

*Changing Students by Osmosis:  
A Literature Review of Nudge Theory in Educational Technology*

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The Asian Conference on Education 2024  
Official Conference Proceedings

**Abstract**

Nudge theory is an influential theory in the behavioral sciences and related fields. With the development of information technology, its integration with the area of educational technology has received increasing attention. The purpose of this study is to explore the theoretical combination and practical application of nudge theory in educational technology. First, on the theoretical level, the integration of nudge and educational technology involves discussion of data-driven interventions, the proposal of online engagement frameworks, and integrated analysis frameworks. Further, in terms of the form of application, it can be categorized into three types: information nudges (e.g., email, short message service, and personal feedback), social nudges (e.g., social comparison and social norms), and digital nudges (i.e., user interface design). Finally, current empirical studies have shown that nudging strategies have significant positive effects on students' learning attitudes, behaviors, and effectiveness. However, the effects of nudging strategies in education are influenced by specific application contexts and individual differences, and it requires further clarification of the conditions under which this theory is applicable. Future research directions include exploring the effectiveness and differentiation of different nudging strategies, developing more personalized and interactive nudging tools, and optimizing nudging strategies with data analytics to build more inclusive and effective learning environments.

Keywords: Nudge Theory, Educational Technology, Information Nudge, Social Nudge, Digital Nudge

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## Introduction

Eating unhealthy food, making poor economic decisions, and polluting the air, people often seem to make decisions that jeopardize their own or the public welfare (Grüne-Yanoff & Hertwig, 2016). In public policy making, governments are faced with the challenges of effectively guiding citizens to promote social well-being. Traditionally, governments have attempted to change people's behavior through conventional propaganda or educational campaigns. Although these methods convey information directly, they demand a high level of proactivity from individuals, requiring them to actively accept these decisions. And some people may even resist the propaganda, making the original intention more difficult to achieve. The proposal of nudge theory provides a new perspective on how to improve people's behavior without causing resentment.

Nudge theory is a term used in behavioral economics, decision-making behavior, and other behavioral sciences. It was clearly articulated in the book "Nudge: Improving Decisions About Health, Wealth, and Happiness" by Nobel Prize-winning economist Richard Thaler and jurist Cass Sunstein (2008). While nudging was originally defined as nudging another person with a body part, such as an elbow, to alert or draw attention to another person, the two authors define nudging as any aspect of a choice architecture that changes people's behavior predictably without prohibiting any choices or significantly altering their economic incentives. Nudging is different from mandating. For example, placing fruit at eye level is a nudge, whereas banning junk food is not (Thaler & Sunstein, 2008). Overall, the core of nudge theory is to guide decision-makers to make better decisions by changing the environment and information without restricting their choices.

With the election of Barack Obama, a former colleague of Sunstein's at the University of Chicago Law School, nudge theory rapidly became mainstream in American public policy, being applied in areas such as healthcare, financial reform, and healthy eating. The United Kingdom also established the Behavioural Insights Team in 2010 to start adopting nudging techniques and policies (Pedwell, 2017). In terms of healthy food choices, implementing digital salience nudges in online supermarkets can reduce the proportion of unhealthy food choices by 63% and increase the proportion of healthy food choices by 30% (Michels et al., 2023). In online shopping, displaying emotive warning messages and incompatibility information at the checkout page can reduce the purchase of incompatible items (Esposito et al., 2017). Besides, Gajewski, Heimann, Meunier, and Ohadi (2024) emphasized the potential of nudges in financial decision-making. Damgaard and Nielsen (2018) synthesized empirical studies on the application of nudges in education, finding that the effectiveness of nudges varies among individuals, with some specific groups, such as those with particular behavioral disorders, potentially benefiting more from nudges.

In an era of rapid technological development, the form of education is also evolving. Considering the critical role that information technology plays in applying nudge theory to the field of education, this paper will focus on the realm of educational technology, specifically examining the integration of nudge theory with educational technology. Given the broad scope of educational technology, which encompasses both general techniques and information technology, this paper will limit its focus to information technology to ensure a clearer structure and more focused content. As information technology intersects with education, nudge theory offers a unique perspective for understanding and adapting to changes in educational technology. Combining nudge theory with technology allows for the design of effective interventions, such as digital interfaces and interactive experiences

(Mitrovic et al., 2023), to subtly improve learners' behavior. The strategic application of nudges can promote key resources and activities to less-engaged learners and enhance their participation (Brown, Lawrence, Basson, & Redmond, 2022). The libertarian paternalism embodied in nudge theory is different from forcing students to change their existing habits or perceptions but rather preserves student autonomy, which may better align with the educational emphasis on free choice, and thus it is valuable to sort out its related research.

In general, this paper aims to discuss the combination of nudge theory and educational technology, including theory combination, intervention approach, and application effects. Through the discussion of this paper, we hope to provide new ideas and strategies for researchers and practitioners in the field of educational technology to design more attractive and effective educational products and services.

### **Theoretical Integration of Nudge Theory With Educational Technology**

In exploring the theoretical integration of nudging and educational technology from a data-driven level, Thomas et al. (2013) proposed combining education with technological nudging through micro-education and cloud computing to enhance individual decision-making capabilities and support sustainable development. Knox, Williamson, and Bayne (2020) presented a data-centric perspective, arguing that the future of education may move towards "machine behaviorism", undermining students' autonomy and engagement, and shaping their behavior through data-driven technological interventions to meet anticipated educational goals.

In terms of students' engagement, Fritz (2017) emphasized using learning analytics tools to nudge students, enhancing their sense of responsibility for their academic progress, and serving as a method to extend student success. Similarly, Brown et al. (2022) combined learning analytics and nudging from the theoretical perspectives of critical discourse and communication theory, proposing a framework to promote online student engagement in higher education, where the nudge component is to motivate students to engage in key learning activities through personalized communication reminders, using course learning analytics data to provide personalized instruction and feedback to students.

Finally, Decuypere and Hartong (2023) offered a broader analytical perspective with their four-dimensional "Edunudge" framework, encompassing technological modes, political economy, spatiotemporal context, and pedagogy. It explores the implementation of nudging strategies in education, considering various technological approaches, the interplay with politics and economics, the influence of time and space, and their integration with teaching methods as educational tools.

Overall, these studies demonstrate the diversity and complexity of integrating nudging theory with educational technology. From data-driven interventions, how to influence student learning behaviors and comprehensive analytical frameworks, they provide theoretical foundations for subsequent researchers to design reasonable nudging strategies in education.

## **Intervention Types of Nudging With Educational Technology**

### **Information Nudging**

Information nudging primarily involves structuring the information environment in slightly different ways to provide clear and targeted information, helping individuals or groups make wiser and more rational choices (Thaler & Sunstein, 2008). Todd, Rogers, and Payne (2011) pointed out in the context of consumption that a better strategy is not to provide more information for consumers to make detailed product comparisons, but rather to design technological interventions that present sufficient information in the right form to facilitate correct choices. Information nudging focuses on the transmission and interpretation of information, aiming to reduce decision biases caused by insufficient information or misunderstandings. Currently, many studies have adopted information-nudging methods to guide individuals in making decisions that benefit their academic performance.

Providing information to students via emails and text messages is the most common form of nudging (e.g. Bälter et al., 2023; Chohan et al., 2019; Lichand & Christen, 2021; Plaxton, 2019). For instance, Matz, Mills, Derry, Hayward, and Hayward (2024) and Taback and Gibbs (2023) utilized general emails to provide students with resources that could potentially enhance their course engagement and learning attitudes. Plak, van Klaveren, and Cornelisz (2023) and Dart and Spratt (2021) explored the impact of personalized emails, tailored to different student characteristics, on improving learners' attitudes or outcomes. Additionally, Chohan et al. (2019) focused on the role of the source of information while employing email nudges and found that disclosures from expert sources were more effective.

Nudging targets are not limited to learners themselves. Several studies have also explored how nudges can have direct or indirect effects when applied to students' guardians or educators. Santana, Nussbaum, Carmona, and Claro (2019) sent text messages to the guardians of Chilean middle school students, encouraging participation in non-academic activities or merely providing administrative information, finding that students whose parents received the nudging messages had higher average math scores, and this effect persisted into the following school year. Furthermore, sending emails to parents about the parent portal information increased family use of the learning management system and modestly improved student performance (Bergman, 2020). Regarding kindergarten stages, Doss, Fahle, Loeb, and York (2019) found that providing differentiated and personalized text-message interventions to kindergarten parents significantly improves their children's reading abilities and increases parental engagement in literacy activities. For educators, Hanno (2023) evaluated the effectiveness of a light-touch text messaging intervention on early educators' knowledge, beliefs, and practices, finding that teachers in the treatment group spoke more to children but listened less. Wolf and Lichand (2023) further found that audio-text messages to parents had no impact on children's learning and slightly increased child labor, with benefits for low-achieving children in the parent group and negative effects for girls in the teacher group.

In addition to message notifications, some researchers have integrated learning analytics technology to prompt students about their learning status via personalized feedback on intelligent platforms, thereby motivating their learning enthusiasm. Zamprogno, Holmes, and Baniassad (2020) provided formative feedback to students through an automatic assessment tool, finding that high-level feedback helped students reassess their course learning outcomes and project standards. Rodriguez, Guerrero-Roldán, Baneres, and Karadeniz (2022)

combined artificial intelligence to develop an intelligent nudging system for guiding online learners, which can provide both general feedback (course-related information) and personalized feedback, and the results showed that it could positively impact their performance and satisfaction while reducing dropout rates and the effect significantly increased depending on the type of nudging. Additionally, Bobadilla, Glassey, Bergel, and Monperrus (2024) developed a bot named SOBO that automatically provides students with feedback on code quality to help them improve their coding practices.

Emails and text messages are commonly adopted means of implementing information nudges, with flexible intervention designs. The content sent may include general notifications or customized resource information, and the recipients are not limited to students but may also involve their guardians or teachers. Moreover, with the advancement of learning analytics technology, providing instant or final personalized feedback based on students' performance may become a more favored intervention approach.

### **Social Nudging**

Social nudging can be described as taking advantage of people's sense of belonging to a group. Thaler and Sunstein (2008) proposed that a social man can be easily influenced by other people due to his tendency to follow the crowd and that nudges can be used to change people's behavioral patterns by telling them what other people are doing. Social nudging may encourage individuals to shift from an "I" frame to a "we" frame in social dilemmas, thereby increasing prosocial and group-oriented behavior (Nagatsu, 2015). Social nudges can be implemented in various forms, such as social comparison to stimulate students' competitive spirit, or social norms to emphasize common goals or showcase others' learning progress, thereby enhancing team collaboration awareness.

When engaging in social comparison, people tend to compare others' information with their own (Raue et al., 2020). The main point of social comparison nudging in education is to allow learners to learn about others, thus stimulating a sense of competition. Brown, Schiltz, Derry and Holman (2019) divided learners into three groups, with the control group not receiving any messages, and the researcher presented students with descriptive normative messages (the average start date of assignments by the deadline) and opinion leader messages (the average start date of assignments for students who performed the same as or better) respectively through an online system and found that opinion leader messages, namely social nudging, showed a greater effect. Schlegel, Schöbel, and Söllner (2023) similarly adopted comparative nudging by presenting better-performing peers on an online learning platform. In addition to presenting information about better-performing learners specifically, it is also possible to present the performance of students in general, such as the data visualization content constructed by Feild (2015), which provides students with comparisons to other students in the class and allows them to compare the amount of time spent on assignments in the course. The learning analytics dashboards devised by Fleur, van den Bos, and Bredeweg (2023) likewise presented learners with the performance of peers who had similar targets to elicit slight comparisons.

Moreover, Wambsganss, Janson, and Leimeister (2022) explored the combined impact of automated feedback nudging and social comparison nudging on undergraduate essay writing. They found that students who received both automated feedback and social comparison nudging produced more persuasive essays with higher-quality arguments compared to students who only received automated feedback or general feedback on grammar rules. This

study indicated that social comparison feedback can not only be utilized alone to stimulate learners' competitive spirit but also can be combined with other kinds of nudges to create a diverse range of nudging mechanisms. This combined approach provides students with more personalized learning support.

Unlike social comparison nudging, social norm nudging focuses on group identity rather than competitive awareness. Norms are formed during group interactions when members are exposed to others' opinions or observe their behaviors (Neville et al., 2021). Collaboration learning is a common way to exert social norm nudging. This approach helps students recognize the worthwhile characteristics of their peers, develop a tendency to imitate or to reflect on, and support each other in working towards a common goal.

In traditional collaborative settings, Buchs, Gilles, Antonietti and Butera (2016) divided students into three groups: those completing tasks individually, those in a cooperative dyadic instruction group (positive goal interdependence, individual accountability, and promotive interaction), and those in a cooperative dyadic interaction group which added cooperative nudging elements such as positive cooperative norms and specific cooperative skills to the cooperative dyadic instruction, and found that the benefits of cooperative learning in statistics increased with the enhancement of cooperative structure. Instead of using traditional forms of collaboration, Yokoyama, Misono, Inaba, and Watanabe (2020) and Kondo, Yokoyama, Misono, Inaba, and Watanabe (2021) respectively developed an application in tablets that incorporated a note visualization feature to visualize how often other learners took notes on the same section of study through shades of color to promote self-regulated learning. From the above study, it can be found that social norms nudging is no longer limited to traditional learning environments, but can be migrated to online platforms as technology advances so that learners can have appropriate knowledge of both their study partners and themselves.

## **Digital Nudging**

Digital nudging employs user interface design elements to influence decision-making processes within digital environments (Weinmann et al., 2016). These design elements encompass graphical design, specific content, text, and minor functionalities (Mirsch et al., 2017). The objective of this approach is to render certain options on the interface more accessible or prominent than others, thereby steering individuals towards more advantageous decisions.

Digital nudging in existing research is often implemented through the development of platforms and systems. For instance, Yokoyama and colleagues (2020) developed a nudging system on tablets to enhance students' self-regulation skills. This system includes four components: note-taking, learning log collection, learning visualization, and learning log confirmation, where the visualization function can present others' note-taking areas by color shades. Similarly, Kondo and colleagues (2021) developed the learning strategy feedback system NoTAS on tablets, which also highlights areas where peers have taken notes.

Besides, a video learning platform called AVW-Space offers four types of personalized prompts: no comment reminder (encouraging students to comment), no comment reference point (reminding students to comment and providing examples), aspects under-utilized (prompting students to comment on the least commented aspects), and diverse aspects (positively reinforcing students). The platform also provides two visualization methods: a comment timeline (showing selected high-quality comments along the video's timeline) and a

comment histogram (indicating the part of the video with lots of comments) (Dimitrova & Mitrovic, 2022; Mitrovic et al., 2019). Additionally, AVW-Space has designed personalized comment displays (Dimitrova et al., 2017).

In terms of design style, Krath, Schürmann, and von Korfflesch (2021) synthesized existing gamification theories and research on serious games, suggesting that gamification design can prompt users to take necessary actions to achieve goals, thereby realizing nudging effects. For example, Afshar (2019) successfully enhanced company employees' enthusiasm for knowledge sharing by meticulously designing a knowledge assessment and reward system that incorporated gamification elements such as achievements, points, levels, leaderboards, competition, and self-expression. This, in turn, significantly improved the organization's knowledge management and performance.

Summarizing the above research, digital nudging demonstrates immense potential in promoting user decision-making, enhancing learning outcomes, and improving user experience. Designers can employ various strategies, from platform design style to specific functionalities, to implement digital nudging effectively.

## **Effects of Nudging in Education**

### **Attitudes Toward Online Learning**

Nudge theory, combined with online learning tools, aims to enhance learners' learning attitudes. Fryer, Bovee, Witkin and Matthews (2023) examined the effects of a series of informational nudge videos on stimulating Japanese university students' interest in learning English. They categorized students into three subgroups: low motivation, moderate motivation, and high motivation, and found that the informational nudge videos had a small but significant impact on the English learning interest of the entire group and the moderate subgroup. Beyond language learning, Taback and Gibbs (2023) investigated the impact of weekly emails offering interesting and practical materials on students' attitudes toward learning statistics and found that this nudge did not improve students' learning attitudes, with similar results observed among students who opened at least one email. Overall, research on students' learning attitudes is still limited, and the effects of nudging on learning attitudes may vary depending on the subjects and nudging strategies. This suggests the need to consider more personalized factors when designing nudges.

### **Online Learning Behaviors**

Nudging theory in the field of educational technology primarily focuses on online learning behaviors in higher education (e.g., Brown, Basson, Axelsen, Redmond, & Lawrence, 2023; Lawrence et al., 2019; Mohammadhassan et al., 2022). However, research on this topic, particularly regarding student engagement, shows mixed results.

On one hand, some studies indicate that nudging strategies can improve students' online learning behavior. Mitrovic and colleagues (2023) conducted a three-year study with undergraduate software engineering students using the AVW-Space platform to learn face-to-face communication skills. The platform encouraged critical commentary on educational videos and anonymous peer rating of comments and the results showed significant differences in engagement, impacting interaction time, the total number of comments, high-quality comments, and perceived learning effectiveness. Additionally, Brown and colleagues

(2023) proposed a nudging protocol for online courses to encourage students to use essential course resources and after three iterations, they found that finely-tuned nudges for a few critical resources effectively stimulated student engagement. Furthermore, Kay and Bostock (2023) sent automated text messages and emails to college students who were at risk of disengaging from the classroom, to encourage them to re-engage with the learning management system and found that nudged students were more likely to re-engage, spend more time on online materials, and maintain the effect for over two weeks. Blondeel, Everaert, and Opdecam (2023) also found that adding supplementary sentences with links in virtual learning environment announcements reduced student procrastination and improved class attendance and preparation rates. Finally, Gatara et al. (2021) highlighted that, from students' perspectives, nudges facilitating self-directed learning, such as social and reinforcement nudges, were most useful for planning and timely completion of assignments on online learning platforms.

However, several point out that nudging strategies are not always effective, and in certain cases, they do not significantly improve students' engagement. Weijers, de Koning, Scholten, Wong and Paas (2024) conducted two experiments to test the effectiveness of nudging prompts. In the first, they changed the virtual background of the instructor to a question prompt to encourage students to ask questions. While the number of questions increased significantly, this was primarily driven by a few active students and did not impact student performance. In the second experiment, setting a target number of questions for each class showed no significant impact on the number of questions, student engagement, or academic performance. Similarly, Baker, Evans, and Dee (2016) conducted a large-scale randomized experiment with 18,043 MOOC students who received emails with course scheduling surveys over two weeks. The nudge did not affect short-term engagement and showed a slight negative impact on long-term course engagement, persistence, and learning outcomes. Furthermore, Garbers, Crinklaw, Brown, and Russell (2023) used digital images of prior performance for public health masters and placed them in the learning management systems and the results indicated that linking course task completion with assessment performance did not significantly change student engagement.

Despite the high expectations, current research presents a complex picture. Existing studies demonstrate that well-designed nudging strategies can enhance online learning engagement through interactive mechanisms on online platforms, fine-tuned resource guidance, or automated text and email reminders. These strategies can increase student investment and perceived learning outcomes to some extent. However, other studies highlight the limitations of nudging. In some cases, nudges are not effective as expected and even have negative effects on certain metrics. This suggests that the effectiveness of nudging may depend on various factors, such as individual student characteristics, the logic of nudge design, and the implementation environment. Therefore, future research needs to delve deeper into exploring the effectiveness and applicability of nudging strategies.

## **Learning Outcomes**

In addition to online learning attitudes and behaviors, studies have also focused on their effectiveness in improving learning outcomes. Regarding academic performance, Smith, White, Kuzyk, and Tierney (2018) developed software for online economics courses that attached personalized messages to each assignment, explaining how the assignment would affect the student's grade. The results showed that this grade nudge improved students' assignment scores by about 4%. Similarly, Motz, Mallon, and Quick (2021) used a mobile



app to send notifications when students had not submitted assignments close to the deadline. Compared to a control group receiving teacher announcements, the reminder system significantly reduced missed assignments and increased submission rates and course grades.

Dart and Spratt (2021) investigated the effects of personalized emails in two undergraduate mathematics courses. Their study found that personalized emails significantly improved final course grades in a scientific quantitative methods course, especially for students with less prior preparation. However, the emails did not significantly impact performance in introductory calculus and algebra courses. In essay writing, Wambsganss et al. (2022) found that combining social comparison nudges with automated feedback nudges, where students could see their peers' performance on the same assignment, led to more persuasive essays and higher-quality arguments.

These studies indicate that while the effectiveness of nudging strategies may vary depending on the subject and course design, they generally enhance student learning outcomes, particularly when the nudges are closely aligned with students' actual needs and learning environments.

## **Conclusion**

This paper explores the multi-faceted applications of nudge theory in the field of educational technology from the perspectives of theoretical integration, intervention types, and effects. Existing research demonstrates the potential of combining nudge strategies with technological tools, highlighting their capacity to improve learning experiences at multiple levels, including attitudes, behaviors, and outcomes. However, these effects are not guaranteed; they may be influenced by the characteristics of the subject matter, individual differences among the targets, and the specific implementation of the nudge.

With the rapid development of artificial intelligence and big data technologies, nudge strategies can become more refined and intelligent, offering personalized learning strategies tailored to students' individual needs and learning habits. Additionally, current research has shown that diversified nudging methods may be more effective (Wambsganss et al., 2022). Researchers can leverage the advantages of social nudges alongside informational nudges to significantly impact learners' motivation. Furthermore, when integrating systems for digital interventions, it is essential to consider the design of interface elements and interactive content. Incorporating social nudge elements can help learners understand their peers' learning progress, thereby stimulating their motivation. While this paper synthesizes existing research in the field of educational technology, future studies could explore research widely adopted in other fields, or focus on how to ensure the long-term effectiveness of nudges (Beshears & Kosowsky, 2020).

However, nudge strategies have their limitations. Firstly, their implementation requires meticulous design to ensure effective intervention. Secondly, the ethicality of nudge strategies is a subject of ongoing debate. Kuyer and Gordijn (2023) proposed four main ethical issues associated with nudges, namely infringement on autonomy, actual welfare improvement, long-term negative impacts, and undermining democratic deliberation. Therefore, when implementing nudge strategies in education, it is crucial to consider whether these strategies violate the principle of learners' autonomous development and whether our nudges merely guide learners toward our expected outcomes.

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