Peer-Awareness to Support Learning
An In-the-wild Study on Notification Timing

Iwashita, Yuichiro; Kurashige, Ryuki; Vargo, Andrew; Tag, Benjamin; Dingler, Tilman; Iwata, Motoi; Kise, Koichi

DOI
10.1145/3675094.3677576

Publication date
2024

Document Version
Final published version

Published in
UbiComp '24

Citation (APA)
Iwashita, Y., Kurashige, R., Vargo, A., Tag, B., Dingler, T., Iwata, M., & Kise, K. (2024). Peer-Awareness to Support Learning: An In-the-wild Study on Notification Timing. In *UbiComp '24: Companion of the 2024 on ACM International Joint Conference on Pervasive and Ubiquitous Computing* (pp. 14-18). ACM. https://doi.org/10.1145/3675094.3677576

Peer-Awareness to Support Learning: An In-the-wild Study on Notification Timing

Yuichiro Iwashita
Osaka Metropolitan University
Sakai, Osaka, Japan
sc23370s@st.omu.ac.jp

Ryuki Kurashige
Osaka Prefecture University
Sakai, Osaka, Japan
sfb01044@st.osakafu-u.ac.jp

Andrew Vargo
Osaka Metropolitan University
Sakai, Osaka, Japan
awv@omu.ac.jp

Benjamin Tag
Monash University
Clayton, Victoria, Australia
benjamin.tag@monash.edu

Tilman Dingler
Delft University of Technology
Delft, Netherlands
t.dingler@tudelft.nl

Motoi Iwata
Osaka Metropolitan University
Sakai, Osaka, Japan
imotoi@omu.ac.jp

Koichi Kise
Osaka Metropolitan University
Sakai, Osaka, Japan
kise@omu.ac.jp

ABSTRACT

Researchers have proposed various approaches to increase motivation for learning. However, in many cases, they are designed to boost motivation but fall short of creating learning habits. Gamification and competition between peers are widely used to urge people to, for example, do more steps in a day. E-learning platforms often use leaderboards to visualize peer progress, but their effectiveness is limited to when users open the platform. In this work, we use notifications to inform peers of each other's progress in real-time to increase motivation for learning. In an in-the-wild study with 19 participants, we investigate the impact of peer-awareness on learning by comparing *real-time notifications* (sent immediately after peers' progress) with *interval-based notifications* (sent at random intervals). Contrary to our initial expectations, our findings reveal that *interval-based notifications* are more effective in promoting learning activities. We introduce the *Peer-Aware Learning System (PALS)*, a mobile application designed to simulate peer effects and provide insights from our user study on notification timing strategies for enhancing learning motivation.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in ubiquitous and mobile computing**.

KEYWORDS

notifications, peer effects, peer pressure, nudge, mobile

ACM Reference Format:
Yuichiro Iwashita, Ryuki Kurashige, Andrew Vargo, Benjamin Tag, Tilman Dingler, Motoi Iwata, and Koichi Kise. 2024. Peer-Awareness to Support Learning: An In-the-wild Study on Notification Timing. In *Companion of the 2024 ACM International Joint Conference on Pervasive and Ubiquitous Computing Pervasive and Ubiquitous Computing (UbiComp Companion '24), October 5–9, 2024, Melbourne, VIC, Australia.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3675094.3677576

UbiComp Companion '24, October 5–9, 2024, Melbourne, VIC, Australia

ACM ISBN 979-8-4007-1058-2/24/10.
https://doi.org/10.1145/3675094.3677576

1 INTRODUCTION

Creating good learning habits is inherently challenging for many individuals. To trigger learning activities, motivation plays an important role [9, 12, 16]. Researchers have proposed some approaches to increase motivation. However, it remains challenging to keep motivation high over longer periods of time.

Learning with peers has been recognized as an effective method to boost motivation [2, 6, 24]. When we study with peers, such as friends or classmates, we tend to be affected by their behavior and progress. For example, research has shown that learning about an academic gap between you and your peers can motivate you to catch up with them [4, 25]. Based on these so-called "peer effects" [2, 11, 21], we call the learning approach that leverages peer effects, *peer-aware learning*. *Peer-aware learning* has been applied to e-learning, e.g., leaderboards visualizing the progress of peers, have been shown to be effective in increasing motivation [13, 30]. However, people can be aware of their peers' progress only when they check the leaderboards, and this may reduce the effectiveness of peer effects.

To solve this problem, we consider amplifying peer effects using mobile notifications. Notifications have been used in mobile learning applications to remind and engage users to learn [7, 8, 18]. Notifications can also be used to summarize the content of leaderboards and make users aware of their peers' progress. We call this approach, *peer-aware notifications*.

In this work, we aim to leverage notifications to foster peer-awareness and increase motivation. However, there are several factors to consider when designing *peer-aware notifications*, such as the timing and content of notifications. To investigate the impact of notification timing, we conducted an in-the-wild study with 19 participants and compared the effectiveness of *real-time* and *interval-based notifications*. *Real-time notifications* are sent immediately after peers make progress, while *interval-based notifications* are sent at random intervals, both describing peers' progress. We hypothesize that with *real-time notifications*, learners can become more aware of their peers and feel closer to them, which can motivate them to learn more. In addition, this experiment was designed with the understanding that frequent and numerous notifications can be stressful for users [17, 19, 20, 22, 28, 29]. However, we hypothesize that *real-time notifications* could overcome this issue by fostering peer-awareness.

Contrary to our initial expectations, the results indicate that *interval-based notifications* are more effective than *real-time notifications*. This highlights the importance of notification timing and provides insights for system designers aiming to leverage peer effects in learning applications. The main contributions of this paper are as follows:

- We developed a mobile application called *Peer-Aware Learning System (PALS)* to simulate peer effects and compare different notification timings aimed at triggering learning activities.
- We conducted an in-the-wild user study to compare the effectiveness of *real-time* and *interval-based notifications*.

2 RELATED WORK

2.1 Peer Effects in Education

The education literature provides a large corpus of works where peer effects were applied and tested in educational settings, demonstrating the impact on learners' motivation [1, 4, 6, 24–26, 30, 31].

The digitization of education technology and the pervasiveness of mobile devices have stimulated more research on the topic in the computing domain. In the field of e-learning, the effects of using leaderboards have been investigated [13, 23]. Some studies investigated peer effects in e-learning other than leaderboards [10, 30]. For example, Zhang investigated how peer effects occur while students ask and answer questions in online forums.

2.2 Notifications

Researchers have investigated the effectiveness and issues of notifications in various contexts. Notifications can serve as timely reminders or prompts to engage in specific activities, including learning. Different researchers have shown the effectiveness of using notifications for learning [7, 8, 18]. For example, Dingler et al. proposed a language learning system that sends notifications to users to learn new words. Contrary to the effectiveness, it has been known that frequent and numerous notifications can be stressful for users [17, 19, 20, 22, 28, 29]. To reduce the burden of notifications, researchers have proposed various approaches to send notifications at optimal timings [5, 7, 14] or summarize notifications [15, 27].

3 PEER-AWARE LEARNING SYSTEM (PALS)

We developed a mobile application called *Peer-Aware Learning System (PALS)* to simulate peer effects and compare the notification timings on *peer-aware learning*. The application works on iOS and Android smartphones. This application enables users to study being aware of their peers' progress by leaderboard and notifications. *PALS* consists of the following features: learning materials (Section 3.1), leaderboard (Section 3.2), and notifications (Section 3.3). The user interfaces of *PALS* are shown in Figure 1.

3.1 Learning material

PALS provides English vocabulary flashcards as shown in Figure 1a. Each card shows an English word, and users can show its definition or Japanese translation by tapping buttons. The Japanese translations of the words are generated by Google Translate API[1]. When users check the card, they can mark if they remember the word or not. To reduce the burden and increase the frequency of learning, *microlearning* is applied. *Microlearning* is a learning method that provides small learning units to users [3, 8]. In our system, users learn three words in one learning session, and they can repeat the session as many times as they want. The learning session is completed when users think they have remembered all three words "by heart." For each learning session, three words are randomly selected from the GRE Wordlist[2] consisting of 1,162 words that frequently appear in the GRE test[3].

3.2 Leaderboard

To make users aware of their peers, *PALS* provides a leaderboard that describes their peers' latest progress as shown in Figure 1b. The leaderboard shows the ranking of the number of words learned by peers, and it updates just after peers make progress. The score shown in the leaderboard is the total number of words learned by peers. Users can change the term, e.g., daily, weekly, or monthly, to see the ranking in the selected term.

3.3 Notifications

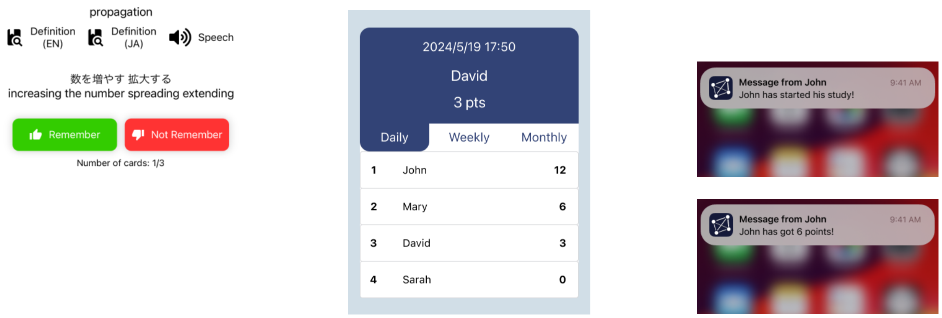
In addition to the leaderboard, *PALS* provides notifications to make users aware of their peers' progress. There are two modes of notifications, which are *real-time* and *interval-based notifications*.

3.3.1 Real-time notifications.

Real-time notifications are sent just after peers make progress. The messages of the notifications describe the real-time learning activity of peers. For example, when John, one of your peers, studies for the first time today, you will receive a notification saying "John has started his study!", while John additionally learns three words later, you will receive a notification saying "John learned three words!".

3.3.2 Interval-based notifications.

Interval-based notifications are sent at random moments throughout the day. These notifications are issued five times daily, with the timing randomly chosen from 16 options: 8 am, 9 am, . . . , and 11 pm. This is selected without biasing the timing to a certain time. The messages of the notifications describe the learning activity done by peers between the last notification and the current notification. For example, when John learns three words, and then Mary learns two words, you will receive a notification saying "Your peers learned five words!".



(a) Learning material (b) Leaderboard (c) Notifications

Figure 1: User interfaces of *Peer-Aware Learning System (PALS)*. Each figure shows (a) learning material, (b) leaderboard, and (c) notifications of *PALS*.

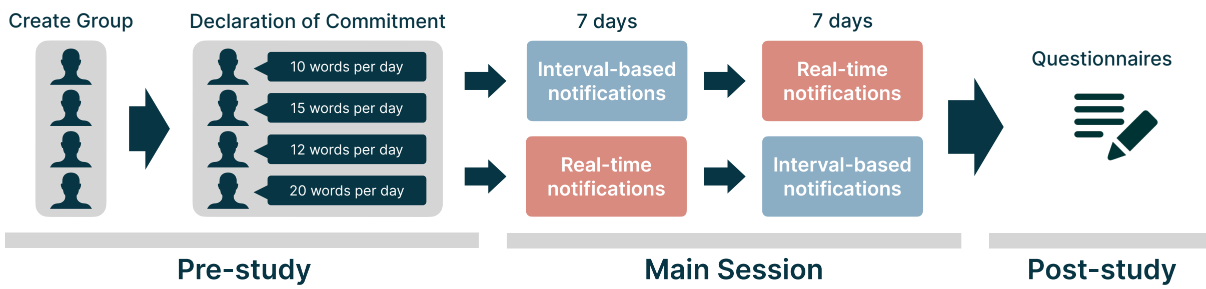


Figure 2: The overview of the experiment. Before the main session, we created groups and the participant declared their commitment to the study. During the main session, participants experienced two modes of notifications. The order of the modes was counterbalanced. After the main session, participants answered questionnaires about their experience.

4 EXPERIMENT

We conducted a user study to compare the effectiveness of the *real-time* and *interval-based notifications*. We recruited 19 participants (1 female) and their ages ranged from 19 to 25 (M = 21.58, SD = 1.50). All participants were Japanese university or graduate school students, and their native language was Japanese. For participation, we gave a maximum of 5,000 JPY (approximately 30 USD) Amazon gift cards to each participant when they completed the study. The amount of the payment was determined by the percentage of the days the participant responded to at least one notification from *PALS*. This was informed to participants before the study. The experiment was conducted fully online, and it consisted of three phases: pre-study (Section 4.1), main session (Section 4.2), and post-study (Section 4.3). The main session was conducted for 14 days. This experiment was approved by the ethics committee in advance.

4.1 Pre-study

We created five groups, which are groups A, B, C, D, and E. Only group E had three participants, and the other groups had four participants. Since it is difficult to create groups with their actual peers, we chose the group members in order of participation.

After creating groups, we conducted online meeting sessions for each group to explain the experiment and let them know each other. During the meeting, we asked them to introduce themselves and declare their commitment to the study. The commitment was about their goal setting which was the number of words they learn per day, e.g., "I will learn 10 words per day during this study". Then, we asked them to install *PALS* on their smartphones and explained how to use it. Also, we asked them to answer demographic questionnaires, including age, gender, and native language.

4.2 Main Session

During the main session, participants were asked to learn English words using *PALS* anytime they wanted. Each participant experienced two modes of notifications during the main session. In the first 7 days, participants experienced *real-time* or *interval-based notifications*, and in the last 7 days, they experienced the other. To reduce the order effects, groups A and B started the main session with *interval-based notifications*, and groups C, D and E started with *real-time notifications*. To analyze the behavior of participants during the main session, we collected the data shown in Table 1. Each event was recorded immediately after it occurred.

4.3 Post-study

After the main session, we asked participants to answer questionnaires about their English learning ability, their general experience

[1]https://cloud.google.com/translate
[2]https://gist.github.com/yiRMT/bc39eac36ebb5e6083f233899fe39dad
[3]https://www.ets.org/gre.html

Table 1: Data collected during the main session.

Event	Description
`app_foreground`	Timestamp the participant opened the app
`received_notifications`	Timestamp the participant received notifications
`tapped_notifications`	Timestamp the participant tapped the notifications
`begin_study`	Timestamp the participant started learning words
`end_study`	Timestamp the participant ended learning words
`tapped_leaderboard`	Timestamp the participant tapped the leaderboard

against notifications in their daily lives, and their experience during the main session. The questionnaires were answered using a 5-point Likert scale and free description.

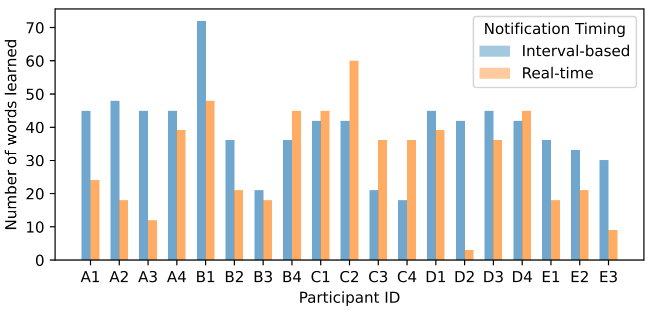


Figure 3: Number of words learned under different notification timings.

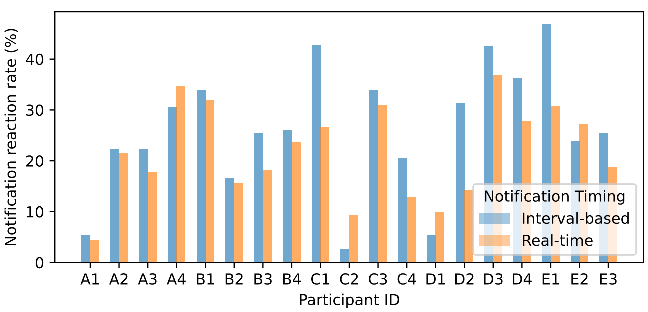


Figure 4: Notification reaction rate under different notification timings, which is calculated by dividing the number of tapped notifications by the number of received notifications.

5 RESULTS AND DISCUSSION

The number of words learned during each condition is shown in Figure 3. The x-axis shows participant IDs, and the y-axis shows the number of words learned. The prefix of the participant ID indicates the group ID, e.g., the group ID for participant A1 is A. We conducted a dependent t-test to compare the number of words learned between the two conditions. The result showed that there was a significant difference between the two conditions (t = 2.296, p = .034 ($<$ .05)), and it suggests that the *interval-based notifications* were more effective in terms of the number of words learned.

The notification reaction rate under different notification timings is shown in Figure 4. The x-axis shows participant IDs, and the y-axis shows the notification reaction rate, which is calculated by dividing the number of tapped notifications by the number of received notifications. We conducted a dependent t-test to compare the notification reaction rate between the two conditions. The results showed that there was a significant difference between the two conditions (t = 2.692, p = .015 ($<$ .05)), and it suggests that the *interval-based notifications* were more effective in terms of the notification reaction rate.

In the post-study questionnaires, we asked participants in which condition they were more aware of their peers' progress. They answered on a 5-point Likert scale, where 1 is *real-time notifications* and 5 is *interval-based notifications*, and the average value was 3.05 (SD = 1.35). This implies that participants were relatively aware of their peers' progress in the *interval-based notifications* condition.

Therefore, the results showed that it is more effective to notify the progress of peers at *interval-based timing* than in *real-time* in terms of the number of words learned and the notification reaction rate. The post-study questionnaires imply that it may be because participants were more aware of their peers' progress in the *interval-based notifications* condition, and it motivated them to learn more words. In addition, it may be possible that the *real-time notifications* were too frequent and participants were annoyed by them, as researchers have reported that excessive notifications can reduce the effectiveness of notifications [17, 19, 20, 22, 28, 29].

6 CONCLUSION AND FUTURE WORK

In this paper, we described the preliminary results for the development of a *peer-aware learning* approach to amplify peer effects in mobile learning applications. We developed a mobile application called *Peer-Aware Learning System (PALS)* to simulate peer effects and compare the notification timings on *peer-aware learning*. We conducted an in-the-wild user study to compare the effectiveness of *real-time* and *interval-based notifications*. The results showed that it is more effective to notify the progress of peers at *interval-based timing* than in *real-time*. The findings of this study can contribute to the design of mobile learning applications that leverage peer effects to enhance motivation and improve learning outcomes.

ACKNOWLEDGMENTS

This work was supported in part by grants from the JST Trilateral AI Research (JPMJCR20G3), JSPS Grant-in-Aid for Scientific Research (23KK0188), and the Grand Challenge of Initiative for Life Design Innovation, MEXT Society 5.0 Realization Research Support Project, Osaka University.

REFERENCES

[1] Xornam S. Apedoe, Michelle R. Ellefson, and Christian D. Schunn. 2012. Learning Together While Designing: Does Group Size Make a Difference? *Journal of Science Education and Technology* 21, 1 (Feb. 2012), 83–94. https://doi.org/10.1007/s10956-011-9284-5

[2] Pontus Bäckström. 2023. Exploring Mechanisms of Peer-Effects in Education: A Frame-Factor Analysis of Instruction. *Educational Review* 75, 7 (Nov. 2023), 1387–1405. https://doi.org/10.1080/00131911.2021.2023100

[3] Jennifer S. Beaudin, Stephen S. Intille, Emmanuel Munguia Tapia, Randy Rockinson, and Margaret E. Morris. 2007. Context-Sensitive Microlearning of Foreign Language Vocabulary on a Mobile Device. In *Ambient Intelligence (Lecture Notes in Computer Science, Vol. 4794)*. Springer Berlin Heidelberg, Berlin, Germany, 55–72. https://doi.org/10.1007/978-3-540-76652-0_4

[4] Te-Sheng Chang, Yin Bai, and Tsai-Wei Wang. 2014. Students' Classroom Experience in Foreign-Faculty and Local-Faculty Classes in Public and Private Universities in Taiwan. *Higher Education* 68, 2 (Aug. 2014), 207–226. https://doi.org/10.1007/s10734-013-9703-z

[5] Xi-Jing Chang, Fang-Hsin Hsu, En-Chi Liang, Zih-Yun Chiou, Ho-Hsuan Chuang, Fang-Ching Tseng, Yu-Hsin Lin, and Yung-Ju Chang. 2023. Not Merely Deemed as Distraction: Investigating Smartphone Users' Motivations for Notification-Interaction. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–17. https://doi.org/10.1145/3544548.3581146

[6] Jean-Baptiste Corrégé and Nicolas Michinov. 2021. Group Size and Peer Learning: Peer Discussions in Different Group Size Influence Learning in a Biology Exercise Performed on a Tablet With Stylus. *Frontiers in Education* 6 (Nov. 2021), 1–13. https://doi.org/10.3389/feduc.2021.733663

[7] Tilman Dingler, Benjamin Tag, Sabrina Lehrer, and Albrecht Schmidt. 2018. Reading Scheduler: Proactive Recommendations to Help Users Cope with Their Daily Reading Volume. In *Proceedings of the 17th International Conference on Mobile and Ubiquitous Multimedia* (Cairo, Egypt) *(MUM '18)*. Association for Computing Machinery, New York, NY, USA, 239–244. https://doi.org/10.1145/3282894.3282917

[8] Tilman Dingler, Dominik Weber, Martin Pielot, Jennifer Cooper, Chung-Cheng Chang, and Niels Henze. 2017. Language Learning On-the-Go: Opportune Moments and Design of Mobile Microlearning Sessions. In *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '17)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3098279.3098565

[9] Zoltán Dörnyei. 1998. Motivation in Second and Foreign Language Learning. *Language Teaching* 31, 3 (July 1998), 117–135. https://doi.org/10.1017/S026144480001315X

[10] Marcel Fafchamps and Di Mo. 2018. Peer Effects in Computer Assisted Learning: Evidence from a Randomized Experiment. *Experimental Economics* 21, 2 (June 2018), 355–382. https://doi.org/10.1007/s10683-017-9538-z

[11] Daniel Herbst and Alexandre Mas. 2015. Peer Effects on Worker Output in the Laboratory Generalize to the Field. *Science* 350, 6260 (Oct. 2015), 545–549. https://doi.org/10.1126/science.aac9555

[12] Martin Lamb. 2017. The Motivational Dimension of Language Teaching. *Language Teaching* 50, 3 (July 2017), 301–346. https://doi.org/10.1017/S0261444817000088

[13] Weiwen Leung. 2019. How Do One's Peers on a Leaderboard Affect Oneself?. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–11. https://doi.org/10.1145/3290605.3300397

[14] Tianshi Li, Julia Katherine Haines, Miguel Flores Ruiz De Eguino, Jason I. Hong, and Jeffrey Nichols. 2023. Alert Now or Never: Understanding and Predicting Notification Preferences of Smartphone Users. *ACM Transactions on Computer-Human Interaction* 29, 5 (Jan. 2023), 39:1–39:33. https://doi.org/10.1145/3478868

[15] Tzu-Chieh Lin, Yu-Shao Su, Emily Helen Yang, Yun Han Chen, Hao-Ping Lee, and Yung-Ju Chang. 2021. "Put It on the Top, I'll Read It Later": Investigating Users' Desired Display Order for Smartphone Notifications. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3411764.3445384

[16] W. L. Quint Oga-Baldwin. 2019. Acting, Thinking, Feeling, Making, Collaborating: The Engagement Process in Foreign Language Learning. *System* 86 (Nov. 2019), 102128. https://doi.org/10.1016/j.system.2019.102128

[17] Veljko Pejovic and Mirco Musolesi. 2014. InterruptMe: Designing Intelligent Prompting Mechanisms for Pervasive Applications. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '14)*. Association for Computing Machinery, New York, NY, USA, 897–908. https://doi.org/10.1145/2632048.2632062

[18] Xuan-Lam Pham, Thi-Huyen Nguyen, Wu-Yuin Hwang, and Gwo-Dong Chen. 2016. Effects of Push Notifications on Learner Engagement in a Mobile Learning App. In *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)*. IEEE, New York, NY, USA, 90–94. https://doi.org/10.1109/ICALT.2016.50

[19] Martin Pielot, Karen Church, and Rodrigo de Oliveira. 2014. An In-Situ Study of Mobile Phone Notifications. In *Proceedings of the 16th International Conference on Human-computer Interaction with Mobile Devices & Services (MobileHCI '14)*. Association for Computing Machinery, New York, NY, USA, 233–242. https://doi.org/10.1145/2628363.2628364

[20] Martin Pielot and Luz Rello. 2015. The Do Not Disturb Challenge: A Day Without Notifications. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15)*. Association for Computing Machinery, New York, NY, USA, 1761–1766. https://doi.org/10.1145/2702613.2732704

[21] Bruce Sacerdote. 2011. Peer Effects in Education: How Might They Work, How Big Are They and How Much Do We Know Thus Far? In *Handbook of the Economics of Education*. Vol. 3. Elsevier, Amsterdam, Netherlands, 249–277. https://doi.org/10.1016/B978-0-444-53429-3.00004-1

[22] Alireza Sahami Shirazi, Niels Henze, Tilman Dingler, Martin Pielot, Dominik Weber, and Albrecht Schmidt. 2014. Large-Scale Assessment of Mobile Notifications. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. Association for Computing Machinery, New York, NY, USA, 3055–3064. https://doi.org/10.1145/2556288.2557189

[23] Marc Schlömmer, Teresa Spieß, and Stephan Schlögl. 2021. Leaderboard Positions and Stress—Experimental Investigations into an Element of Gamification. *Sustainability* 13, 12 (Jan. 2021), 6608. https://doi.org/10.3390/su13126608

[24] Ruey-Shiang Shaw. 2013. The Relationships among Group Size, Participation, and Performance of Programming Language Learning Supported with Online Forums. *Computers in Education* 62, 1 (March 2013), 196–207. https://doi.org/10.1016/j.compedu.2012.11.001

[25] Arna Vardardottir. 2013. Peer Effects and Academic Achievement: A Regression Discontinuity Approach. *Economics of Education Review* 36 (Oct. 2013), 108–121. https://doi.org/10.1016/j.econedurev.2013.06.011

[26] Kristel Vignery and Wim Laurier. 2020. Achievement in Student Peer Networks: A Study of the Selection Process, Peer Effects and Student Centrality. *International Journal of Educational Research* 99 (2020), 101499. https://doi.org/10.1016/j.ijer.2019.101499

[27] Peng-Jui Wang, Yi-Chi Lee, Uei-Dar Chen, and Yung-Ju Chang. 2023. NotiSummary: Exploring the Potential of AI-Driven Text Summarization on Smartphone Notification Management. In *Adjunct Proceedings of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing (UbiComp/ISWC '23 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 113–117. https://doi.org/10.1145/3594739.3610702

[28] Tilo Westermann, Sebastian Möller, and Ina Wechsung. 2015. Assessing the Relationship between Technical Affinity, Stress and Notifications on Smartphones. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct (MobileHCI '15)*. Association for Computing Machinery, New York, NY, USA, 652–659. https://doi.org/10.1145/2786567.2793684

[29] SungHyuk Yoon, Sang-su Lee, Jae-myung Lee, and KunPyo Lee. 2014. Understanding Notification Stress of Smartphone Messenger App. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14)*. Association for Computing Machinery, New York, NY, USA, 1735–1740. https://doi.org/10.1145/2559206.2581167

[30] Xiaodong Zhang. 2023. Peer Pressure and Web-Based Peer Learning: An Exploratory Case Study. *Education and Information Technologies* 28, 8 (Aug. 2023), 10405–10420. https://doi.org/10.1007/s10639-023-11609-8

[31] Dong Zhao. 2021. Peer Pressure in BIM-Based Collaboration Improves Student Learning. *Journal of Civil Engineering Education* 147, 2 (April 2021), 04020019. https://doi.org/10.1061/(ASCE)EI.2643-9115.0000038