

Designing Nudges for Self-directed Learning in a Data-rich Environment

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Abstract: Nudges have been known to trigger behavior change for individuals in different contexts. In this study, we focus on designing nudges in the context of self-directed learning (SDL) of university students and aim to identify challenges and difficulties they faced while using an online learning platform during a semester-long undergraduate reading based elective course. We describe how multiple challenges can be identified from the data logged in the learning platform. We focused on 4 of the identified challenges and designed useful nudges based on existing literature to support learners to overcome these challenges. We further examined the perceived usefulness of these nudges with a questionnaire. We found that students perceive nudges which help them plan how to complete their assignments as most useful. We also found that when students propose nudges, they mostly propose social nudges and reinforce nudges. We discuss the need of nudges to support SDL and provide a basis for future design and development of nudges in self-directed learning contexts.

Keywords: Self-directed learning, Nudges in Education, Human-Computer-Interaction, LEAF, GOAL platform

1. Introduction

Self-directed Learning (SDL) is considered a necessary skill in this 21st century (P21 framework, 2015). Consider real life scenarios like learning from a self-paced course. Learners have to be intrinsically motivated, set their own goals and be responsible for their own behaviour but barriers to motivation in a SDL context may differ from one learner to another (Skinner, Furrer, Marchand, & Kindermann, 2008). Learners regulate their behaviour using multiple approaches such as hiring a coach, attending a physical lecture, talking to like-minded people who have set similar goals, and changing environments to allow them to achieve the desired results (Sumaya Abuloha et al, 2019). In SDL, learners often need a subtle instructor's intervention to stay motivated for tasks. Behavioral constraints (such as a lack of self-control, restricted attention, and social standards) are likely to impact choices in such situations. Low-cost nudges that gently push behaviour in the desired direction can help in such a situation (Damgaard & Nielsen, 2018). In our research, we aim to understand in the context of SDL, when would a learner need such a nudge and what would be perceived as a useful nudge. Our guiding research questions are, (RQ 1) What are the possible indicators in an e-learning context to detect difficulties that students face during SDL? (RQ 2) What nudges are perceived useful to address these difficulties?

2. Background

2.1 Nudges for Behavior Change

A nudge is defined as “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any option or significantly changing their economic incentive” (Thaler and Sunstein 2008). Thaler and Sunstein (2008) introduced the notion of nudging to talk about how subtle

changes in the 'choice architecture' can alter people's behaviors in predictable ways. This idea has since been widely adopted in Human Computer Interaction (HCI) and applied in multiple contexts including health, sustainability and privacy (Caraban et al. 2019). For instance, changing from an opt-in to an opt-out organ donation policy, as in the example above, has a positive impact on societal welfare, without forbidding individuals' options or significantly changing their economic incentives. Similarly, replacing cake with fruit in the impulse basket next to the cash register has been found to lead people to buy more fruit and less cake, when both choices are still available (Sunstein and Thaler 2008). However, aspects such as the processes underlying the concept, the nudge's effectiveness in different contexts, and in the long term are still poorly understood (Zimmermann et al. 2021). Further, as technology evolves with time, these nudges should be contextualized, translated and mapped to the affordances of the technology. The term 'digital nudging' (Weinmann et. al. 2016) refers to the use of nudges in the digital realm. Caraban et al. (2019) found 74 examples of nudging in HCI literature. Their analysis identified 23 distinct mechanisms of nudging, grouped in 6 overall categories, and leveraging 15 different cognitive biases. The broader categories include Facilitate, Confront, Deceive, Social Influence, Fear, and Reinforce type nudges which we discuss further in this paper. Facilitate nudges enable decision-making by diminishing an individual's physical or mental effort. They are designed to encourage people to intuitively pursue a predefined set of actions which resemble people's best interests and goals. Confront nudges attempt to pause an unwanted action by instilling doubt. Tapping into the regret aversion bias—people's tendency to become more careful decision makers when they perceive a certain level of risk—they attempt to break mindless behavior and prompt a reflective choice (Samuelson and Zeckhauser 1988). The Deceive Nudges category uses deception mechanisms in order to affect how alternatives are perceived, or how activities are experienced, with the goal of promoting particular outcomes. Social influence nudges take advantage of people's desire to conform and comply with what is believed to be expected from them. Fear nudges evoke feelings of fear, loss and uncertainty to make the user pursue an activity. These nudges take advantage of people's desire to conform and comply with what is believed to be expected by them. It raises visibility of user's actions and leverages public commitment. The goal is to create a sense of responsibility as a community. If the learners are timely reminded of what their peers are doing, they may take their assignment more seriously. The learners fear public humiliation. Nudges in the Reinforce category attempt to reinforce behaviors through increasing their presence in individuals' thinking.

2.2 Nudges in Education

The barriers in decision making from a behavioural economics perspective and a broad discussion of the evidence are available in DellaVigna (2009). Closer to our context, there are multiple behavioral barriers in decision making that students face which restrict them from achieving their desired outcome. Literature suggests that the key behavioural barriers in education include self-control, limited attention and cognitive ability, loss aversion, default biases, self and social image, social norms and other biased beliefs (Damgaard & Nielsen, 2018). Since these behavioural barriers influence decision-making it may be necessary to target these barriers and create interventions to remove them. Literature also proposes a typology of nudge types that can better support decision making to overcome these behavioural barriers as seen in Figure 1. It provides an overview of the types of interventions considered in this review classified by two dimensions: (1) whether the interventions are likely to induce active or passive decision-making and (2) whether they involve changes or additions to the decision environment.

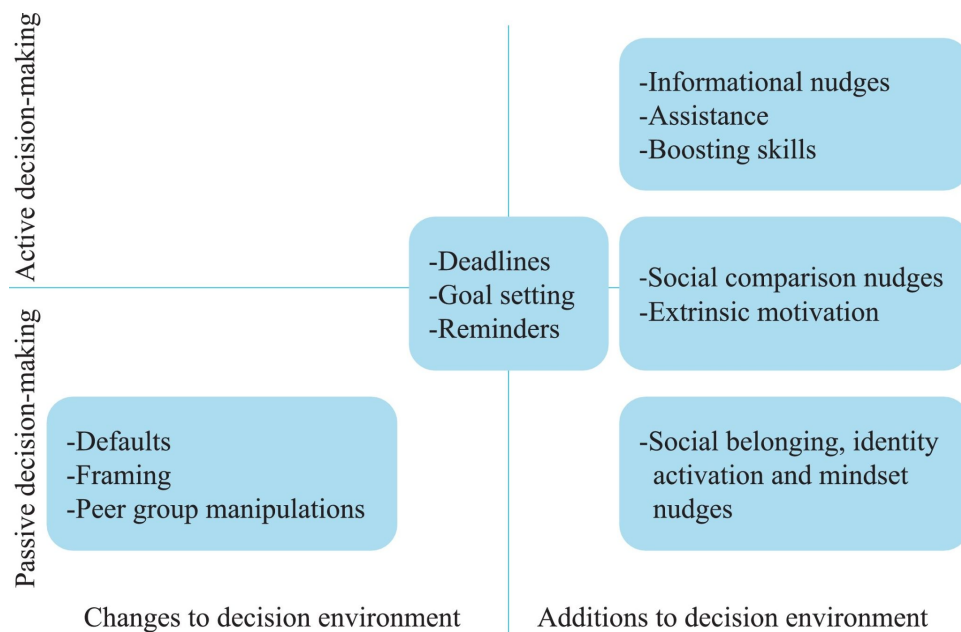


Figure 1. Typology of nudges, reproduced from (Damgaard & Nielsen, 2018).

While research broadly suggests the types of nudges that may be useful for education (Damgaard & Nielsen, 2018) there have been few investigations regarding how nudging behaviour changes according to the context, affordances of the technology, the quality of communication or the timing of the nudges. Therefore, in this work we perform a study to explore the challenges or barriers faced by students in our context. We then design nudges that can be useful for our specific SDL context and a wearable technology medium, and examine their perceived usefulness for students.

3. Materials and Methods

3.1 Context and Procedure

The study focused on the context of a reading based undergraduate elective course (15 weeks duration) related to educational data analytics and visualisation in a university in Japan. Due to the covid19 restrictions, the classes were moved online and conducted through Zoom after the initial two face to face sessions. The LEAF platform (Ogata et al. 2018) made the transition easier to integrate the SDL tools to the learning management system (LMS), Sakai. The LMS gave access to the enrolled students, maintained discussion forums and provided the course assignments. There were multiple reading, summarizing and presentation assignments in the course. All the reading materials were distributed by BookRoll (Ogata et al. 2015).

3.2 Learning Traces from E-Learning Context.

In the LEAF platform (Ogata et al. 2018) external systems like BookRoll (Ogata et al. 2015) and GOAL (Majumdar et al. 2018) are also linked to the LMS. These enable students to make a reading plan and monitor that while they continue with reading the course material. The infrastructure enables collection of students' reading interactions in the BookRoll platform as xAPI statements; their assignment submission events and discussion activities in the LMS; their self-directed planning and monitoring behaviors in the GOAL system. The GOAL system also has the potential to communicate with wearable devices running wear OS or iOS. Hence it would give the advantage to the students to use the same infrastructure to securely connect with their learning logs and receive personalised feedback on their mobile application or the wearable device. The overall data flow is presented in figure 2.

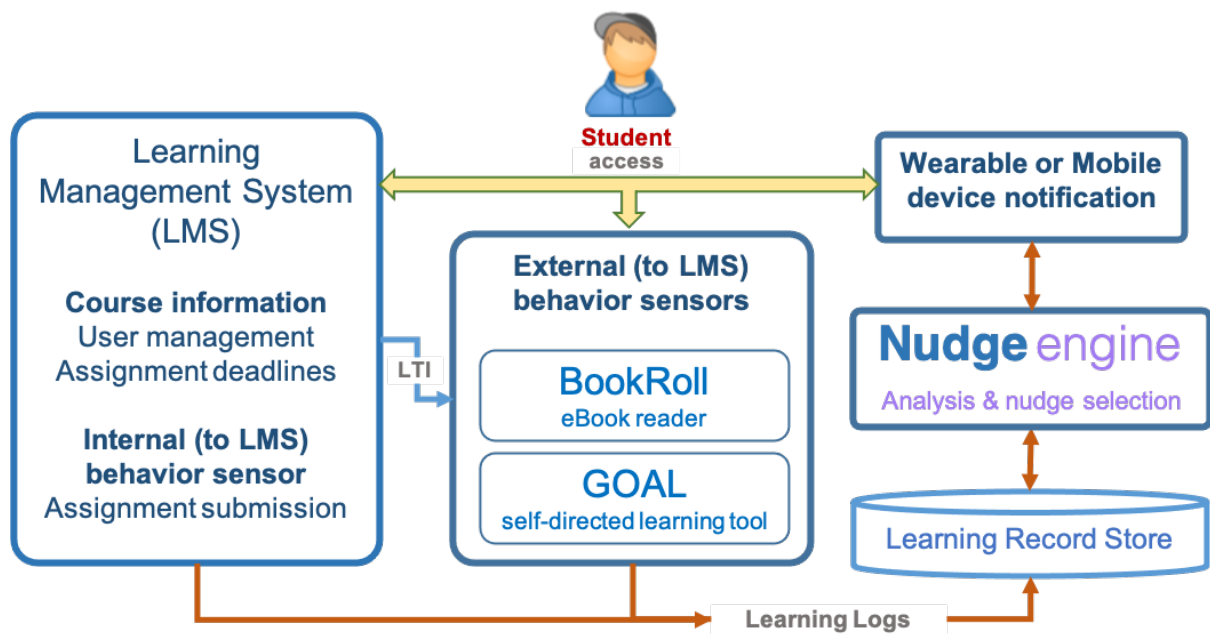


Figure 2. The technical architecture to deliver Nudges based on LEAF.

3.3 Analysis and Design Methods

Given the above context, to answer RQ1 the instructor of the course (one of the co-authors) observed students' behaviors regarding course participation and assignment submissions. These learning traces were captured in the LEAF system. Based on these observations, we selected four challenges that the instructor identified. Messages as nudges were designed to mitigate these challenges based on the 23 approaches proposed in Caraban et al (2019). The process we followed to design the nudges is as follows.

A persona of a student was developed and named Ren, who is in a self-directed learning context similar to the students in the course. He also has a wearable device whose persona was named Kotoura and who wished to support Ren's SDL activities. A tone of the voice for the communication was set to ensure empathy and user centricity (see Kotoura's persona sketch in Fig 3).



Figure 3. Persona as presented to the learner with a perspective of a wearable device.

To answer RQ2, we conducted a survey with participants from the course and other students who had experience in using the BookRoll system. We did purposive sampling to include students and academic staff outside the course too but those who related to the issues of SDL. For each of the designed alternative nudges given in the context of a hypothetical student undertaking SDL, a 5 point Likert scale question asked perceived usefulness of that nudge in the participants' context (item

wording: *This nudge would be useful for me too. 1: Strongly Disagree - 5: Strongly Agree*). A second question also in 5 point Likert scale solicits their preferred frequency of the particular nudge (item wording: *How frequently would you like to have this nudge?. 1: Only once - 5: repeatedly*)

4 Findings and Designed Alternatives

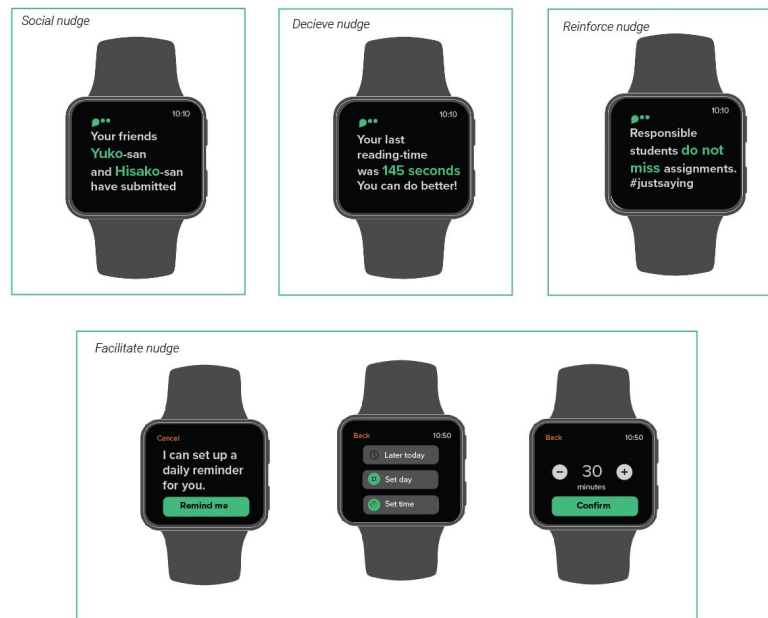


Figure 4. Some examples of designed nudge solutions as presented to the learner with a perspective of a wearable device.

4.1 Detecting Student Difficulties from Learning Logs

To answer RQ 1, Table 1 provides the details of how to identify the four SDL challenges based on the data collected in LEAF's e-learning environment. For instance the corresponding indicator for participation was the bookroll activities such as interactions within and outside the class hour (Majumdar, Flanagan & Ogata, 2021) and the assignment submission time as recorded in the LMS.

Table 1. *Detecting Problem Context Based on Data Logged In E-Learning Environment*

Challenges during SDL	Possible detection in e-learning context
#1 Students not submitting summary notes of a given reading assignment	The reading materials are accessed in BookRoll, but neither memos are written either in BookRoll nor any submissions in the LMS.
#2 Students not previewing/reviewing materials	There are no or few logs recorded corresponding to the uploaded lecture and activity materials.
#3 Students spend a lot of time on a certain portion of reading material.	There are more interactions and time spent on certain materials or pages in a particular material.
#4 Students rushing assignment submissions at the end moment	The assignment deadline and the status of a student at a particular time is available from the LMS.

4.2 Designed Alternative Nudges

For the selected 4 challenges during SDL contexts mentioned in section 4.1. in Table 2 we mapped our design alternatives to the strategy of nudging in Caraban et al (2019).

Table 2. Messages Designed for Mitigating Challenges during SDL.

Challenges during SDL	Messages and associated nudges
#1 Students not submitting summary notes of a given reading assignment	<i>i. Hi Ren, Kotoura, here. Did you miss submitting the summary? (Social nudge)</i> <i>ii. Your friends, Yuko-san and Hisako-san have submitted the summary. (Social nudge)</i> <i>iii. If you don't submit you'll receive a penalty! #justsaying (Confront nudge)</i> <i>iv. Responsible students do not miss assignments. #justsaying (Confront nudge)</i> <i>v. Do you want to consider setting a reward for yourself? (Facilitate nudge)</i>
#2 Students not previewing/reviewing materials	<i>i. Oops! Did you miss reviewing the materials?(Confront nudge)</i> <i>ii. Do you want me to set a reminder?(Facilitate nudge)</i> <i>iii. Sorry you cannot go ahead until you review this page. (Facilitate nudge and Fear nudge)</i>
#3 Students spend a lot of time on a certain portion of reading material.	<i>i. You have completed the task, right? #just checking (Deceive nudge)</i> <i>ii. Do you want me to set a reminder?(Facilitate nudge)</i> <i>iii. Your last reading time was 145 seconds. You can do better!(Deceive nudge)</i>
#4 Students rushing assignment submissions at the end moment	<i>i. Deadline is in 5 days. No pressure! (Reinforce nudge)</i> <i>ii. You had submitted the last assignment 3 days late, do you want to be late on this one too? (Deceive nudge)</i> <i>iii. I can set up a daily reminder for you. (Facilitate nudge)</i>

4.2.1 Challenge 1: Students Not Submitting Summary Notes of A Given Reading Assignment

For the first challenge regarding, “Students not submitting summary notes of a given reading assignment”, we used three different strategies of nudging and designed 5 example communication messages. Messages i and ii are associated with Social nudges. The tendency for learners to look at other learner's behaviour or to assist and guide their own behaviour is known as a social-proof heuristic. Students may prefer to orient towards the conduct of others, seeking for social proof when unable to discern the right style of action in a given scenario, because social norms affect human behaviour. Message iii and iv are associated with confront nudges. It reminds the learner of consequence. This creates a sense of tension and fear to fuel motivation. Fear is a powerful motivator because it makes the learner uncomfortable, and he may want to move away from that discomfort towards his comfort zone. In message ii we instigate empathy through negative reinforcements. Negative reinforcement and indirect suggestions may promote positive behaviours. In reaction to a stimulus, something unpleasant is taken away with negative reinforcement. Message v is associated with facilitate nudge. A reward is a stimulus that drives an appetite to alter behaviour. Rewards typically serve as reinforcers. That is, they make us repeat behaviours that we perceive (unconsciously) as good for our survival, even when they're not.

4.2.2 Challenge 2: Students Not Previewing/Reviewing Materials.

For the second challenge regarding, “Students not previewing/reviewing materials.”, we used three different strategies of nudging and designed 3 example communication messages. Message i is associated with *confront nudge*. Procrastination can become chronic and habitual. Students may keep putting things off until they have a cumulative effect on themselves. They procrastinate more if they have a lot of things to do or if they don't enjoy what you have to do. Procrastination becomes a vicious cycle, they become overwhelmed by the amount of work that has to be done and the lack of time available to do it, they may grow increasingly agitated, and feel trapped and unable to go forward. One of the reasons that may stop motivating students can be lack of confrontation. This nudge option can help in that area.

Message ii is associated with a *facilitate nudge*. Simple reminders may have a healthy impact on a learner's behaviour. Including deadline, goal-setting, and reminder treatments, encourage learners to utilise these behavioural tools in situations where they may otherwise fail to use them effectively to self-regulate their behaviour. Students often have a lot on their thoughts, they may forget, become busy, or just put off starting a task. Message iii is *associated with Facilitate nudge and Fear nudge*. The goal of this nudge is to let students overcome their fears or move past them to reach a healthier place. One of the most well-known approaches to nudging is to change defaults. Because of default bias, people tend to choose the default option and as a result changing defaults can be a powerful policy tool. (Damgaard & Nielsen, 2018)

4.2.3 Challenge 3 Students Spend a Lot of Time on A Certain Portion of Reading Material.

For the third challenge regarding, “Students spend a lot of time on a certain portion of reading material.”, we used two different strategies of nudging and designed 3 example communication messages. For message i and iii are associated with *deceive nudges*. Deceive nudges are used as deception mechanisms in order to affect how alternatives are perceived, or how activities are experienced, with the goal of promoting particular outcomes. Here, in message i, we made it seem like the error was on the bot's side and masked it like a deceptive reminder message. In message iii, we reminded the students about their last reading time. Message ii is *associated with Facilitate nudge* for reminders.

4.2.4 Challenge 4 Students Rushing Assignment Submissions at The End Moment.

For the third challenge regarding, “Students rushing assignment submissions at the end moment.”, we used three different strategies of nudging and designed 3 example communication messages. Message i is associated with the nudge type, *reinforce nudge*. Nudges in this category attempt to reinforce behaviours through increasing their presence in individual thinking. Pleasant emotions and sadness elicited more empathic emotion than did shame and anger. When the student is sad, the motivation increases intellectual empathy, and when the target person is happy, it increases empathy. Message ii is associated with the nudge type, *deceive nudge*. These nudges use deception mechanisms in order to affect how alternatives are perceived, or how activities are experienced, with the goal of promoting particular outcomes. Letting students know the consequences of their own past decisions by constantly monitoring students and their actions, information about that person's previous decisions becomes available and can be used to inform users of the long-term consequences of their continued actions. Message iii is associated with *facilitate nudge*. Simple reminders may have a healthy impact on a learner's behaviour. Including deadline, goal-setting, and reminder treatments, encourage learners to utilise these behavioural tools in situations where they may otherwise fail to use them effectively to self-regulate their behaviour.

4.3 User Perception of Nudges

Based on the questionnaire responses (n=19) the perceived usefulness and the frequency of 15 nudges that were designed is reported in table 2.

Further we analysed the open responses of the students where they provided suggestions of nudges that would be useful for them. We performed content analysis and coded the nudges based on the 23 categories of nudges available in literature Caraban et al (2019). Two researchers independently coded 50% of the data and then discussed the categorization to resolve differences until there was 100% inter-rater agreement. One researcher then coded the rest of the data. The findings are shown in the table below. We find that the most common type of nudge suggested for context #1 is of Social nudge, for context # 2 is of Social and reinforce nudge, for context # 3 is Reinforce nudge and for context # 4 is facilitate nudge.

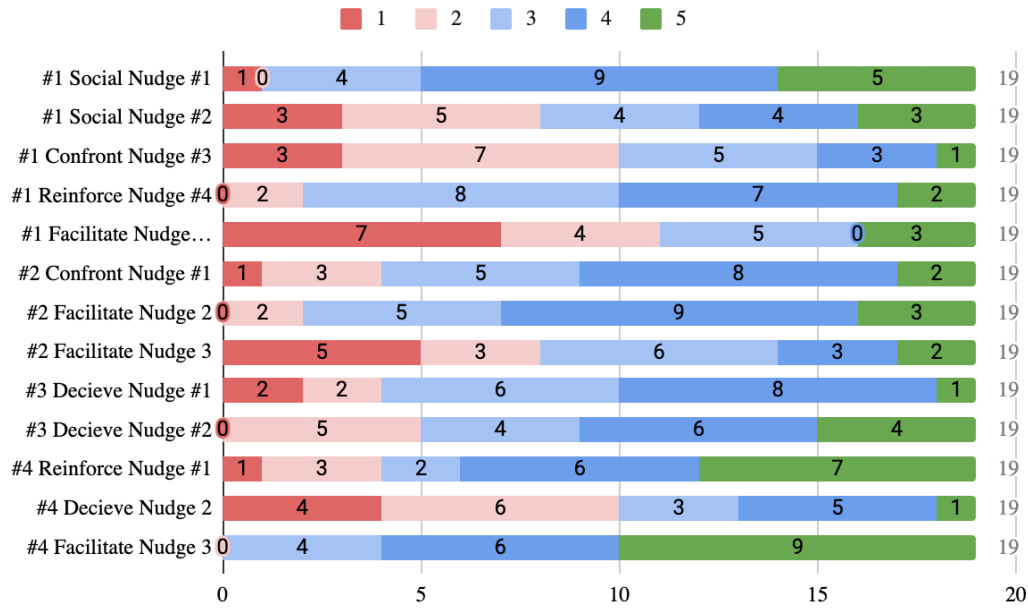


Figure 5. Student responses of perceived usefulness of each nudge (n=19)

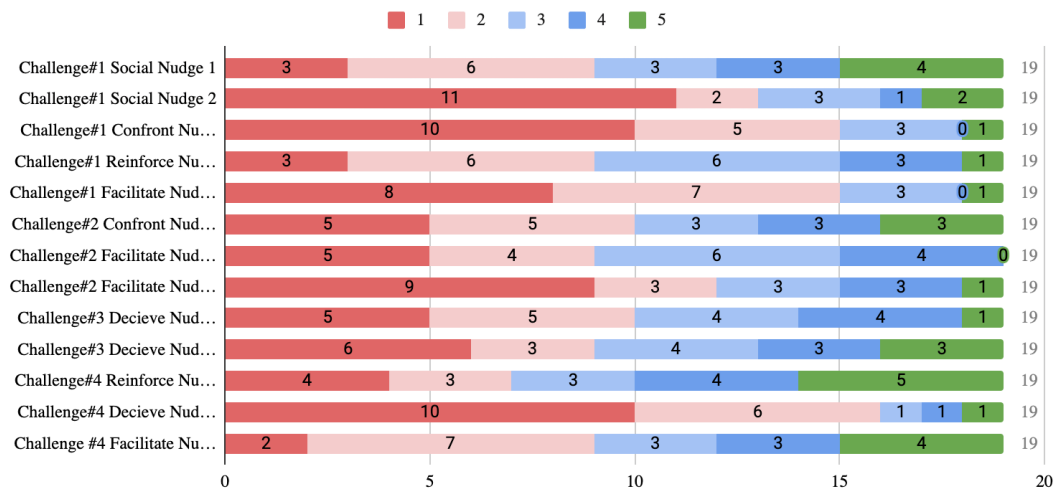


Figure 6. Student responses of perceived frequency of each nudge (n=19)

Table 3. Proposed Nudge Message from The Participants (n=37)

Challenges faced in SDL	Category (% of responders) - Example given by students
#1 Students not submitting summary notes of a given reading assignment	Social nudge (30%) : I think message two [<i>Did you miss submitting the summary?</i>] was useful. Reinforce nudge (23%) : I think it's better to use positive words such as trying hard or feeling good, rather than appealing that you shouldn't fail, you have to do it, and the people around you are doing it. Confront nudge (16%) : I may send a message to ask what's bothering him to refrain from doing his assignment. Facilitate nudge (16%) : Maybe have Ren set their own personal schedule on what to be reminded about (probably that's what nudge #4 is?) Fear nudge (8%) : Tell him that he has little time to do the assignment NA (7%)
#2 Students not previewing/reviewing materials	Social nudge (22%) : show your friend / classmate has reviewed it Reinforce nudge (22%) : Reviewing can lead to better performance Confront nudge (11%) : Are you a student? What are you doing without studying?

	Facilitate nudge (11%): alarm NA (34%)
#3 Students spend a lot of time on a certain portion of reading material.	Social nudge (10%): compared to others, what is your reading time? What is the position of the reading time of all device users? Reinforce nudge (40%): I propose another nudge with questions. Questions offer a chance to think about your style of learning. Confront nudge (10%): Do you understand the materials? Check it!!! Facilitate nudge (10%): Display reading speed of the certain material Deceive nudge (10%): I think it would be better to show how much he did his goal and how much more he needed to do to reach his goal. Fear nudge (10%): Your next class is on OO, which means you still have OO days (hours) to preview/review for your class NA (10%)
#4 Students rushing assignment submissions at the end moment	Social nudge (16%): alert every time one friend /classmate of Ren makes a submission :) Confront nudge (16%): Asked by system about the task and recall the task by himself. Facilitate nudge (33%): I think it would be better to suggest modifying the plan so that the goals he originally set can be displayed at the same time. Deceive nudge (16%): Deadline is over. Just kidding. Fear nudge (16%): Hurry up otherwise you will face consequences NA (3%)

5. Discussion and Conclusion

5.1 Findings and Contribution of the Current Work

We designed nudge solutions for students based on the challenges detected from learning logs. Based on the analysis of the perceived usefulness and desired frequency of the designed nudge (Table 2), we see that there is a positive association between these two variables. Results of the Pearson correlation indicated that there was a significant positive association between the perceived usefulness of the nudge and how frequently the student would like to have this nudge ($r(17) = .92, p < 0.001$). This gives indicators that students do not mind being nudged more frequently provided that they perceive that these nudges are useful for them. We intend to validate this finding in future studies where we design a wearable with such nudges and conduct field studies with students.

From Table 2, we also see that Challenge #4, Nudge #3 (“*I can set up a daily reminder for you*”) was perceived as the most useful nudge by students. This can indicate that students perceive those nudges which will help them plan how to complete their assignments as most useful. This could be because students are often juggling with a lot of assignments from various courses they take up at once. Setting up frequent reminders helps them to constantly stay on track. In the quadrant, Fig 1 this fits in the ‘reminders’ section which is neutral to the four aspects of passive and active decision making and changes and additions to the decision environment.

On the other hand, Challenge #1, Nudge #5 (“*Do you want to set a reward for yourself?*”), shows the lowest overall usefulness. The reason for this nudge being on the lower side of usefulness can be that this nudge is not connected to the corresponding problem context. It is possible that reward driven nudges don't work for this particular problem context but they may work for other contexts. It could also be that this nudge does not provide any direct action such as a “reminder” but instead proposes a more abstract “reward”. In the quadrant, Fig 1 this fits in the ‘reminders’ section which is neutral to the four aspects of passive and active decision making and changes and additions to the decision environment.

We can also infer from Table 2 that there is no apparent correlation between the category of nudge, and the perceived usefulness of the nudge. For example, from Table 2, we see that Problem context #1, Nudge #5 is a Facilitate category nudge, and students reported the lowest usefulness (2.4 out of 5). However, Problem #2 Nudge #2, and Problem #4, Nudge #3 are also Facilitate nudges but they received the highest usefulness in Problem #2 (3.7 out of 5) and Problem #4 (4.3 out of 5). This gives indicators that for different problem contexts, different categories of nudges might be beneficial

to learners.

From Table 3, we see that when students propose nudges, they mostly propose social nudges followed by reinforce nudges. The students likely preferred additions to the decision environment and active decision making from Figure 1. This suggests that learners in our context are primarily motivated by social norms and positioning themselves with respect to other learners. Further they like to receive positive reinforcement, encouragement and useful suggestions to complete their work.

5.2. Limitations and Future Work

We tested the proposed solutions on undergraduate students at a national university in Japan. The quality of the communication nudge messages we receive from the students as alternate nudge options may have been subject to the colloquial use of their language and variations in interpretation when translated to english so we made students express their thoughts in the language of their choice for a better understanding.

In the future, we propose more studies to understand the usefulness of nudging for students in a self-directed-learning context. We intend to understand the use of wearables for nudging in a long term SDL environment, the emphasis on the quality of communication messages and other nudging behaviours that are translated to the various affordances of technology. We intend to design the wearable and are planning to conduct a study to replicate the findings from Table 2. We intend to understand whether students still perceive that the nudges are useful to them. We also intend to validate if there is a positive correlation between frequency and usefulness in future studies.

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