

# Nudging students' interest: An experimental proof of concept for an online informational-nudge

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## **ABSTRACT:**

Motivating students to persist in learning they did not choose is one of the most challenging parts of being an educator. Psychological, classroom-based interventions have been popularised, but less research has explored online support outside the classroom. An experimental test of the efficacy of a programme of informational nudge videos for the support of students' interest in learning a new language during a compulsory university course in Japan was conducted. First/second year students ( $n=2364$ ;  $F=627$ ), participated in the experimental study. The experimental group watched 14 engaging informational videos (mean=56 secs) twice. The control group watched 14 videos that taught a specific English phrase for roughly the same amount of time. Prior/post individual interest prior utility-value for learning English, and their prior course self-efficacy were collected. Students' prior/post English knowledge and their persistence in their course 's online learning component was collected. Following latent profile analysis based on prior variables, the full sample and each subgroup was used to test a fully-forward longitudinal Structural Equation Model, which tested the impact of the experiment on students' future individual interest in learning English. The Latent Profile Analysis revealed three latent subgroups labelled low, moderate and high motivation. SEM indicated a small, positive experimental effect for the full sample ( $\beta=.05$ ) and a larger effect for the moderate motivation subgroup ( $\beta=.08$ ). Post individual interest for the moderate group was a significant predictor of e-learning persistence ( $\beta=.23$ ), which predicted future knowledge ( $\beta=.10$ ). This pilot programme of informational nudges presented a small/medium significant longitudinal effect for future individual interest for the full sample and moderate motivation subgroup. This was followed by subsequent mediated links to e-learning persistence and knowledge growth. The informational nudge experiment presented positive results indicating that these informational, "light-touch" nudges have a capacity to support students' interest in learning.

## **Keywords:**

**Interest, Experimental, Informational Nudge, Structural equation modelling**

## 1 Introduction

Patterns of decline in students' motivation/beliefs for learning are a persistent issue in formal education (Frenzel et al., 2012; Jacobs et al., 2002; Miyamoto et al., 2020). Psychological interventions have become an established means of redressing issues relating to both general motivation (Hulleman & Harackiewicz, 2009, 2021) and ability beliefs (Yeager et al., 2019), as well as the lack of interest in something as specific as a university course (e.g., Canning et al., 2018; Hulleman et al., 2010).

Many of the psychological interventions tested over the past two decades have been intensive, short-term attempts that have required of participants a substantial amount of direct engagement from students (e.g., Blackwell et al., 2007; Hulleman & Harackiewicz, 2009). Such psychological interventions are often implemented on just one occasion (Walton & Cohen, 2007), but can include several separate occasions (Blackwell et al., 2007). Psychological interventions are often specific in their target and approach (for a recent review, see: Hulleman & Barron, 2016). Some recent attempts to mix target theories (Paunesku et al., 2015) and approaches (Canning & Harackiewicz, 2015) have been met with inconsistent but informative outcomes. An early utility-value intervention took a lighter and more sustained *nudge informational* approach (Harackiewicz et al., 2012). Due to its light touch, low resource demand, in conjunction with its sustainable impact, the intervention by Harackiewicz and colleagues was seen as a breakthrough, not only in its specific area (i.e., science education for female students), but also in regards to the broader issue of motivational support for educational perseverance. Despite these successes, this type of intervention continues to be underutilised relative to more direct approaches (e.g., Hulleman & Harackiewicz, 2021).

Educators and researchers alike acknowledge that student reengagement, which is essential for learning, is driven by a diverse range of beliefs, emotions, and motivations (Brophy, 2013). Since these vary based on students' past domain-specific experiences (Renninger & Hidi, 2015), a one-size-fits-all approach is unlikely to support persistent reengagement of all students. Furthermore, obstacles to student persistence are often domain specific, meaning that students require different kinds of support tailored to each learning environment (e.g., a class or course). At university, students must be supported anew in every course to help them make a personal connection to the course content (Hulleman & Harackiewicz, 2021), believe they can learn the content (Bergey et al., 2019), and (hopefully)

enjoy the learning process (Pekrun et al., 2022). While instructors, peers, and curricula all undeniably contribute to the achievement of these aims, what if additions to the curricula could play a larger role in nudging along motivations, beliefs, and emotions in a manner that surpasses conventional sources of support?

In the current study, a large scale, longitudinal experiment was conducted to test this type of nudge support for students' individual interest (Four-phase Model; Hidi & Renninger, 2006; Renninger & Hidi, 2011). The study was designed to update, expand, and diversify the kinds of informational nudges originally achieved by Harackiewicz and colleagues through the use of direct-mail pamphlets (Harackiewicz et al., 2012). The overarching aim of the current study was to establish a "proof of concept" for large-scale informational nudges through short videos. Proof of concept is a commonly used business term that refers to a developmental stage (usually in software development) that allows a business (usually a start-up) to rigorously test and validate a new idea.

To this end, an experiment was conducted to assess the effect of a series of custom-made informational nudge videos on students' individual interest in learning a foreign language. Individual interest is an important mediated and direct source of persistence and achievement in foreign language learning courses: e.g., predicting standardised test outcomes (Fryer, et al., 2019b), engaging with online AI learning partners (Fryer et al., 2017; 2019a), and enhancing course engagement (Fryer, et al., 2016; 2021).

The current study was conducted by embedding short videos into students' weekly e-learning assignments (control and intervention randomly assigned) which constituted part of their mandatory English as a foreign language course. Latent structural equation modelling of data across the 15-week course (one academic semester) confirmed a small/medium sized contribution to future interest (i.e., a light informational nudge) from the experimental condition (relative to a comparable control) and robust forward connections from future interest to e-learning persistence across the academic semester.

## **2 Background**

### ***2.1 Motivations to learn at school***

Getting and keeping students motivated to learn at school is a concern as old as school itself. For decades, empirical research has signalled declines in motivations to learn in formal education (Frenzel et al., 2012; Jacobs et al., 2002; Miyamoto et al., 2020). Despite the non-compulsory nature of tertiary education, it is not immune from such motivational malaise,

especially in more modern and often complex learning environments (e.g., blended or entirely online; Parker et al., 2018). There are many theories regarding the reasons underlying low motivation to learn, from value-orientated perspectives like self-determination theory (Ryan & Deci, 2020), to frameworks derived from ability beliefs such as perceived control theory (Skinner, 2016). Different beliefs and types of motivation have been researched and cited as critical. Among these, student interest stands out, not only as a long-term concern that extends far beyond the walls of education, but also as a source of motivation that is particularly sensitive to intervention (Renninger & Hidi, 2015).

As a source of motivation, interest functions as an essential lever for a number of reasons. It describes the connection an individual develops with an object (Renninger & Hidi, 2015). If developed, it can become a sustainable reason to reengage with an object, resulting in the kind of persistent engagement that is required for success in many academic domains. Interest can develop progressively via students' persistent reengagement with an object of study (i.e., across four phases; Hidi & Renninger, 2006; Renninger & Hidi, 2011). This process of development across a long series of reengagements can rely on affordances from the learning environment. Particularly for students with nascent interest, the environment, its affordances (e.g., fun activities, social sharing) and its emotional messages (e.g., surprising, exciting, strange) can play a large role in whether students successfully develop through the initial phases (stimulated and maintained situational interest). The role of environmental support (e.g., for students' learning-related value, and ability-beliefs) changes as interest matures into a more sustained and increasingly internal source of motivation (i.e., emerging and well-developed interest). In any given classroom, student interest will initially be dispersed across these phases. Different students will therefore require different types of support to stimulate the continued development of their interest. A one-size-fits-all approach to intervening in their interest development is likely to only help a very small subset of students.

## ***2.2 Intervening in students' motivations to learn***

One sign that the field of psychological interventions is maturing is the number of recent reviews on the topic. Several recent reviews have explored the range of interventions undertaken and their relative impact on learning and related processes (Hecht et al., 2019; Hulleman & Barron, 2016; Lazowski & Hulleman, 2016; Walton, 2014). Evidence suggests that psychological interventions framed by robust theory, and which are carefully designed and appropriately analysed, can consistently present meaningful results. Results range from

latent (e.g., enhanced beliefs and interest) to observed learning outcomes (Hulleman & Barron, 2016). While the majority of interventions target proximal outcomes (e.g., Hulleman & Harackiewicz, 2021), intervention studies with longer-term designs have suggested persistent effects are possible by setting reciprocal processes in motion (e.g., enhanced ability-beliefs predicts higher achievement predicts enhanced ability beliefs) (Walton, 2014).

Psychological interventions are not new. However, over the past two decades interventions targeting student motivations and beliefs have become increasingly refined in purpose and design (Walton & Crum, 2022). Seeking to address growing concerns about persistence in STEM fields, Harackiewicz and colleagues (2012) conducted an early informational intervention, mailing pamphlets designed to provide families with support for discussing STEM opportunities at home. This programme of research, which sought to enhance value and persistence in STEM education, presented clear proximal and distal adaptive outcomes, suggesting that interventions as simple as direct mailing can have an impact on short- and long-term educational choices.

Also working with utility-value, Hulleman and colleagues (Hulleman et al., 2010; Hulleman & Harackiewicz, 2009) took a more direct approach to supporting students' connection to, and thereby interest in, learning. This programme of research established that a relatively short intervention can have a meaningful, proximal impact on student learning with both secondary and tertiary students.

Student beliefs, specifically those regarding their own ability, have also proven amenable to intervention. The amount of research testing the impact of psychological interventions based on theories of student intelligence (mindset, fixed and incremental; Dweck, 1999; Dweck & Leggett, 1988; Dweck & Yeager, 2019) has grown rapidly. "Mindset" interventions have had consistent adaptive, small effects on student beliefs and learning outcomes across a variety of participants and have demonstrated both short-term and sustained effects (for a recent large scale example see Yeager et al., 2019).

While the majority of recent interventions have involved students engaging in additional extra-curricular activities, covert natural experimental approaches have also proven successful. Goal framing studies, or research that frames learning in a manner designed to support students' adaptive motivation to learn, are a good example of this kind of intervention. Research in this area (e.g., Vansteenkiste et al., 2008) has demonstrated that something as simple as changing the written purpose of a learning activity can have both short- and longer-term impacts on learning.

Like many aspects of educational psychology, interventions are often siloed into their respective research groups and preferred theories. Recent research, however, has taken steps to integrate multiple theories into a single intervention (Paunesku et al., 2015) and incorporate multiple approaches (Canning et al., 2018). Despite Canning et al.'s mixed outcomes, it is an important demonstration that constructs can be targeted in pairs. This is important for interest research, which in addition to being developmental in its theoretical orientation, is also supported by emotional, motivational, and knowledge components. As noted, interventions targeting one aspect of interest (i.e., connections to content, Hulleman & Harackiewicz, 2009) have consistently demonstrated impacts on student interest. However, they have ignored the likelihood that students might be at different stages of interest toward the content, and that students may be more effectively supported by interventions that both align with their current phase of interest and attend to its developmental nature (Renninger & Hidi, 2020). While giving every student a different intervention that aligns with their phase of interest may not be possible at present, it might be possible to expose students to a wide variety of informational interventions. Such “broad-spectrum” approaches to interventions might provide students with the support they need in a smaller, but still meaningful dose. The question is, of course, how this could be operationalized, and subsequently how its efficacy might be tested.

### **2.3 *Nudging in education***

In an intervention like the one framed by the current study, the aim is to induce a meaningful differential effect on a large number of students by means of an *informational nudge*. The implementation of nudges in unobtrusive, large-scale interventions on human behaviour was popularized largely due to the work of Richard Thaler. His best-known writing in the field of behavioural economics outlines a range of large-scale nudge interventions which produced substantial positive effects in a variety of international contexts (Thaler & Sunstein, 2009). They define a nudge as follows:

“A nudge, as we will use the term, is any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be cheap and easy to avoid. Nudges are not mandates.” (Thaler & Sunstein, 2009, p.6).

Nudge theory has been applied frequently within behavioural economics, one example being the changing of pension plan enrolment from an opt-in to an opt-out decision.

In addition to their use in behavioural economics, nudges have been increasingly used in a wide variety of contexts (Chande et al., 2015), such as the environment (Campbell, 2018), personal fitness (Arno & Thomas, 2016), sex support (Pugatch & Schroeder, 2021), driving behaviours (Rosenfield, 2018), and education (Damgaard & Nielsen, 2018). In contrast to the adjustments to choice, which are commonly employed in early behavioural economics research, many of these nudges are informational in nature. Informational nudges are “light-touch” messages which, through repeated notifications and cues, support an individual in making better choices and help them understand why and how they can persist with an activity (e.g., Chetty et al., 2014). Within education, a consistent and light informational nudge approach could be a useful means of supporting student interest in a subject or course. In order to gauge the capabilities of such an approach, the minimum required components are a method for delivering the nudge and a tool for measuring its efficacy.

#### ***2.4 The power and potential of advertising to nudge***

Consider for a moment what an informational nudge might look like, and one pervasive form may come to mind: advertising. Advertising is a multibillion-dollar industry (563 billion dollars internationally; Guttman, 2019) that affects many aspects of our lives. One of the primary purposes of advertising is to persuade viewers to purchase products, typically by highlighting their value and efficacy. To this end, advertising campaigns generally take a sustained informational nudge approach that often incorporates a variety of messages in order to reach a broad range of potential consumers. Although the prominence of advertising in the global economy is testament to its effectiveness (Turow, 2012), little is known about precisely how advertising works. The field of advertising does, however, offer several important lessons for educators who wish to “advertise” a course of study to their students. The first is that while much of advertising is hit-or-miss, it can also produce sustained effects (Lodish et al., 1995). Commercial advertising aims to influence purchases that are typically sporadic, making continuous nudging more effective than burst (i.e., brief and intense) nudging (Newstead et al., 2009). The second is the idea that most advertisements have a half-life of around 28 days (Lodish et al., 1995). Finally, a single advertisement can nudge more than one reason to buy a product (Brierley, 2005). A multi-pronged informational nudge campaign that takes these lessons into account might help the message reach a wider audience.

Some of these lessons from the field of advertising can be integrated into informational nudges that build on existing educational psychology intervention research.



Nudges can be designed to help students consider reasons for engaging and, more critically, reasons for persistently reengaging with important (but perhaps unpopular) subjects of study. Throughout formal education, and even into university, compulsory subjects are often the least popular amongst students. Compulsory courses by their very nature limit students' autonomy; students might entirely lack the freedom to choose when and indeed whether to take such courses. These limitations are often further compounded by reduced choice in how students can engage with course contents (i.e., due to an unavoidable uniformity in the learning experience resulting from courses with large enrolments). This lack of choice can negatively impact students' need for autonomy (Ryan & Deci, 2017) and thereby the quality of their motivation and engagement throughout their formal education (Gillet, et al., 2012). The fact is that across much of Asia, English as a foreign language is a perennially unpopular compulsory subject. In many countries where English is an important but rarely used day-to-day foreign language, it is notoriously difficult for students to develop the kind of connection (Loh, 2019) necessary for their interest to develop into a source of sustainable interest that drives reengagement throughout and beyond higher education (for an extensive review see Fryer, 2019).

## **2.5 The current study**

The current study was conceived as an alternative to more conventional “intensive” psychological interventions devised to support student interest in course content. It examined the potential for continuous informational nudging to support student interest in studying by leveraging short “commercials” specifically designed to trigger and possibly maintain student interest across a full range of phases (i.e., Hidi & Renninger, 2006; Renninger & Hidi, 2022). Several years of development were conducted prior to this study. Over four years, small to medium scale trials (from 24 to around 200 students) were conducted based on the use of videos to support students' value for their compulsory language courses and for the English language more generally. Video development was intermittently funded by the host institution, and white paper reports (generally in Japanese) were written to detail progress. One written in English (Fryer et al., 2014), outlines the guiding principles of the initial nudge video creation and discusses early piloting. The present study, the first large-scale experimental intervention, aimed to establish a proof of concept for informational nudges in the form of a series of videos, which we will call *informational nudge videos* (nudge videos for short). To this end, 14 nudge videos were created (26-51 seconds each; Table 5, Appendices) and embedded into students' weekly e-learning assignments. The nudge videos

were designed to primarily target either value or ability beliefs for learning. Many of the nudge videos contained emotional content (e.g., surprising and/or funny) that sought to stimulate students and catch their attention.

In the experimental design, a series of motivational nudge videos and a series of similar-length educational videos that introduced basic English phrases, but which lacked explicitly motivational content, were randomly assigned to participants. Half of the participants, as the experimental group, watched the nudge videos; the other half, as the control group, watched the educational (i.e., non-motivational) videos. The participating students watched each of the 14 nudge videos or control videos twice in the natural course of completing their compulsory e-learning.

The study was conducted across one 15-week academic semester. Controlling for students' biological sex (0=female, 1=male), (a) pre-post standardised achievement, (b) interest in learning English as a foreign language, and (c) e-learning persistence were modelled (latent Structural Equation Modelling; SEM) with the experimental condition (dummy variable: 0=experimental, 1=control) to assess the effect of the intervention on students' interest, and the effect of interest on both standardised achievement and e-learning persistence (Figure 1 presents the full sequence of the data collection). Considerable previous research has pointed to the differential effects of psychological interventions on subgroups (e.g., high/low self-efficacy; e.g., Hulleman et al., 2009). For this reason, latent profile analysis was conducted after modelling the full sample. The results of the latent profile analysis were then used to conduct latent SEM for each subgroup. This two-stage approach aimed to refine our understanding of any potential outcomes of the experiment on potential latent subgroups.

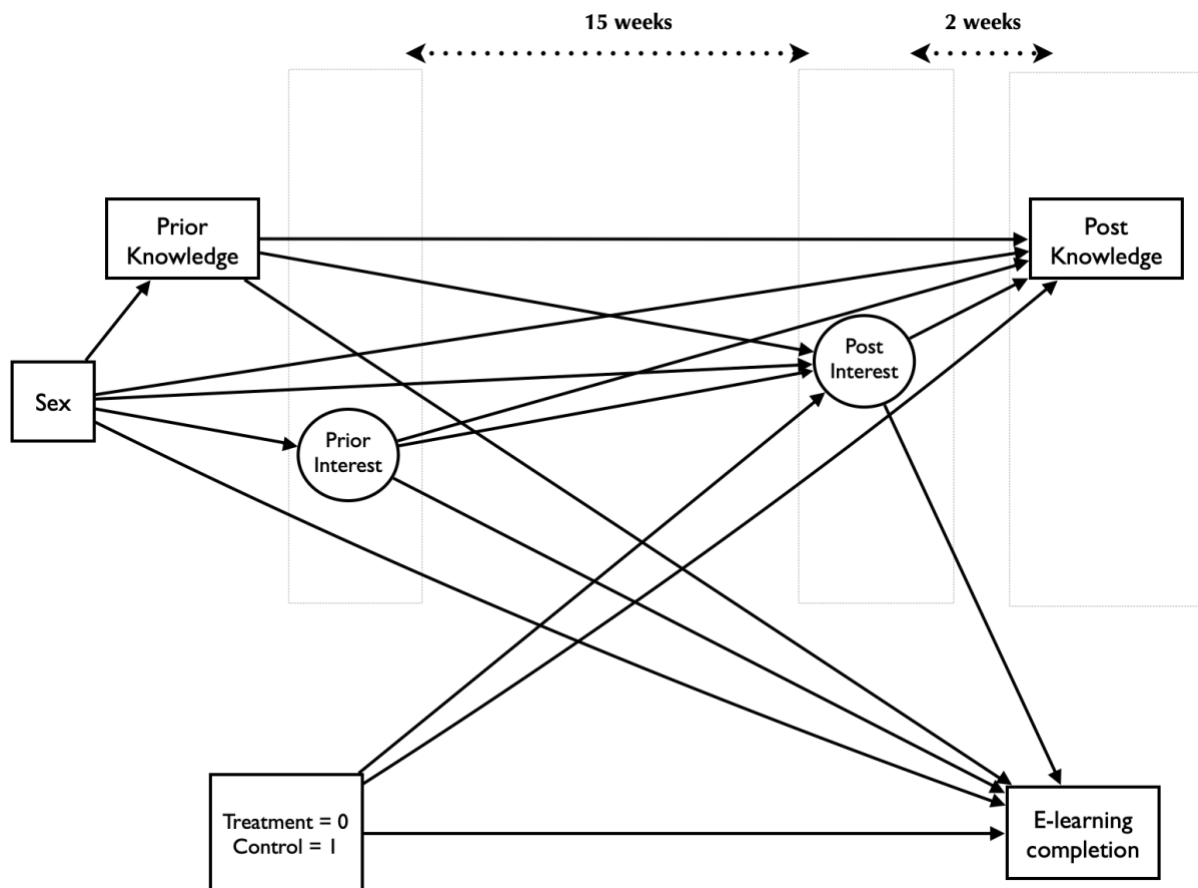


Figure 1. Research Design

### 3 Aims

This study addressed three research questions and three hypotheses. First, what is the experimental effect of students watching a series of videos across a 15-week semester (Research Question 1; RQ1)? The experiment was expected to confirm that a programme of informational nudge videos could have a positive nudge effect on students' interest relative to a control group (Hypothesis 1; H1) (consistent with Chetty, et al., 2014). Second, what is the effect of nudge videos on specific latent subgroups (RQ2)? We expected the experimental, less motivated subgroup to report the most increased interest (H2) (consistent with past interest interventions; e.g., Hulleman, et al., 2009). Finally, what are the relationships between students' interest in learning, online persistence (e-learning), and their standardised achievement scores across one 15-week academic semester (RQ3)? Interest was expected to have small to moderate longitudinal effects on both online learning persistence and standardised semester-end achievement (Fryer et al., 2019b) (H3).

## 4 Methods

### 4.1 *Participants and Ethics*

The current study was undertaken at a four-year private university in western Japan. First and second-year undergraduate students ( $n=2364$ , Female=627; sex balance consistent with the institution as a whole; all students aged 18-20) from all 18 of the university faculties participated in the study. Students were invited to participate in the research from within their weekly e-learning assignments for their English as a foreign language courses. Informed consent was obtained from all students included in the present study. A small percentage of the students opted not to participate in the research at some point during the project ( $n=157$  of the potential 2364 students).

At the university where this study was conducted, no university-wide ethics review board was in place. Consistent with institutional practices, ethical clearance for the present study was obtained in two stages. First, the study was funded by a [university name removed] presidential grant. The grant application process included a review, by the researchers, outlining the study's ethical considerations and anticipated practical benefits for students. In the second stage, the Language Education and Research Centre at which the study was conducted reviewed and granted ethical approval to conduct the study.

### 4.2 *Instrumentation*

For the current study, prior knowledge and post knowledge were assessed with a standardised test of English listening and reading skills (Stewart et al., 2013). The 60-minute test was used across the two-year programme of compulsory English as a foreign language as a means of placing students into classes appropriate to their level. The test administered at the end of the semester comprised 20 percent of the semester grade. E-learning completion refers to the overall percentage of the assigned weekly e-learning that students had completed by the end of the semester (Fryer, 2010; Bovee & Fryer, 2011).

Before the experiment, self-report surveys were conducted to assess course self-efficacy, domain utility-value, and personal interest. Course self-efficacy and domain utility-value were conducted to support person-centered analyses. Domain utility-value was comprised of three items (e.g., "The English I study at university is useful to me") from Hulleman et al. (2010). The personal interest scale consisted of three items (e.g., "I am interested in learning English") from Ichihara and Arai (2004). Self-efficacy was measured using five items (e.g., "I can do almost all the work in this class if I don't give up") from the

Patterns of Adaptive Learning Scales (Midgley et al., 2000). All questions were self-reported across a cumulative scale from one (not at all like me) to six (exactly like me). All items for each scale, both the original English and the Japanese translations, are presented in Table 6 in the Appendix.

### **4.3 Procedures**

The study employed a total of 28 videos: 14 for the treatment group and 14 for the control group. The 14 animated motivational videos for the treatment group were made using VideoScribe, an online application for creating whiteboard animations (<https://videoscribe.co>) (see Table 5 in the Appendix for a summary of the videos). The additional 14 videos for the control group, each of which taught a single English phrase—but which lacked an overtly motivational message—were made by a third-party and were freely available on YouTube. Videos varied in length from 26 to 73 seconds (average of 51 seconds).

All of the videos and surveys employed in the study were incorporated into a compulsory e-learning system used by the students for approximately one hour per week outside of class, typically on their smartphones. (Although students could choose to opt out of the study by checking a box in the online surveys, watching the videos lacked this option as they had been incorporated into the curriculum.) The approximately 30 students in each of the 101 classes participating in the study (52 first-year, 49 second-year) were randomly divided into two groups of equal number, with each having access to only the treatment or control group videos.

The videos were interleaved with the e-learning activities such that students were required to engage with five videos every two weeks, or approximately one video per 25 minutes of e-learning use. The two groups watched each of their 14 videos at least twice over the 15-week semester. Three mechanisms ensured that students engaged with the videos at regular intervals: In the first viewing, students were required to answer a single multiple-choice question (with ten choices) regarding the content of the video. In the second viewing, students were required to answer a free-response question about what they thought or felt about the video. Lastly, e-learning activities that followed each video remained inaccessible until automatically unlocked by completing both first and second viewings. Students concluded their e-learning for the semester with an activity that prompted them to review all 14 videos and ranked their top three favourites. The five surveys employed in the study were similarly interleaved with the e-learning activities. The sequence of surveys and videos

presented to students over the semester was as follows across the 15-week semester: Prior self-efficacy, value, and interest survey (week 2); Videos 1-8 (during weeks 2-4); Videos 9-14 (during weeks 5-7); Videos 1-6 (during weeks 7-9); Videos 7-9 (during weeks 7-14); Post interest Survey 5 (during week 14).

#### **4.4 Analyses**

All latent analyses were conducted using *Mplus* 8.0 (Muthén & Muthén, 1998-2017). Missing data was very low (< 1%) due to the data being collected during students' online studies. The small amount of missing data that existed was due to students missing a section of the e-learning or failing to take the pre-post standardised tests. For all latent analyses, we accounted for the fact that students were nested within classes by using cluster-robust standard errors within *Mplus* (Muthén & Muthén, 1998-2017).

Analyses for the current study proceeded in four stages. First, construct validity (convergent and divergent) and reliability were assessed with Confirmatory Factor Analysis (configural and then invariance CFA for individual interest) and Raykov's Rho (Raykov, 2009) respectively. Second, pairwise correlations were calculated for all modelled variables. Third, a fully-forward structural model test of the impact of the experimental versus control conditions on future interest was conducted with the full sample (Hypothesis 1). Finally, the same model was tested with each of the three subsamples based on a Latent Profile Analysis of the sample (based on initial personal interest, course self-efficacy, and utility-value) (Hypothesis 2 & 3).

Structural models were assessed using four fit indexes: Root Mean Square Error of Approximation (RMSEA), with values < .08 and .05 indicating acceptable and good fit respectively (Browne & Cudeck, 1992), Tucker Lewis Index/Confirmatory Fit Index (TLI/CFI) with values above .90 and .95 indicating acceptable and good fit respectively (Marsh et al., 1988), and Standardized Root Mean Square Residual (SRMR) where values less than .08 are generally considered a good fit (Hu & Bentler, 1999).

Following configural confirmatory factor analysis, invariance testing in the present study followed the example of Marsh et al. (2013). Invariance testing (metric) of domain interest (pre-post) used CFI and RMSEA comparisons to assess the adequacy of the invariance across the study. Chen (2007) contended that the assumption of invariance is tenable if CFI does not change by greater than .01 and the RMSEA increases no more than .015 for the invariant model.

Following construct validity testing, person-centred analysis was conducted to assess the sample for underlying latent subgroups. Latent Profile Analysis is a type of Latent Class Analysis (Hagenaars & McCutcheon, 2002) which uses continuous rather than categorical indicators. Latent Profile analysis classifies participants to classes based on their probability of being in classes which in turn is based on a profile pattern of the variables analysed (for an in-depth review see, Muthén & Muthén, 2000). As class assignment is based on probabilities, the exact number or percentage of sample members within each class cannot be determined with complete confidence (Weller et al., 2020), but must be determined based on best fit and relative confidence (see below). The fact that Latent Profile Analysis does not demand full assignment to one class provides a means of accounting for measurement error in responses (Bray, et al., 2015).

For the person-centered analysis, fit was assessed by two likelihood ratio tests and four information criterion indexes. The Vuong-Lo-Mendell-Rubin Likelihood Ratio Test (Vuong, 1989) and Lo-Mendell-Rubin Likelihood Ratio Test (Lo et al., 2001) both provide a test of whether a solution with one group less than the identified set of latent subgroups was a better fit. The Akaike Information Criterion (AIC; Akaike, 1987), the Bayesian Information Criterion (BIC; Schwartz, 1978), and the sample size-adjusted BIC model all stipulate that lower values indicate the preferred model. Finally, an entropy criterion, which is a summary statistic of all posterior probabilities derived by the model, was employed (Celeux & Soromenho, 1996). Entropy is interpreted as incremental, with numbers closer to one representing better classification of a sample into subgroups. Entropy is generally employed as a supplementary *ad hoc* signal for the quality of the finalised classification (Nylund et al., 2007). In addition to the fit statistics reviewed, the relative size of the latent subgroups as well as their theoretical meaningfulness also guided the final decision of subgroup arrangement. The classification of individuals to subgroups within the finalised solution, relied on *Mplus*' native 'most likely membership' classification. A widely accepted heuristic for using 'most likely membership' (as output by *Mplus*) is that it is appropriate as long as entropy for the solution is above .80 (Muthén, 2008).

The present study relied on standardised regressions ( $\beta$ s) to estimate the effects of variables and the intervention across time within structural equation models. For variables such as Domain interest and achievement which are cross-lagged, Orth et al., (2022) suggest that .03 (small effect), .07 (medium effect), and .12 (large effect) be employed as benchmark  $\beta$  values. For the  $\beta$  that was not cross-lagged (e-learning completion), Keith's (2015)

guidelines for estimating effect size in educational research are followed: Small, medium and large effects estimated by  $\beta | \geq .05/.10/.25$  respectively.

## 5 Results

### 5.1 Construct Validity, Reliability, and Invariance

Confirmatory Factor Analysis of all variables together suggested an excellent fit based on the fit guidelines presented (Table 1). Metric invariance test for pre-post individual interest suggested that invariance across the 14-week gap was tenable. Reliability (i.e., Cronbach's Alpha) for the latent constructs were well above generally accepted cut-offs for acceptability (Table 2;  $>.70$ ; DeVellis, 2012). These results indicated reasonable confidence in the validity and reliability of the latent constructs, supporting their use in subsequent modelling.

Table 1. Configural and Invariance Confirmatory Factor Analyses

	All variables configural CFA	Pre-post interest configural CFA	Pre-post Interest metric invariance CFA
RMSEA	.06 (.056-.062)	.03(.019-.038)	.03(.021-.039)
CFI/TLI	.94/0.93	.99/.99	.99/.99
Chi-Square	1337.380 (DF 146)	43.081 (DF 15)	56.208 (DF 18)
SRMR	.03	.01	.02

### 5.2 Descriptive Statistics

Individual interest presented a very small decline across the 15-week study ( $t(2363)=2.18, p=.03; M1=4.59, M2=4.50, d=.06$ ), while students' language knowledge increased substantially ( $t(2363) = 24.27, p = .001; M1 = 4.32, M2 = 5.75, d = .71$ ). Pairwise correlations between the latent constructs were broadly consistent with theory and past research with these variables (see Table 2). Consistent with reviews of the field (Voyer & Voyer, 2014), male students were marginally less interested ( $r = -.06$ ), but conversely marginally valued ( $r = .05$ ) learning English more. At the same time, they were marginally more likely to have weaker prior and post knowledge ( $r = -.06, -.04$  respectively). Rounding out these weaknesses, male students were less likely to complete the course e-learning assignments ( $r = -.15$ ).



Table 2. Correlations, Means and Cronbach's Alpha

	Sex	Prior Knowledge	Interest T1	Value T1	Self-efficacy T1	Interest T2	Post Knowledge	E-learning Completion
Sex								
Prior Knowledge	-.06**							
Interest T1	-.02	** .17						
Value T1	.05*	** .18	** .77					
Self-efficacy T1	.00	** .22	** .76	** .73				
Interest T2	-.06**	** .15	** .50	** .42	** .43			
Post Knowledge	-.04*	** .48	** .13	** .19	** .12	** .13		
E-learning Completion	-.15**	** .09	* .05	** .09	* .06	** .08	** .09	
Means		4.32	4.59	5.17	4.60	4.50	5.75	.84
Standard Deviations		2.00	1.44	1.41	1.35	1.39	2.05	.23
Cronbach's Alpha			.90	.90	.86	.93		

note: \*  $p < .05$ , \*\*  $p < .01$ ; E-learning Completion is % complete

### 5.3 Latent Profile Analysis (LPA)

In preparation for the Structural Equation Model test of the experiment's outcomes, an LPA was conducted to determine how many latent subgroups existed in the sample based on students' initial utility-value for and interest in English as a foreign language, and their self-efficacy for the course of study in English as a foreign language. As presented in Table 3, up to seven latent subgroups were examined with BIC and Entropy, supporting three subgroups as the best fit for the data/sample. Entropy was .86, the highest entropy of the seven subgroup solutions reviewed. This supported using the finalised subgroup classification (modal assignment of students to three subgroups), based on 'most likely membership', for subsequent analyses (Muthén, 2008).

Table 3. Latent Profile Analyses Fit Statistics

	c1	c2	c3	c4	c5	c6	c7
AIC	34801.376	32247.253	30611.630	29994.025	29771.765	29624.837	29538.562
BIC	34847.52	32322.239	30715.456	30126.692	29933.273	29815.185	29757.75
Sample-size Adjusted BIC	34822.103	32280.935	30658.267	30053.616	29844.311	29710.337	29637.016
Vuong-Lo-Mendell-Rubin	.00	.00	.00	.00	0.005	0.023	0.008
Lo-Mendell-Rubin	.00	.00	.00	.00	0.056	0.025	0.009
Parametric	.00	.00	.00	.00	.00	.00	.00
Entropy		0.785	0.856	0.822	0.810	0.840	0.780

Consistent with the strong correlated indicators used for profiling, only the level but not the shape of the profile could be distinguished (for an introduction to shape vs. level please see Fryer & Shum, 2020). The profiles were therefore simply labelled Low ( $n = 219$ ), Moderate ( $n = 1269$ ) and High ( $n = 876$ ) motivation (subgroup profiles presented in the appendices for the reader's reference; Figure 2).

#### 5.4 Longitudinal Latent Structural Equation Modelling

A structural model testing the predictive impact of the nudge video experiment on students' future interest and forward connections to their e-learning completion and achievement (post-test) was constructed and analysed (Figure 3 for Full sample, Low, Moderate and High sub sample). The full sample was used first with the subsequent analyses exploring potential differences for the three subgroups previously identified in the LPA. Fit for the structural model for all three sub samples and full sample is presented in Table 4.

Table 4. Fit for full sample and three latent subgroups

	Full Sample	Low subgroup	Moderate subgroup	High subgroup
Chi-Square	138.01 (46)	60.59 (46)	105.26(46)	99.94(46)
RMSEA	.03	.05	.04	.03
CFI/TLI	.99/.99	.97/.96	.97/.96	.98/.96
SRMR	.02	.06	.03	.03

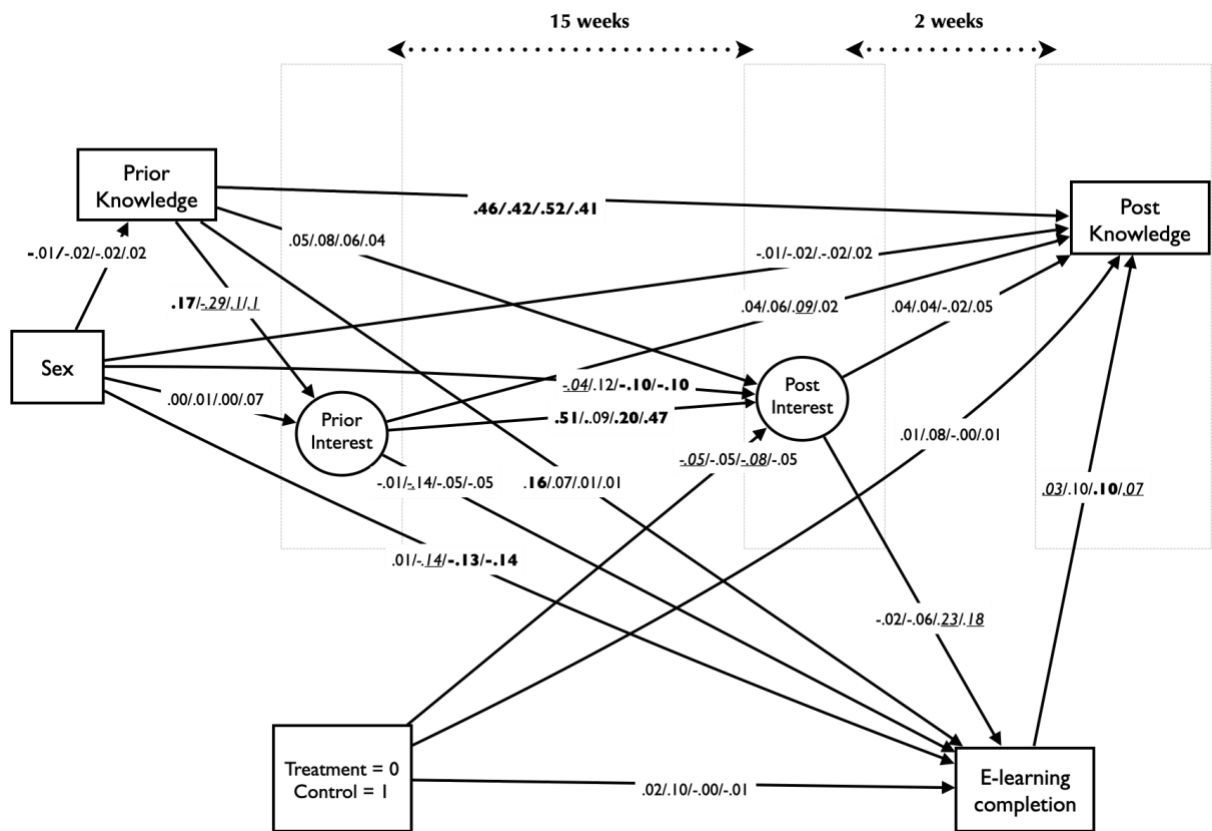


Figure 3.

Note: Full sample / Low motivation / Moderate motivation / High motivation. **BOLD** =  $p < .01$ , UNDERLINED =  $p < .05$

The modelling results will be presented from left to right. First, significant ( $p < .05$ )  $\beta$ s for sex, prior interest and knowledge will be reviewed, followed by the experiment's forward connections. Sex presented statistically significant, very small ( $\beta = -.04$ ) forward connections for post interest. Prior knowledge presented significant large ( $\beta = .46$ ) and moderate ( $\beta = .16$ ) forward connections for post knowledge and e-learning completion. Prior interest presented significant large ( $\beta = .46$ ) forward connections for post interest. The experimental and control conditions presented a forward-significant small prediction ( $\beta = -.05$ ; Hypothesis 1), suggesting that, after all of the controls were accounted for, the intervention was having a small positive effect (small  $\beta$ ; Ortho, et al., 2021), but that it was on average very small for the entire sample. Post interest presented no significant forward connections. E-learning completion presented a very small, significant connection to post knowledge ( $\beta = .03$ ; Hypothesis 3).

The same SEM was analysed using the three subsamples confirmed by the LPA (See Figure 3). An overview of the major differences from the full sample will be reviewed in the same order as the full-sample model findings. Only statistically significant ( $p < .01$  or  $.05$ )  $\beta$ s will be reviewed.

With regard to sex, stronger statistically significant connections were present for the moderate and high motivation subgroups for post interest ( $\beta = -.10, -.10$ ) and moderate and high motivation subgroups for e-learning completion ( $\beta = -.13, -.14$ ). Prior knowledge was the strongest predictor of post knowledge ( $\beta = .52$ ) for the moderate subgroup; as a predictor of e-learning completion, the relationship was statistically significant only for the full sample ( $\beta = .16$ ). For prior interest, there was a strong relationship with post interest ( $\beta = .20$ ) for the moderate subgroup and large ( $\beta = .47$ ) for the high motivation subgroup, and a moderate relationship with e-learning completion ( $\beta = -.14$ ) for the low motivation subgroup. The experiment presented a stronger relationship (medium effect size; Ortho, et al., 2021) for the moderate group ( $\beta = .08$ ; Hypothesis 2). Post interest presented considerably stronger relationships with e-learning completion for the moderate and high motivation groups ( $\beta = .23, .18$ ; Hypothesis 3). The prediction of e-learning completion for post knowledge was also strongest (still small but statistically significant) for the moderate subgroup, but also larger for the high motivation group ( $\beta = .10, .07$ ; Hypothesis 3).

## 6 Discussion

The current study was designed to update, extend, and upscale a growing tradition of

psychological interventions in student learning. Fourteen short videos were constructed and embedded into students' weekly e-learning assignments as light informational nudges seeking to support students' motivation to learn in their compulsory foreign language classes. Across the fifteen-week experiment (random assignment of intervention and control videos), participating students watched each nudge video twice. The effect of the informational nudge from the short videos was tested in a longitudinal latent structural equation model controlling for prior interest and standardised prior knowledge. Forward outcomes—from future interest to e-learning completion, and from e-learning completion to semester-end examinations—were included in modelling. In addition to the model test of the general sample, separate tests with three latent subgroups based on an LPA were also conducted in supplemental SEMs.

Modelling results suggest that the experimental informational nudge made a small contribution to the average students' future interest in learning English as a foreign language (Hypothesis-1). Supplemental modelling of all three subgroups suggested that the effect was moderate but only significant for the subgroup characterized by moderate amounts of initial motivations/ability-beliefs for learning (medium effect size); there was no effect for the low or high motivation subgroups (Hypothesis-2). This moderate subgroup also demonstrated the strongest forward connections from future interest to semester-end e-learning completion, and from e-learning completion to final achievement (Hypothesis-3).

The fully-forward modelling of the full group and each of the three motivational subgroups (low/moderate/high) indicated that the female students in the moderate and high subgroups were likely to report more interest in learning a language at the end of the semester (but not at the beginning). Female students from the same groups were also more likely to complete the weekly e-learning assignments. Only students from the low subgroup demonstrated statistically significantly more e-learning completion as a result of higher prior knowledge.

### ***6.1 Theoretical Implications***

The primary aim of this study was to establish a proof of concept: that a light and consistent mixed informational nudge to students' interest in learning can have a small-medium positive impact on students' learning experience. This experiment demonstrates that videos designed to support interest through light informational nudges to students' ability-beliefs and value for a domain of study have the potential to contribute to the increase of interest. This support was small for the full sample but somewhat stronger when specific latent subgroups were examined. For the three subgroups tested, the intervention only

contributed significantly (medium effect size; Ortho, et al, 2021) to students who started the course with a moderate level of motivations/ability-beliefs/interest. This result starkly contrasts with some direct utility-value interventions that presented stronger support for students with initial low expectations for success and utility-value (e.g., Hulleman & Harackiewicz, 2009; Hulleman et al., 2010). The authors propose two reasons for this outcome. The first is that students with very low starting motivation might have lacked the motivation to fully engage with the videos' messages. Unlike direct intervention approaches (e.g., a writing exercise completed during class time), students in the present experiment could choose not to cognitively engage deeply with the intervention videos—although all students had to complete short questions after each video to ensure they watched each one. In other words, they could have mindlessly clicked through the video activities, doing only the minimum amount necessary to complete the questions that followed them. The second reason is the broad-spectrum nature of the informational nudges. The aim was for as many students as possible, who are at different phases of interest, to benefit from a degree of support from the video nudges. This approach—as one might expect—is best suited for the average student.

The contribution of interest (prior and post) to e-learning completion pointed to the role of the categorical nature of the subgroups' initial motivation (Low, Moderate, and High). For students starting out with low motivation and beliefs, interest does not appear to be of substantive benefit. Only for the moderate and high groups does more post interest predict increased persistence in the e-learning assignments. This finding suggests that, at least in this environment, there is a baseline level of motivation below which both interventions and additional interest more broadly provide little benefit. This might suggest that a certain level of readiness (Renninger & Hidi, 2020) is necessary for interest to be helpful. These low motivation students might need the kind of direct utility-value intervention Hulleman and colleagues have used to help students develop an initial connection to the domain as a first step.

Despite continuous calls for researchers to attend to the reality that subpopulations exist, and that they should be integrated into research design and analyses, the practice remains relatively uncommon. When it is attended to, it tends to be limited to a rough division into high and low groups, using relatively crude statistical tools that neglect latent subdivisions. The present research makes clear that latent subgroups are differentially affected by interventions and interact with learning environments differently across time.

Modelling has even suggested how sex differences are hidden but exposed by full and subgroup analyses. If we want to begin to understand the dynamics of students' experiences and resulting learning outcomes, latent subgroups must be considered.

## **6.2 Practical Implications**

The central practical implication that can be drawn from this study is that just under twenty minutes of informational nudging from short videos distributed across a 15-week semester have the potential to make a small, potentially incremental, contribution to students' interest in a domain of study. Our rigorous experimental test demonstrates that the contribution is small (full sample) to medium (moderate motivation subgroup) in size. Moreover, the effects were produced using relatively unrefined, broad-spectrum videos. This suggests that the contribution of the nudge videos might be increased by using more focused videos with higher production values. The low cost of intervention for educators (i.e., in terms of its development and implementation) and students (i.e., in terms of time investment) are additional reasons for pursuing this type of light nudge psychological intervention. While videos were used in the present study, informational nudges delivered through other modalities, such as static images (e.g., wall posters, computer desktop backgrounds; e.g., Caris, et al., 2018) and text (e.g., framing of learning activities and text message reminders and cues; e.g., Chande, et al., 2015), are worth exploring as well.

The broad-spectrum, light-touch intervention approach used here is flexible and easily applied to many domains and levels of study. Either in class as an introduction to, or as a break within lectures, or in online environments (e-learning or flipped components), videos or the other informational nudge approaches discussed can easily be integrated into curricula for challenging compulsory classes such as statistics, calculus, or, as in the current case, foreign languages.

One practical implication that will be of concern to educators and researchers alike is that students, starting a course with low motivation/beliefs about learning English, experienced increased interest to be of no benefit to persistence with e-learning assignments (relative to the moderate and high subgroups, which both experienced a moderate benefit). This result suggests that devoting efforts to raise the interest of Low students might not be the most effective way to support them. Any attempt to help such students should consider starting by identifying them. Once identified, these students likely need targeted support to provide them with whatever their limiting reagents are. Without this additional support, it seems likely that students in a Low motivation/belief subgroup are likely to remain there and

may never develop the persistent desire to reengage. This desire is critically important in our context, as it is a fundamental characteristic of all successful foreign language learners.

The present experiment provides a measure of support for the growing body of research pointing towards significant gaps in male and female learning experiences (Voyer & Voyer, 2014). While the present study's results did not suggest that the intervention differentially affected men and women, longitudinal modelling revealed that the sex differences for persistence in learning (specifically e-learning in our context) were primarily relevant for students with moderate to high initial motivation. Studies have often shown that girls/women often outperform boys/men academically, and much of this is attributed to self-control which supports persistence across long-term learning (Duckworth, et al., 2019). However, for students with low motivation/beliefs for learning, sex differences are likely overshadowed by broader self-control issues (Duckworth & Seligman, 2006). The current study's results suggest that particularly for the Low subgroup, motivation to learn is an issue that supersedes any fundamental differences between the sexes.

## **7 Limitations and Future directions**

This study was an initial, large scale experimental proof of concept test: Can short videos deliver informational nudges that contribute to raising student interest in learning in a specific university course? The small to medium contribution of the experimental condition is enough to suggest this is a line of intervention research that deserves additional attention. Further investigation is necessary to increase confidence in the light-touch, broad-spectrum nudge approach applied in the current study, and further refinement is required to increase its efficiency and impact. Along with additional large-scale replication/extension, small-scale experimental mixed method studies are necessary to provide direction for improving both the development and delivery of the videos.

The series of video informational nudges used in this study employed a broad-spectrum approach to supporting students' interest. The idea underpinning this approach was that a wide variety of student interest (i.e., potentially at different phases of interest; Renninger & Hidi, 2020) requires different types of support to foster continued development. It may be the case that consistent support for a single latent motivation/belief (e.g., utility-value, self-efficacy, mindsets, general perceived control, emotions, etc.) is more effective generally, or for specific subgroups. To test this hypothesis, we call on researchers to conduct further tests of these light informational nudge variations in a wider variety of course contexts.



It is possible that younger students, perhaps in secondary school, may prove to be even more amenable to the kinds of informational nudge supports tested in our study. We envision nudge videos being integrated into classroom curricula, framing ongoing learning materials, providing a rationale for studying, and directing students' ability beliefs in favourable directions.

The university where this study took place has a strong sex skew towards male students. This is a common issue for many technical universities in Japan, Asia and internationally. The sample used in this study was representative of the university, and sex was employed as a control variable for modelling to ameliorate the potential impact of this imbalance. It is important, however, that in addition to replicating this study at different levels of education, that it should also be replicated at a wide variety of tertiary institutions.

As noted in the analysis section, Latent Profile Analysis is probabilistic, classifying students to subgroups based on the pattern of variables analysed while also providing a probability for class membership. This probability is used to suggest 'most likely membership'. While fit statistics, like entropy, supported this classification (modal assignment), the probabilistic nature of these results should be acknowledged and strengthen the call for replication of this type of study in other contexts.

## **8 Conclusion**

The present study sought to frame and test a proof of concept: do informational nudges delivered via short videos show promise for students in motivationally challenging environments like compulsory university courses? Results from this study's experiment provide some support for the proof of concept tested. Beyond the small positive contribution of the intervention for students' interest, there are a few other reasons why the current proof of concept is worthy of further research and refinement. First, relative to many other motivational interventions, they have a low cost of production, can be easy to deliver (interleaved within online learning) and they have comparatively low demands for students' engagement. Despite all of these factors these "light touch" interventions can make a real, if small to medium, contribution to students' interest in learning; but chiefly for students who were already moderately motivated. With replication and refinement, such informational nudges have the potential to join the growing toolbox of psychological interventions that support student learning. Consistent informational nudges could be delivered via diverse modalities, both online and off, across weeks, months, and even years. Due in part to the

affordances these video nudges offer (i.e., production, delivery, etc), they could play a role in a menu of sustainable motivational supports that helps students persist in pursuing their educational goals; ultimately opening doors to the array of life opportunities that every individual deserves, but only good choices and a heavy dose of persistence yields.

## **Compliance with Ethical Standards**

### *Disclosure of potential conflicts of interest:*

The authors declare no known conflicts of interest regarding the presented study.

### *Research involving human participants and/or animals:*

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants.

### *Informed consent:*

Informed consent was collected from all participating students prior to the first data collection of survey reports online.

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## 10 Appendix

Table 5. Summary of motivational videos (treatment group)

	Title	Length (sec)	Target	Synopsis
1	Tunnel	51	Utility (employment)	Once you pass through this tunnel of education, you will probably look for a job. English ability will help you stand out from the crowd.
2	Salary	40	Utility (employment)	In Japan, individuals with English language skills command a 17% to 40% higher salary than those who lack it.
3	Internet	53	Utility (connecting to the world)	Most of the information available on the Internet is in English. If you are interested in the wider world, English is essential.
4	Choices	43	Utility (increasing opportunities)	English will broaden your options after graduating from college, whether for travel, employment, meeting new people, or influencing others.
5	Comfort zone	41	Utility (increasing opportunities)	English is the key that will help you leave your comfort zone of familiar surroundings and unlock a variety of new opportunities.
6	Communicating	38	Ability/Effort (nature of language)	Willingness to communicate is more important than pronunciation or grammar. Don't worry about the small things.
7	Study time	40	Ability/Effort (prior knowledge)	By the time you graduated high school, you had studied some 1,200 words in 800 hours of English classes. You know more than you think; take advantage of it.
8	You can do it, too!	26	Ability/Effort (comparison with peers)	Other students at your university have improved their English in a short amount of time. Many have even studied abroad. If they can do it, so can you.
9	Lingua franca	49	Utility (employment/identity)	English has become the lingua franca of the world. In a business setting, you are

				more than likely to use it to communicate with other non-native speakers.
10	What do we want?	32	Utility/Ability/Effort (general)	English will help you get the things you want in life. It is fundamentally no different from learning any other skill. You just need to decide to do it.
11	Accents	40	Ability (nature of language)	Unlike Japanese, English is spoken around the world, and there is no single perfect accent--so don't let pronunciation be a barrier to your learning.
12	Your chance	38	Effort (using time wisely)	University is a special time set aside for you to focus on learning. Many people are too busy to study after graduating, so don't let this chance pass you by.
13	Interlanguage	62	Ability/Effort (nature of language)	The development of language ability must necessarily pass through an intermediate stage of flawed production. So don't be shy, as practice is essential.
14	Children	36	Utility (family)	English ability benefits not only you, but also the children you may someday have. Set an example for the people you love.

Table 6. Surveys for the study (Japanese with English translations)

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**Domain Interest:**

1. 英語はいつも面白いと考えている。
  2. 今年、英語の学習を好きになりたいと思っている。
  3. 興味が湧くだろうと思っている。
  4. いつも英語をより多く学習したいと考えている。
1. I always consider English to be interesting.
  2. This year, I want to develop an interest in learning English.
  3. I am sure I will become more interested.
  4. I am always looking to learn more English.

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**Course Self-efficacy**

**Stem:** 今年の英語の授業について教えてください。

1. 今年、授業で教わる技能を習得することができるかと確信している。
2. 最も難しい授業の学習方法が分かると確信している。
3. たとえ勉強が大変でも習得できる。
4. やりさえすれば、この授業の最も難しい勉強でもついていくことができる。
5. もし、あきらめなければ、授業でほとんどすべての勉強についていくことができる。

**Stem:** Please answer in regards to your English classes this year.

1. I am confident that I will be able to master the skills taught in class this year.
2. I am certain I can figure out how to do the most difficult class work.
3. I am confident that I can learn, even if the work is hard.
4. I am sure that I can keep up with the hardest parts of this class if I just do it.
5. As long as I don't give up, I can keep up with almost everything in class.

**Value for the Domain of study:**

1. 今年英語の授業で学ぶことは、私の人生に関係があると思う。
  2. 大学で学んでいる英語は役に立っていると思う。
  3. 今年の英語の授業は、個人的に意味があると思う。
  4. 大学で英語を学ぶことは、将来役立つだろうと思う。
1. What I am learning in English class this year is relevant to my life.
  2. The English I am learning at university is useful.
  3. This year's English classes are personally meaningful to me.
  4. I think that learning English at university will be useful to me in the future.
-



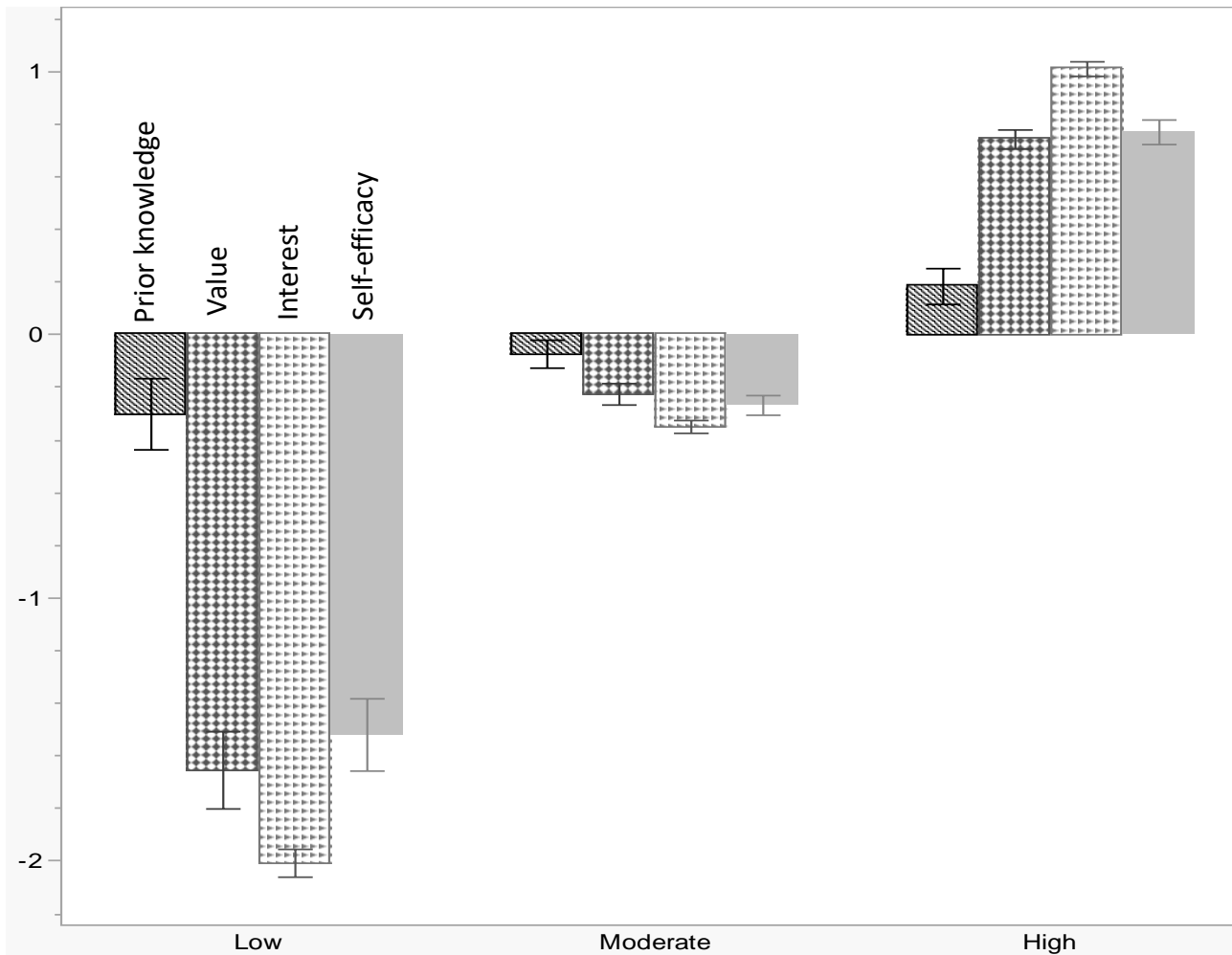


Figure 2. Profiles for the three subgroups: Low ( $n = 219$ ,  $F = 52$ ,  $M = 167$ ), Moderate ( $n = 1269$ ,  $F = 336$ ,  $M = 933$ ) and High ( $n = 876$ ,  $F = 239$ ,  $M = 637$ ).  
*note:* Graphs are based on standardised values for each variable. Error bar were constructed using a 95% confidence interval.