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LETTER

Real-time Interactions with Photos and Texts in Large Classrooms

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SUMMARY This letter presents a solution for large classroom interactions using cloud computing and mobile devices. A lecturer can collect student photos or texts and give real-time feedback. Students confirmed in anonymous surveys that this solution enabled them to actively participate in classes and enhanced their learning even in large classrooms.
key words: *classroom interactions, photo sharing, real-time feedback, synchronous message sharing.*

1. Introduction

Interactions between a lecturer and students in a classroom help both the lecturer and students improve the teaching and learning process. Many studies on classroom interactions using mobile devices such as smartphones, tablets, or notebooks have been proposed [1]. Especially smartphone messaging has been suggested for quizzes [2] or asking questions [3] in large classrooms during experimental trials.

The COVID-19 pandemic forced universities, colleges, and schools to introduce remote online classes using tools, systems, and devices [4]. Images or smartphone photos have been used for various interactions during remote online classes [4], [5]. As a result, after COVID-19, lecturers and students can comfortably use digital-pen drawings, photos, or other class materials on mobile devices in addition to or as a supplement to face-to-face classes in classrooms [6], [7].

This letter suggests a simple solution [8] for real-time interactions in large classrooms. This solution has been refined from the previous study [5]. With this solution, using cloud computing and mobile devices in a classroom, a lecturer can collect and share students' photos or texts and give real-time feedback, as shown in Fig. 1 and Fig. 2. As listed in Table 3, Table 4, and Table 5, students anonymously evaluated that this solution enabled them to stay focused and to participate in various classroom interactions, even in large classrooms and therefore, improved their learning.

2. Photo and Text Messaging in Large Classrooms

The goal of this solution is to enable a lecturer to interact with every student even in a large classroom with minimal difficulty, as shown in Fig. 1. No special preparation for a lecturer or students is required to use this solution. This solution supports collecting and sharing photos, drawings,

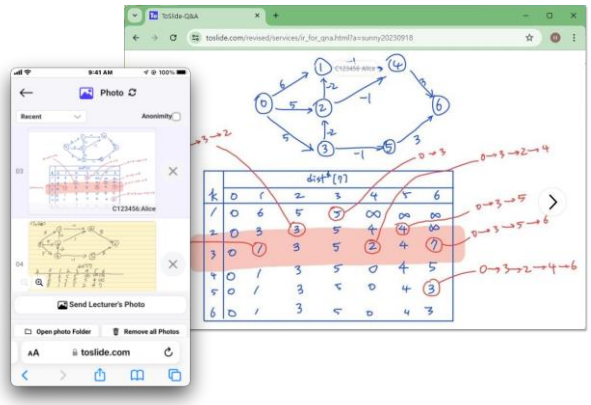

Fig. 1 An example of an image collected from students in a classroom [8]. A lecturer can give real-time feedback while sharing photos or texts with every student in a classroom. A lecturer can also use his or her own smartphone to control this web-app, as shown in the left corner.

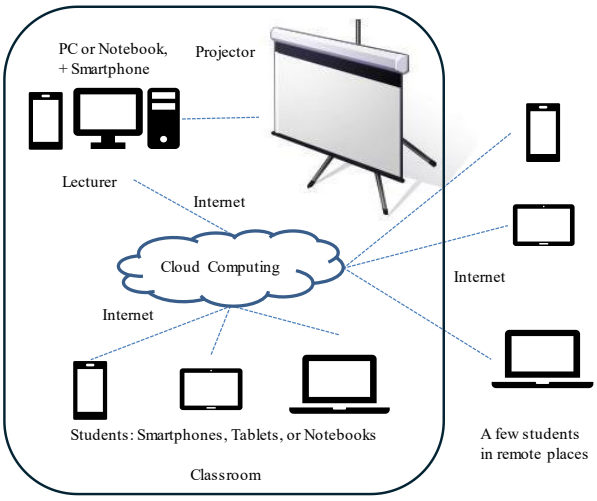

Fig. 2 The architecture of this solution. Cloud computing and mobile devices enable lecturers to interact with their students in a classroom. A few students can also remotely participate in the same interactions.

or texts under a lecturer's guidance, using mobile devices in a typical classroom, as shown in Fig. 2. As illustrated in Table 3, Table 4, and Table 5, sharing students' photos and texts and real-time feedback helped students reflect on their own and others' messages. This enhanced their learning even in a large classroom.

2.1 Implementation

This solution as a web-app [8] has been improved upon,

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since the previous study [5]. As shown in Fig.1, a web-browser enables a lecturer and every student in the classroom to use this solution, if they have a Google account.

As described in Fig.2, cloud computing is implemented using HTML with Bootstrap, CSS, and JavaScript, Google Drive API, Google Slides API, and Real-Time Firebase databases. Moreover, as shown in the left corner of Fig. 1, the lecturer's smartphone can be used as a remote control for this web-app. This remote-control feature has been added since the previous study [5]. Using his or her smartphone, a lecturer can confirm or filter student messages privately before or while displaying them publicly in the classroom.

Collected photos or texts can be saved in a lecturer's Google drive as before. Students' access to messages have been extended to meet the needs of students as suggested in previous surveys [5]. Collected messages are saved in a Google drive only during the semester. During or after a class, every student can access their own messages.

2.2 Usage

This solution can be used for various classroom interactions between a lecturer and students. These interactions include student questions, pop quizzes, or attendance verification. Moreover, interactions between classmates are also possible. During a student's presentation in a classroom, peer-review [9] or questions to the presenter can also be easily collected, discussed, and shared with every student.

To use this solution [8], a lecturer should first sign into his or her google account. Later students may sign in with their google accounts. Students should also specify their lecturer's google account to link with their class.

Whenever a lecturer allows or asks, students can send their digital drawings, photos, images, or texts using their mobile devices. The lecturer can then display and share these messages with everyone in the classroom, facilitating real-time feedback as shown in Fig. 1. If necessary, a few students in remote places can also connect to the class (i.e. using Webex) and participate in the same class interactions, as shown in Fig. 2.

A lecturer can flexibly decide the time for a quiz depending on the flow of each lecture. The number of responses, i.e., photos or texts, collected from or shared with students varied depending on requirements or the time allowed. Texts or photos for simple quizzes were usually required for every student. Sharing all the simple responses were used to check attendance or encourage students' participation. Or a lecturer could select only several correct or incorrect responses to share with the class if the time was limited. The lecturer could usually confirm more than 80% of the responses collected while students are uploading their photos or texts.

3. Continuous and Extended Experiments

This solution [8], improved since the previous study [5], has been continuously used in face-to-face classes of Data Structures and Programming (i.e., DS) in the Department of Computer Engineering at Hongik University in the 2nd semesters of 2022 and 2023, as indicated in Table 1. The same lecturer led all five subclasses of DS using this solution in large classrooms. The same class materials were used in these classes as in previous lectures [5]. In 2022, several students in each subclass could not come to the classroom, due to COVID 19. They were allowed to connect to the same lectures in the classrooms using Webex from their homes. They signed into this web-app and participated in the same interactions as the students in the classrooms.

A lecturer and every student brought their smartphones into the classroom. If necessary, students could also rent tablets, iPads, or notebooks from the department. The internet is easily accessible from all cities in South Korea.

In all DS classes, illustrated in Table 1, all the responses uploaded by students for required quizzes were shared with the class. Collecting and sharing simple responses from every student usually took about 5 minutes. Photo quizzes, such as shown in Fig. 1, usually lasted 10 minutes. 7 minutes were allocated for students to draw and upload photos and 3 minutes were used to share and discuss selected photos. As listed in Table 2, depending on the difficulty or the amount of drawing required in a limited time, about 66% of students on average uploaded photos in DS classes in 2023.

Students participated in anonymous surveys at the end of each semester. As listed in Table 3 and Table 5, the results showed that using this solution enabled students to actively participate in various interactions and improved their learning, even in large classrooms.

In the 2nd semester of 2023, this solution was also used for peer-review [9] in a special class, PROJECT2. PROJECT2 is a small class of about 20 students. It is for senior students only and is required for graduation. Students are grouped into teams of up to 3 students. They should propose, develop, and present their team projects in the classroom. Using this solution during student presentations, in a classroom, the lecturer was able to collect constructive comments and questions for each presenter from other students. This peer-review feedback was shared with everyone. The presenter was also required to respond appropriately to questions or comments from other students in the classroom. Later, every student could improve their projects based on the peer-review process. As listed in Table 4, students evaluated this solution as highly effective for peer-review.

3.1 Evaluation using Anonymous Student Surveys

As shown in Table 1, there was a total of 264 students in the five DS classes. This solution was actively used in every lecture in a large classroom. 244 students voluntarily responded to an anonymous survey on this solution, as listed in Table 3. A link to an anonymous survey form created with Google Forms was provided to students and the survey form

Table 1 Students in the classes of Data Structures & Programming

Sub Class	Year	Students from the College of Liberal Arts	Students from Other Engineering	Students from Computer Engineering	Total No. of students registered
Class-4	2022	1	15	33	49
Class-5	2022	1	16	31	48
Class-6	2022	4	11	31	46
Class-3	2023	8	18	32	58
Class-4	2023	8	10	45	63
Total		22	70	172	264

Table 2 Examples of the number of photos uploaded in DS of 2023

Sub Class	Total No. of students	Photos of Insertion Sort	Photos of Quick Sort	Photos of Merge Sort	Photos of Heap Sort
Class-3	58	48	37	34	28
Class-4	63	49	44	42	38
Total	121	97	81	76	66
Rate		80.2%	66.9%	62.8%	54.5%

Table 3 Anonymous student surveys on this solution in the classroom

Data Structures & Programming (DS)	1)	2)	3)	4)	5)	Positivity
a) Ease of use						
Three subclasses-2022	0	0	21	65	44	83.8%
Two subclasses-2023	0	4	28	53	29	71.9%
Totals/Average Result	0	4	49	118	73	78.3%
b) Stay focused						
Three subclasses-2022	0	1	13	62	54	89.2%
Two subclasses-2023	1	1	21	54	37	79.8%
Totals/Average Result	1	2	34	116	91	84.8%
c) Communication						
Three subclasses-2022	0	0	6	68	56	95.4%
Two subclasses-2023	0	1	14	54	45	86.8%
Totals/Average Result	0	1	20	122	101	91.4%
d) Lab result images						
Three subclasses-2022	0	2	12	60	56	89.2%
Two subclasses-2023	0	2	16	49	47	84.2%
Totals/Average Result	0	4	28	109	103	86.9%
e) Participation						
Three subclasses-2022	0	1	10	58	61	91.5%
Two subclasses-2023	0	3	16	51	44	83.3%
Totals/Average Result	0	4	26	109	105	87.7%
f) Photo quizzes						
Three subclasses-2022	0	1	6	52	71	94.6%
Two subclasses-2023	0	0	10	47	57	91.2%
Totals/Average Result	0	1	16	99	128	93.0%

Table 4 Anonymous student surveys on this solution for peer-review

PROJECT2	1)	2)	3)	4)	5)	Positivity
1. Ease of use	0	1	6	6	5	61.1%
2. Communication	0	0	3	6	9	83.3%
3. Focus and participation	0	1	2	7	8	83.3%
4. Comprehension of presentations	0	0	3	10	5	83.3%

Table 5 The level of student satisfaction surveyed by Hongik University

Data Structures & Programming (DS)	1)	2)	3)	4)	5)	Sum	Average
Class-4 (2022)	1	0	5	6	34	46	4.57
Class-5 (2022)	0	1	1	8	34	44	4.70
Class-6 (2022)	1	1	1	5	37	45	4.69
Class-3 (2023)	1	0	7	11	36	55	4.47
Class-4 (2023)	0	1	9	12	38	60	4.45
Total	3	3	23	42	179	250	4.56

did not collect students' email addresses. The surveyed questions were as follows:

a) How difficult was it to use this solution?
   1) very hard 2) hard 3) ordinary 4) easy 5) very easy

b) Does this solution help you stay focused in the classroom?
   1) not at all 2) a little 3) average 4) a lot 5) very much

c) Does this solution help you interact and communicate with your lecturer in the classroom?
   1) not at all 2) a little 3) average 4) a lot 5) very much

d) Does sharing of captured images of lab results help you participated in programming labs?
   1) not at all 2) a little 3) average 4) a lot 5) very much

e) Does this solution encourage you to participate in classroom interactions?
   1) not at all 2) a little 3) average 4) a lot 5) very much

f) Do quizzes using smartphone photos or digital drawings enhance your understanding of lectures in the classroom?
   1) not at all 2) a little 3) average 4) a lot 5) very much

The positivity in each table was calculated by adding and averaging responses in 4) and in 5), which means high and very high responses for each question.

93% of students replied in f), that answering pop quizzes with smartphone photos or digital drawings highly enhanced their learning in the classroom. In c), 91% of students were satisfied with communicating with their lecturer using this solution in the classroom. 84% and 87% of students in b) and e) could highly focus and participate in classroom interactions. In d), 86% of students admitted that sharing captured images of programming labs with everyone in the classroom helped to enhance their programming abilities.

In addition, students also wrote comments describing the advantages of this solution. Some of the responses are: To timely answer pop quizzes, there was no choice but to stay focused in lectures. Drawing answers by hand enabled students to clearly confirm if they understand the lecture. The lecturer's real-time feedback not only to my messages, but also to other students' messages highly motivated students to participate in and also enhanced their learning in the classroom. The allowed access to student messages after class also helped them reflect on important concepts and prepare for exams.

A total of 18 students were registered in PROJECT2, in the 2nd semester of 2023. This solution was used for peer-review during student presentations. The following questions were anonymously surveyed:

1. How difficult was it to use this solution?
   1) very hard 2) hard 3) ordinary 4) easy 5) very easy
2. Does this solution help a presenting student communicate with other students during a presentation?
   1) not at all 2) a little 3) average 4) a lot 5) very much
3. Does this solution help you stay focused on student presentations and participate in the peer-review process?
   1) not at all 2) a little 3) average 4) a lot 5) very much
4. Does this solution help you to understand student presentations?
   1) not at all 2) a little 3) average 4) a lot 5) very much

As listed in Table 4, 83% of students perceived this solution facilitated active communication between a presenting student and other students. Students also

recognized that this solution helped them concentrate on other students' presentations as well as their own. Moreover, students wrote that the peer-review feedback using this solution gave them the opportunity to judge other students work objectively and also reflect on their work, as mentioned in [9].

In both surveys, students also suggested ideas to upgrade this solution. They asked for more login options with other SNS accounts in addition to Google. They suggested providing more accessibility to collected messages after class. Better WiFi was also mentioned to deal with instant surges of messages in a large classroom.

3.2 Survey of Student Satisfaction

Hongik University also surveys student satisfaction for every class at the end of each semester. Students registered in a class are required to participate in surveys anonymously. The question related to student satisfaction is:

Q. Overall, was this class satisfactory?

1) not at all 2) somewhat 3) average 4) highly 5) very much

Table 5 shows the survey results of students in DS classes only, to compare these results with the previous study [5]. 250 students of the total 264 students in DS classes anonymously responded. The perceived level of student satisfaction was also very high, 4.56 out of 5 on average, which is a little higher than that of the previous study [5].

3.3 Discussion

Anonymous student surveys in Table 3, Table 4, and Table 5 indicate that students consider this solution as highly useful for various interactions and learning even in large classrooms.

In Table 3 and Table 5, the positivity and the level of student satisfaction of classes in 2023 are still higher than the previous study [5] but lower than those in 2022. One of reasons may be the increased enrollment of students from the college of liberal arts. Notice, in Table 1, that the students with other majors accounted for 36.6% of the total students taking DS classes in 2023. Even if DS is an essential class in computer engineering, the curriculum may need to be changed to deal with the increased enrollment of students with other majors, based on the student survey results.

4. Conclusion

This letter suggests a refined solution for real-time classroom interactions using mobile devices and cloud computing. This solution has been intensively used in face-to-face classes for various interactions in 2022 and 2023.

The utility of this solution was also demonstrated by the anonymous survey results described in this letter. Students who responded to those surveys suggested that this solution, using photos and texts, enabled them to actively communicate with a lecturer and students even in large classrooms. Also, the students concluded that this solution helped them concentrate on and participate in classes, reflect on their understanding of the lecture, and finally enhanced their learning in the classroom.

Grouping similar messages in real-time using AI will help a lecturer to promptly analyze and subsequently discuss various student concerns during lectures. Therefore, the real-time analysis of collected messages using AI will be studied in the future.

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References

[1] P. Kumari, S. Deb and B. Debnath, "Systematic Study to Identify the Usage and Role of Mobile Devices for Classroom-Interaction," 2019 IEEE 10th Int'l Conf. Tech. for Education (T4E), pp. 270-271, Dec. 2019, DOI: 10.1109/T4E.2019.00069.

[2] Y. Kim, S. Jeong, Y. Ji, S. Lee, K. H. Kwon and J. W. Jeon, "Smartphone Response System Using Twitter to Enable Effective Interaction and Improve Engagement in Large Classrooms," IEEE Trans. on Education, vol. 58, no. 2, pp. 98-103, May 2015, DOI: 10.1109/TE.2014.2329651.

[3] H. Lee, "APS: Audience presentation system using mobile devices," IEICE Trans. Inf. & Syst., vol. E102-D, no. 9, pp. 1887-1889, Sept. 2019, DOI:10.1587/transinf.2019EDL8061.

[4] S. Asgari, J. Trajkovic, M. Rahmani, W. Zhang, R. C. Lo, and A. Sciortino, "An observational study of engineering online education during the COVID-19 pandemic," PLoS ONE, 16(4): e0250041. April 15, 2021, DOI:10.1371/journal.pone.0250041.

[5] H. Lee, "Synchronous Sharing of Lecture Slides and Photo Messaging during Real-Time Online Classes," IEICE Trans. Inf. & Syst., vol. E105-D, no.7, pp.1348 - 1351 July 2022, DOI: 10.1587/transinf.2022EDL8013.

[6] F. Ansari, M. Muzyyab Ajmal, A. Basit, H. Ali Khattak, A. Nawaz and S. Ahmed, "Evaluating Readiness for Technology Integration in the Classroom Post-Pandemic," 2022 Advances in Sci. and Eng. Tech. Int. Conf. (ASET), pp. 1-7, Feb. 2022, DOI: 10.1109/ASET53988.2022.9735101.

[7] N. Kleopatra, "Students' Mobile Phone Practices for Academic Purposes: Strengthening Post-Pandemic University Digitalization," Sustainability14(22), 14958, Nov. 2022, DOI: 10.3390/su142214958.

[8] https://toslide.com, accessed April 22, 2024.

[9] G. V. Helden, V. Van Der Werf, G. N. Saunders-Smits and M. M. Specht, "The Use of Digital Peer Assessment in Higher Education—An Umbrella Review of Literature," in IEEE Access, vol. 11, pp. 22948-22960, Mar. 2023, DOI: 10.1109/ACCESS.2023.3252914.