experiment group.

For qualitative data, the two open-ended survey questions were the same as Study 1: "*How do you feel after watching this video*" and "*Do you have any suggestions for the program?*" Students' answers to these questions were also synthesized through thematic analysis (Creswell et al., 2011). We first conducted open coding to identify common phrases. We then marked and recorded the identified common phrases. We adopted axial coding following the open coding to group the data into themes. We obtained students' answers directly from the survey without transcription because the answers were typed into the survey.

4.9. Results

4.9.1. Preliminary analyses

We first performed the Pearson correlations among motivations at the baseline time (see Appendix E). Most motivation variables were moderately correlated, except for the correlation between integrated regulation and introjected-ego regulation ($r = 0.009$) and between intrinsic motivation and introjected-ego regulation ($r = 0.072$), which were weak. Table 3 reports the descriptive statistics for the control and experiment groups by time conditions for Study 2.

To examine baseline differences, we conducted multiple one-way ANOVAs. First, we tested whether participants who completed the pretest differed from those who did not on baseline motivation scores. Results indicated no significant differences across all motivation subscales (all p's $> .05$; see Appendix F). Next, we examined whether baseline motivation scores differed by gender, excluding participants with missing gender data. Results showed no significant differences between male and female participants on any motivation subscale (all p's $> .05$; see Appendix G). We also tested for differences by race (0 = Han, 1 = Other). No significant differences were found between Han (n = 281) and minority participants (n = 43) on baseline motivation (all p's $> .05$; see Appendix H). Finally, we compared baseline scores between the control (n = 199) and experimental (n = 125) groups. Results indicated no significant pre-intervention differences on any motivation subscale (p's $\geq .12$; see Appendix I) or in average performance scores ($\beta = 1.63$, $F[1178] = .622$, $p = .43$).

4.9.2. Group differences in intervention effects on motivation scores

The results of piecewise regression, illustrated in Fig. 2, revealed the significant impact of the intervention, which was implemented between time points 3 and 4. Across all measured outcomes except for introjected-ego, the experiment group (green dotted line) exhibited desirable changes during this period, while the control group (orange line) remained relatively stable or showed only minor changes. Specifically, the experiment group demonstrated a pronounced upward trajectory in key outcomes such as identified regulation, integrated regulation, and intrinsic motivation, indicating the effectiveness of the intervention in promoting positive changes.

The timing of the intervention corresponds with the observed improvements, strongly indicating that these changes can be attributed to the program. The first three time points prior to the intervention show stable trends, while a rapid and significant shift occurs immediately after the intervention. This stark contrast, particularly the divergence between the experiment group and the control group during this critical period, underscores the intervention's pivotal role in driving these outcomes. Moreover, the large magnitude of change observed in the experiment group highlights its effectiveness in fostering not only immediate self-reflection among students but also in enhancing their autonomous motivation, which was sustained one month after the intervention.

Furthermore, we tested the effect size of group differences for each type of motivation with the 95% confidence interval, and F tests of the intervention effect (control vs. experiment) using the piecewise regression. As reported in the first 4 columns of Table 4, for the control group, there were no statistically significant differences in the control group between the pretest and posttest conditions. However, for the experiment group, we found statistically significant differences between the pretest and posttest (identified internalization ($\beta = 1.30$, 95%$CI = [.21, 2.38]$) and integrated internalization ($\beta = 2.27$, 95%$CI = [.69, 3.85]$). Consistent with the results of piecewise regression, results of F-test (see the last column of Table 4) suggested significant contributions of group (control vs. experiment) and time (posttest vs. pretest) on the growth of identified internalization scores ($F[2687] = 4.047$, $p < .05$), integrated internalization ($F[2687] = 7.003$, $p < .05$), and the intrinsic motivation scores ($F[2687] = 5.559$, $p < .05$).

4.9.3. Qualitative data results

Participants in Study 2 provided similar answers as those in Study 1 to the question "*how do you feel after watching this video?*" In

Table 3
Descriptive Information of motivation scores at S2T1/2/3/4 in Study 2.

	S3T1 (n = 155)				*S3T2 (n = 115)*				*S3T3 (n = 191)*				*S3T4 (n = 179)*			
Group	Control (n = 104)		Experiment (n = 51)		Control (n = 82)		Experiment (n = 33)		Control (n = 108)		Experiment (n = 83)		Control (n = 91)		Experiment (n = 88)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
External Regulation	15.18	5.82	15.20	6.97	16.55	5.35	14.55	5.31	17.66	6.92	15.78	6.94	16.79	7.29	16.26	7.81
Introjected ego Regulation	12.90	4.40	12.33	5.02	13.26	5.03	12.64	4.74	13.56	4.60	13.42	4.52	13.21	5.66	13.75	5.43
Introjected guilt Regulation	18.04	4.47	18.71	4.85	18.61	4.54	18.15	4.74	18.47	4.22	18.64	4.87	18.41	5.18	17.60	5.86
Identified Regulation	19.10	4.12	20.22	4.38	19.93	4.47	19.30	3.69	19.59	4.55	20.30	4.47	20.08	5.10	21.13	4.80
Integrated Regulation	27.25	6.30	27.39	5.06	28.43	6.36	27.42	5.48	28.18	6.93	28.46	6.29	29.46	7.46	30.56	7.29
Intrinsic Motivation	26.57	4.61	26.16	4.44	28.05	5.61	26.30	3.73	28.16	5.67	27.06	4.90	28.36	6.22	29.01	6.35

Note. *S2T*1 = first pre-intervention measure; *S2T2* = second pre-intervention measure; *S2T3* = third pre-intervention measure; *S2T4* = forth post-intervention measure; *M* = average sum score of each subscale; *SD* = standard deviation of sum scores*; Control* = control group without taking intervention; *Experiment* = experiment group with taking intervention.

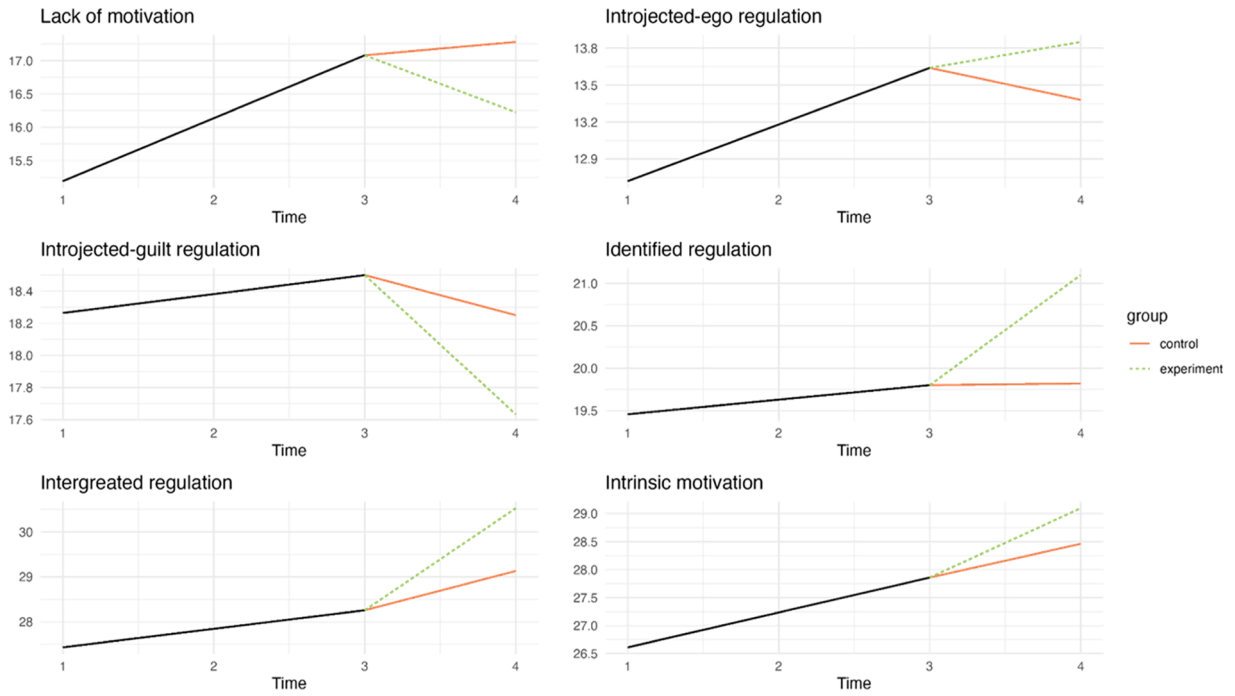

Fig. 2. Path Plot for Predicted Internalization and Motivation Scores Across Time Study 2.

Table 4
Piecewise Regression Results and F-tests Results for Study 2.

	Control		Experiment		*Control vs. Experiment*	
Variable	*B*	*95 % CI*	*B*	*95 % CI*	*F-value*	*p*
External	0.20	[−1.36, 1.76]	−0.86	[−2.46, 0.75]	1.057	0.348
Introjected Ego	−0.26	[−1.41, 0.89]	0.21	[−0.97, 1.39]	0.633	0.531
Introjected Guilty	−0.25	[−1.38, 0.88]	−0.86	[−2.02, 0.29]	0.974	0.378
Identified	0.02	[−1.04, 1.08]	**1.30**	**[0.21, 2.38]**	**4.047**	**0.018**
Integrated	0.87	[−0.67, 2.41]	**2.27**	**[0.69, 3.85]**	**7.003**	**0.001**
Intrinsic	0.60	[−0.65, 1.86]	1.24	[−0.05, 2.53]	**5.559**	**0.004**

Note. * : $p < .05$, * *: $p < .01$, * ** : $p < .001$; *B* = Unstandardized regression coefficients in piecewise regression models are presents; 95 % *CI* = 95 % confidence interval of estimates; Columns *Control* and *Experiment* present the among of increase/decrease of regulation from phase A to phase B for the control group and the experiment group, respectively. F-tests with significant results are boldfaced.

addition to the themes identified in Study 1 (attitudes toward learning, motivation toward learning, and reflection on current emotion status), one more theme appeared when considering participant responses in Study 2. Twelve participants found this intervention practical and instrumental. For example, one participant said, "*After watching this video, I have a clearer direction for learning and have a way to relieve anxiety.*" Another participant stated, "*Because I am an anxious person, a student in the video said that anxiety is useless, we should solve things to reduce our anxiety. I think this is helpful to me.*" One student also said this video helped them understand that one should "*Pay attention to the learning process, refuse to be lazy and give up halfway, refuse to be anxious and uneasy in learning, [and] refuse self-denial and self-loathing.*"

In Study 2, participants provided more insights for the second question: *Do you have any suggestions for the program?* Their responses will be helpful for future practices. For example, four students had specific suggestions on the content of the intervention video: "*I suggest finding those seniors who feel very sorry for not achieving their goals to educate us first, and then find seniors who are more successful in pursuing their ideals to build our confidence.*" "*You can interview more classmates or add some tables, statistics, etc.*" "*A few small experiments can be done to enhance the attention of new students.*" A student also responded, "*It is great. It would be perfect if [you] could give a few more specific examples that are closer to life. Freshmen who have just entered college may have problems in their studies, but they also have many problems in life*." Another student made a suggestion about the delivery method: "*More innovative ways can be used to attract attention [of the audience].*" Two students mentioned teaching strategies: "*Providing some basic learning methods so freshmen can find the best ways to improve themselves," and* "*I think more learning methods and strategies should be shared.*" Six students asked for more activities like this: "*I would like more activities like this,*" and *"[this activity] can be disseminated widely to engage many people and help them understand the joy of learning.*" Three students said the video should have better resolution: "*You can interview more people and improve the picture quality.*" Only one student said this activity was meaningless: "*It is meaningless.*"

5. Discussion

This study, grounded in self-determination theory (SDT), aimed to address these challenges by developing and testing an online intervention designed to promote autonomous motivation among first-year college students. Our findings align with and expand upon existing SDT research by demonstrating that directly addressing students' motivational orientations can lead to meaningful shifts toward autonomous forms of motivation, even in online settings.

In Study 1, the pilot intervention showed promising results, with increases in students' integrated regulation and qualitative evidence of improved understanding of achievement motivation. These findings underscore the importance of fostering autonomous motivation, as these forms of motivation are associated with recognizing the value of learning and integrating it with personal goals (Ryan & Deci, 2020). Feedback from Study 1 participants was instrumental in refining the intervention, resulting in a more targeted and effective design for Study 2.

Study 2 demonstrated that the enhanced intervention significantly increased all types of autonomous motivation—identified regulation, integrated regulation, and intrinsic motivation—among the experimental group. These findings align with previous research indicating that interventions promoting autonomy, competence, and relatedness can enhance intrinsic motivation and engagement (Reeve, 2009; Jang et al., 2012; Su & Reeve, 2011). It also demonstrated consistent results with other SDT intervention on college students (Niemiec & Muñoz, 2019; Behzadnia & FatahModares, 2023). Our study expands on these findings by showing that even short, scalable interventions can foster meaningful motivational shifts in first-year college students. However, compared to prior studies on classroom-based SDT interventions (Reeve et al., 2014), our intervention was more self-guided, suggesting that additional instructor involvement may further enhance its impact. However, we did not observe a significant increase in academic performance, suggesting that while students recognized the importance of learning, further efforts may be needed to cultivate enjoyment and deep engagement in academic tasks (Vansteenkiste et al., 2018). Qualitative responses from participants revealed additional benefits, such as improved future planning and reduced feelings of anxiety and self-loathing, highlighting the intervention's capacity to address emotional barriers to learning.

Despite these successes, the intervention did not yield significant differences in academic performance between the experimental and control groups. This may be due to the relatively short intervention period, as motivational shifts might take longer to translate into measurable academic outcomes (Taylor et al., 2014). Alternatively, academic performance may be influenced by additional factors, such as teaching quality or students' prior academic preparation, which were not directly addressed in this study.

This research contributes to the growing body of SDT-based interventions targeting college students by focusing on internal processes rather than solely external supports, as seen in prior studies (e.g., Butz & Stupnisky, 2017; Moll-Khosrawi et al., 2021). While most SDT interventions emphasize teacher autonomy support, this study highlights the potential of directly engaging students in cultivating their motivation, a less explored approach in SDT literature. By incorporating SPI principles such as timing, brevity, and contextual relevance (Walton, 2014; Yeager & Walton, 2011), the intervention was designed to be accessible and impactful, even within the constraints of an online setting.

Moreover, the study demonstrated the importance of tracking motivation across multiple time points, providing evidence that changes in motivation were attributable to the intervention rather than external factors. This approach aligns with recent calls for more nuanced methodologies in studying motivational dynamics (Vansteenkiste et al., 2018; Wang & Wind, 2020a). The inclusion of diverse student voices in the intervention video also fostered relatedness, which, as SDT research suggests, is a critical factor in sustaining motivation (Ryan & Deci, 2020).

6. Limitations

Despite its strengths, this study has several limitations. First, the intervention was tested on a population with relatively low academic performance and achievement motivation, raising questions about its generalizability to higher-performing or already autonomously motivated students. Future research should explore whether the intervention is equally effective across diverse student populations. Second, while this study focused on individual motivation, environmental factors such as teacher and parental autonomy support also play crucial roles (Deci et al., 2001; Ryan & Deci, 2020). Combining this student-centered intervention with teacher or parent-focused strategies could enhance its impact.

Moreover, while our intervention was designed to foster autonomy, competence, and relatedness, future research could benefit from a more structured classification of need-supportive behaviors. Ahmadi et al. (2023) developed a comprehensive system categorizing teachers' motivational behaviors, which could serve as a valuable framework for designing and assessing SDT-based interventions. Future studies could leverage such classification systems to refine intervention strategies and enhance their effectiveness across different educational contexts.

Additionally, the lack of recorded student discussions during the intervention limited our ability to analyze how participants processed and applied the content in real-time. Collecting this data in future studies could provide richer insights into students' cognitive and emotional responses. Finally, while this study measured motivation toward learning in general, future research should examine more specific contexts, such as motivation related to particular courses or relationships with peers and instructors (Eccles & Wigfield, 2020; Wentzel, 2022).

7. Conclusion and future directions

This research highlights the potential of an SDT-based online intervention to promote autonomous motivation among first-year

college students, particularly during transitional periods that challenge their motivation. The findings underscore the importance of addressing students' internal motivational processes and equipping them with strategies to seek environments that support their basic psychological needs. However, further research is needed to explore the intervention's long-term effects, extend its application to diverse student populations, and integrate additional support systems, including teachers and parents.

The study also emphasizes the importance of innovative and engaging intervention activities. According to participants' feedback, college students value opportunities to reflect on their motivation and are drawn to interventions that provide practical strategies for managing challenges. By continuing to refine and expand SDT-based interventions, researchers can develop more effective tools to support students' motivation, well-being, and academic success in increasingly complex educational contexts.

Ethics approval

The Ethics Committee of the Dalian Neusoft University of Information approved the study.

Protocol Number [2021]166. The treatment of those subjects was in accordance with established ethical guidelines and appropriate institutional approval has been obtained.

Code availability

The authors will share the code on the Center of Open Science Website

Consent to participate

Informed consent was obtained from all individual participants included in the study. For participants under 18 years old, parent and guardian consent was obtained.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Wang Yurou: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Zhao Yadan:** Writing – review & editing, Supervision, Resources, Investigation. **Zhang Jihong:** Writing – original draft, Visualization, Methodology, Data curation. **Man Kaiwen:** Validation, Data curation. **Lu Junfei:** Writing – review & editing, Validation.

Declaration of Competing Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.lmot.2025.102118.

Data availability

The data that has been used is confidential.

References

Alessandri, G., Zuffianò, A., & Perinelli, E. (2017). Evaluating intervention programs with a pretest-posttest design: A structural equation modeling approach. *Frontiers in Psychology, 8*. ⟨https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00223⟩.

Alhadabi, A., & Karpinski, A. C. (2020). Grit, self-efficacy, achievement orientation goals, and academic performance in University students. *International Journal of Adolescence and Youth, 25*(1), 519–535.

Ahmadi, A., Noetel, M., Parker, P., Ryan, R. M., Ntoumanis, N., Reeve, J., … Lonsdale, C. (2023). A classification system for teachers' motivational behaviors recommended in self-determination theory interventions. *Journal of Educational Psychology*.

Anderman, E. M., & Koenka, A. C. (2017). The relation between academic motivation and cheating. *Theory Into Practice, 56*(2), 95–102.

Behzadnia, B., & FatahModares, S. (2023). A self-support approach to satisfy basic psychological needs during difficult situations. *Motivation and Emotion, 47*(1), 61–83.

Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education, 84*(6), 740–756. https://doi.org/10.1002/1098-237X(200011)84:6< 740::AID-SCE4> 3.0.CO;2-3

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Butz, N. T., & Stupnisky, R. H. (2017). Improving student relatedness through an online discussion intervention: The application of self-determination theory in synchronous hybrid programs. *Computers Education, 114*, 117–138.
Chemers, M. M., Hu, L. T., & Garcia, B. F. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of Educational Psychology, 93*(1), 55.
Clements, A. J., & Kamau, C. (2018). Understanding students' motivation towards proactive career behaviours through goal-setting theory and the job demands–resources model. *Studies in Higher Education, 43*(12), 2279–2293.
Cohen, G. L., Garcia, J., Purdie-Vaughns, V., Apfel, N., & Brzustoski, P. (2009). Recursive processes in self-affirmation: Intervening to close the minority achievement gap. *science, 324*(5925), 400–403.
Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and Conducting Mixed Methods Research* (Third ed.). Sage Publications.
Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). Best practices for mixed methods research in the health sciences. *Bethesda (Maryland): National Institutes of Health, 2013*, 541–545.
Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125*, 627–668.
Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research, 71*(1), 1–27. https://doi.org/10.3102/00346543071001001
Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01
Deci, E. L., & Ryan, R. M. (2008). "Facilitating optimal motivation and psychological well-being across life's domains": Correction to Deci and Ryan (2008), 262–262 *Canadian Psychology/Psychologie Canadienne, 49*(3). https://doi.org/10.1037/0708-5591.49.3.262.
Demetriou, C., & Schmitz-Sciborski, A. (2011). Integration, motivation, strengths and optimism: Retention theories past, present and future. Paper presented at the 7th National Symposium on Student Retention, Norman, Oklahoma. Conference Publication retrieved from ⟨https://studentsuccess.unc.edu/files/2012/11/Demetriou-and-Schmitz-Sciborski.pdf⟩.
Dusenbury, L., Brannigan, R., Falco, M., & Hansen, W. B. (2003). A review of research on fidelity of implementation: Implications for drug abuse prevention in school settings. *Health Education Research, 18*(2), 237–256. https://doi.org/10.1093/her/18.2.237
Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon, & N. Eisenberg (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (5th ed., pp. 1017–1095). John Wiley & Sons, Inc.
Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology, 61*, 1–13. https://doi.org/10.1016/j.cedpsych.2020.101859
Efird, J. (2011). Blocked randomization with randomly selected block sizes. *International Journal of Environmental Research and Public Health, 8*(1), 15–20.
Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in learning. *Asian Journal of Education and Social Studies, 10*(4), 16–37.
Friedman, B. A., & Mandel, R. G. (2011). Motivation predictors of college student academic performance and retention. *Journal of College Student Retention: Research, Theory Practice, 13*(1), 1–15.
Girelli, L., Alivernini, F., Lucidi, F., Cozzolino, M., Savarese, G., Sibilio, M., & Salvatore, S. (2018). Autonomy supportive contexts, autonomous motivation, and self-efficacy predict academic adjustment of first-year university students (November). In *Frontiers in Education, 3* p. 95). Frontiers Media SA (November).
Gonida, E.N., & Lemos, M.S. (2019). Motivation in education at a time of global change: Theory, research, and implications for practice. In *Motivation in Education at a Time of Global Change*. Emerald Publishing Limited.
Gonzalez, R., & Griffin, D. (2001). Testing parameters in structural equation modeling: Every "one" matters. *Psychological Methods, 6*, 258–269. https://doi.org/10.1037/1082-989X.6.3.258
Hospel, V., & Galand, B. (2016). Are both classroom autonomy support and structure equally important for students' engagement? A multilevel analysis. *Learning and Instruction, 41*, 1–10.
Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *science, 326*(5958), 1410–1412.
Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880.
Haynes, T. L., Ruthig, J. C., Perry, R. P., Stupnisky, R. H., & Hall, N. C. (2006). Reducing the academic risks of over-optimism: The longitudinal effects of attributional retraining on cognition and achievement. *Research in Higher Education, 47*, 755–779.
Jang, H., Kim, E. J., & Reeve, J. (2012). Longitudinal test of self-determination theory's motivation mediation model in a naturally occurring classroom context. *Journal of Educational Psychology, 104*(4), 1175.
Kantanis, T. (2000). *The role of social transition in students': adjustment to the first-year of university, 9* pp. 100–110). Journal of Institutional Research.
Kowalski, P. (2007). Changes in students' motivation to learn during the first year of college. *Psychological Reports, 101*(1), 79–89.
Law, W., & Liu, S. (2021). Basic Need Satisfaction Intervention for Mainland Chinese International Students' Adjustment to College. *Journal of Studies in International Education*, 10283153211052772.
Mayer, R. E. (2014). *The Cambridge handbook of multimedia learning* (2nd ed.). Cambridge University Press.
Moll-Khosrawi, P., Cronje, J. S., Zöllner, C., Kubitz, J. C., & Schulte-Uentrop, L. (2021). Understanding how the motivational dimension of learning is influenced by clinical teaching in medical education: A prospective cohort study. *Annals of Medicine and Surgery, 65*, Article 102366.
Niemiec, C. P., & Muñoz, A. (2019). A need-supportive intervention delivered to English language teachers in Colombia: A pilot investigation based on self-determination theory. *Psychology, 10*(07), 1025.
Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom: Applying self-determination theory to educational practice. *Theory and Research in Education, 7*(2), 133–144.
O'Donnell, C. L. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research. *Review of Educational Research, 78*(1), 33–84. https://doi.org/10.3102/0034654307313793
Paap, H., Koka, A., Meerits, P. R., & Tilga, H. (2025). The effects of a web-based need-supportive intervention for physical education teachers on students' physical activity and related outcomes: A randomized controlled trial. *Children, 12*(1), 56.
Patall, E. A., Zambrano, J., Kennedy, A. A. U., Yates, N., & Vallín, J. A. (2022). Promoting an agentic orientation: An intervention in university psychology and physical science courses. *Journal of Educational Psychology, 114*(2), 368–392. https://doi.org/10.1037/edu0000614
R. Core Team (2019) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. ⟨https://www.R-project.org/⟩.
Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educational Psychologist, 44*(3), 159–175.
Reeve, J., Vansteenkiste, M., Assor, A., Ahmad, I., Cheon, S. H., Jang, H., & Wang, C. J. (2014). The beliefs that underlie autonomy-supportive and controlling teaching: A multinational investigation. *Motivation and Emotion, 38*, 93–110.
Pelletier, L. G., & Rocchi, M. (2023). Organismic integration theory: A theory of regulatory styles, internalization, integration, and human functioning in society. In R. M. Ryan (Ed.), *The Oxford handbook of self-determination theory* (pp. 53–83). Oxford University Press.
Russell, D. W., Kahn, J. H., Spoth, R., & Altmaier, E. M. (1998). Analyzing data from experimental studies: A latent variable structural equation modeling approach. *Journal of Counseling Psychology, 45*(1), 18–29. https://doi.org/10.1037/0022-0167.45.1.18
Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology, 42*, 450–461.
Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.
Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology, 61*, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Siu, K., & Lopez, V. (2010). Intrinsic motivation inventory: Translation and validation in Chinese women with urinary incontinence. *International Journal of Urological Nursing, 4*(1), 39–46.
Sobral, D. T. (2004). What kind of motivation drives medical students' learning quests? *Medical Education, 38*(9), 950–957.
Van Soom, C., & Donche, V. (2014). Profiling first-year students in STEM programs based on autonomous motivation and academic self-concept and relationship with academic achievement. *PloS One, 9*(11), Article e112489.
Su, Y. L., & Reeve, J. (2011). A meta-analysis of the effectiveness of intervention programs designed to support autonomy. *Educational Psychology Review, 23*(1), 159–188.
Taljaard, M., McKenzie, J. E., Ramsay, C. R., & Grimshaw, J. M. (2014). The use of segmented regression in analysing interrupted time series studies: An example in pre-hospital ambulance care. *Implementation Science, 9*(1), 1–4.
Taylor, G., Jungert, T., Mageau, G. A., Schattke, K., Dedic, H., Rosenfield, S., & Koestner, R. (2014). A self-determination theory approach to predicting school achievement over time: The unique role of intrinsic motivation. *Contemporary Educational Psychology, 39*(4), 342–358. https://doi.org/10.1016/j.cedpsych.2014.08.002
Ulitzsch, E., Yildirim-Erbasli, S. N., Gorgun, G., & Bulut, O. (2022). An explanatory mixture IRT model for careless and insufficient effort responding in self-report measures. *British Journal of Mathematical and Statistical Psychology, 75*(3), 668–698.
Valsamis, E. M., Ricketts, D., Husband, H., & Rogers, B. A. (2019). Segmented linear regression models for assessing change in retrospective studies in healthcare. *Computational and Mathematical Methods in Medicine, 2019*.
van den Bogaard, D., Soenens, B., Brenning, K., Flamant, N., & Vansteenkiste, M. (2024). Can students learn to optimize their need-based experiences and mental health during a stressful period? Testing a need-crafting intervention in higher education. *Journal of Happiness Studies, 25*(5), 1–31.
Vansteenkiste, M., Aelterman, N., Muynck, G.-J. D., Haerens, L., Patall, E., & Reeve, J. (2018). Fostering personal meaning and self-relevance: A self-determination theory perspective on internalization. *The Journal of Experimental Education, 86*(1), 30–49. https://doi.org/10.1080/00220973.2017.1381067
Walton, G. M. (2014). The new science of wise psychological interventions. *Current Directions in Psychological Science, 23*(1), 73–82.
Wang, Y., Wang, H., Wang, S., Wind, S. A., & Gill, C. (2024). A systematic review and meta-analysis of self-determination-theory-based interventions in the education context. *Learning and Motivation, 87*, Article 102015.
Wang, Y., & Wind, S. A. (2020a). Comparing internalization of learning motivation between American and Chinese college students. *Journal of Psychological and Educational Research, 28*(2), 7–30.
Wang, Y., & Wind, S. A. (2020b). Psychometric evaluation of a new internalization of learning motivation (ILM) scale. *Current Psychology*. https://doi.org/10.1007/s12144-020-00909-8
Wentzel, K. R. (2022). Does anybody care? Conceptualization and measurement within the contexts of teacher-student and peer relationships. *Educational Psychology Review, 34*(4), 1919–1954. https://doi.org/10.1007/s10648-022-09702-4
Whitehead, J. R., & Corbin, C. B. (1991). Youth fitness testing: The effects of percentile-based evaluative feedback on intrinsic motivation. *Research Quarterly for Exercise and Sport, 62*, 225–231.
Wind, S., & Wang, Y. (2022). Using Mokken scaling techniques to explore carelessness in survey research. *Behavior Research Methods*, 1–46.
Wu, A. M., Lai, M. H., & Chan, I. T. (2014). Coaching behaviors, satisfaction of needs, and intrinsic motivation among Chinese university athletes. *Journal of Applied Sport Psychology, 26*(3), 334–348.
Yeager, D. S., & Walton, G. M. (2011). Social-psychological interventions in education: They're not magic. *Review of Educational Research, 81*(2), 267–301.
Zepke, N., & Leach, L. (2010). Improving student engagement: Ten proposals for action. *Active Learning in Higher Education, 11*(3), 167–177.
Zhang, X. (2021). Preparing first-year college students' academic transition: What is the value of complementary web-based learning? *Computers Education, 172*, Article 104265.
Zhang, Z. (2016). Univariate description and bivariate statistical inference: the first step delving into data. *Annals of translational medicine, 4*(5), 91.