Blending Digital and Face-to-Face Interaction Using a Co-Located Social Media App in Class

Sten Govaerts, Adrian Holzer, Bruno Kocher, Andrii Vozniuk, Benoît Garbinato, and Denis Gillet

Abstract—Improving face-to-face (f2f) interaction in large classrooms is a challenging task as student participation can be hard to initiate. Thanks to the wide adoption of personal mobile devices, it is possible to blend digital and face-to-face interaction and integrate *co-located social media* applications in the classroom. To better understand how such applications can interweave digital and f2f interaction, we performed a detailed analysis of real-world use cases of a particular co-located social media app: SpeakUp. In a nutshell, SpeakUp allows the creation of temporary location-bound chat rooms that are accessible by nearby users who can post and rate messages anonymously. We find that the use of co-located social media is associated with an increase in content-related interaction in the class. Furthermore, it is associated with an increase in the perceived learning outcomes of students compared to a control group. We further provide design guidelines to blend digital and f2f interaction using co-located social media in the classroom based on 11 case studies covering over 2,000 students.

1 Introduction

Any questions? ... So is everything clear? In many classrooms silence does not mean that everything is understood. Fostering lively face-to-face (f2f) interaction is difficult, especially in large classrooms. This can partially be due to the fact that many students have difficulty interacting in large audiences [2], and because of shyness or the impression that their questions are uninteresting for others [51]. This is particularly worrisome, since in order to effectively transmit knowledge in class f2f interaction is a key factor of success [21]. Interestingly, there is an increase in the popularity of flipped classrooms [6], [36] and other novel teaching modes that break away from the typical one-way lecturer-to-audience interaction and towards more inclusive and multi-sided interactions, either in the *frontchannel* (directed to the teacher) or in the *backchannel* (directed to other students). Furthermore, adding a digital channel (e.g., an online forum), can help to improve interaction and can be perceived as comfortable and less aggressive than f2f interactions [58]. However, two completely separate channels might not always be desirable, and online fora are not always successful (e.g., the time between postings and response can be long and thus discourage users [58]). With the wide adoption of personal devices in classrooms, it is possible to blend digital and f2f interaction through *co-located social media* applications (i.e., applications where users share a physical space and thus can both interact digitally (by creating and sharing digital content) and in person).

1.1 Originality and Contribution

The contribution of this paper is to provide elements to better understand how to make use of co-located social media applications that blend digital and f2f interaction. To achieve this, the paper investigates the following two research questions:

RQ1: How is co-located social media linked to interaction in classroom audiences?

RQ2: How can co-located social media be designed for a synergy between digital and face-to-face interaction?

This study uses SpeakUp as an instance of a co-located social media application. In a nutshell, SpeakUp allows the creation of temporary, location-bound chat rooms accessible by anyone nearby and allows to post and rate anonymous messages. A preliminary evaluation of SpeakUp in a course was presented in [27]. This article extends this analysis substantially by empirically testing 7 novel hypotheses and performing an in-depth analysis of the messages posted by students in terms of content and of their intended recipients (whether front- or backchannel). Furthermore, it provides 8 novel design guidelines to improve the synergy between digital and f2f interaction. This study uses a controlled field experiment with a treatment and a control group as well as input from a large set of 11 semester long courses which made use of SpeakUp and covering over 2000 students. Most previous studies have less participants, and often cover a shorter period (e.g., [2], [9], [14]) and few have control groups (e.g., [44]). Our work extends previous research by analyzing free interaction based backchannels and teacher feedback, whereas prior research has mostly focused on constrained communication in time [9], [13], quantity [9] and format [2]. Furthermore, we analyze a

- *S. Govaerts, A. Vozniuk, and D. Gillet are with the REACT Group, Swiss Institute of Technology, Lausanne (EPFL), Lausanne 1015, Switzerland. E-mail: {sten.govaerts, andrii.vozniuk, denis.gillet}@epfl.ch.*
- *A. Holzer is with the Information Management Institute, University of Neuchâtel, Neuchâtel 2000, Switzerland. E-mail: adrian.holzer@unine.ch.*
- *B. Kocher and B. Garbinato are with the Department of Marketing and the Department of Information Systems, University of Lausanne, Lausanne 1015, Switzerland. E-mail: {bruno.kocher, benoit.garbinato}@unil.ch.*

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system with anonymous and temporary interaction to encourage participation and inclusion. In most other free-text systems, students have some form of identity and messages are long lived (e.g., on a forum [13] and Twitter [9]), while SpeakUp users valued anonymity and temporariness. Moreover, we evaluate both quantitative and qualitative results from students and instructors, in different use scenarios. The majority of other studies are confined to one setting and are often conducted from the student perspective. We discuss the etiquette of how to guide interaction and solve a common Computer-Supported Collaborative Learning (CSCL) problem [33] (i.e., increasing interaction).

1.2 Structure

This paper is organized as follows, Section 2 elaborates on the functionality of SpeakUp. Section 3 discusses related research and similar co-located social media applications. Following this, Section 4 presents the research methods used in Study 1 (Section 5) and Study 2 (Section 6). Section 7 introduces design guidelines for co-located social media apps, and Section 8 concludes with a conclusion and discussion of future research.

2 The SpeakUp App

SpeakUp[1] is a co-located social media app, which provides anonymity, social rating, and co-located *here & now* interaction support. SpeakUp was designed using a design-based research methodology [38], which requires to first identify a problem, second design an artefact to address the problem, and third iteratively evaluate and improve the artefact. This approach was used for both the UI design and the feature requirements.

Fig. 1 shows the SpeakUp UI. Initially, the chat rooms in the user's vicinity are displayed on the home screen (screen 1 in Fig. 1). Users can either enter a room by tapping its name, or join or create a new room with the "+" button (screen 3). Anyone can create a new room as long as there is a GPS fix, or join a room if she has the room number. The message list is displayed inside the room (screen 2) and is sorted either by time or by score. Each message can be rated up or down, which adds or removes a point from the total message score. Note that users see which message they have posted, thus they can see how well they were rated.

SpeakUp has no sign-up process and does not require personal information. Anyone who is nearby (within a 200m radius) can access a room without needing special privileges. In addition people not located nearby can access a room by using its unique number. The room number is shown under the room name in screen 2 of Fig. 1 and can be entered in the JOIN tab in screen 3. In order to confine interactions to a classroom session, rooms disappear after a set time. Currently a room closes 24 hours after the last interaction. A first basic evaluation of SpeakUp was published in [28] and preliminary evaluation results of the one of the courses were published in [27].

3 Related Work

In this section, we will discuss related work. We will start by discussing related tools and associated studies. Then we will look beyond classroom facilitation tools and consider larger issues of group interaction.

1. SpeakUp is freely available at http://www.speakup.info

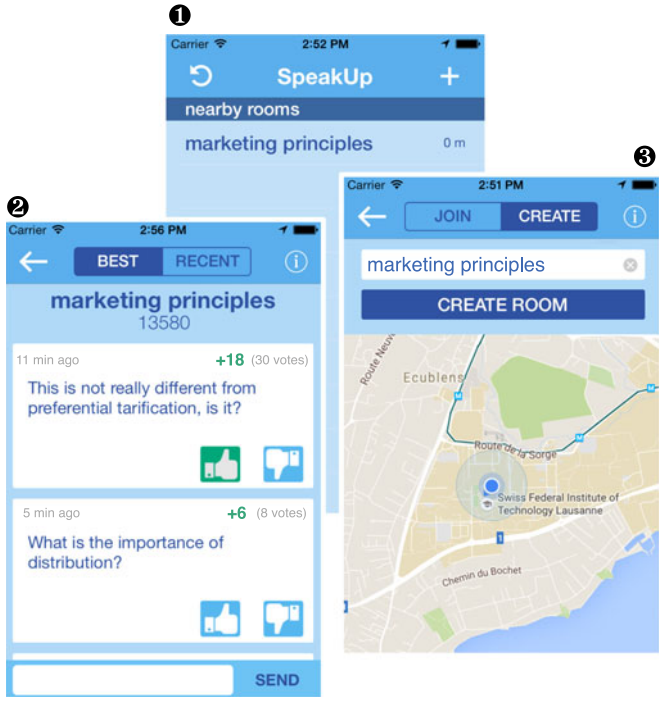

Fig. 1. The SpeakUp mobile app. (1) Home screen. (2) Inside a room. (3) Joining a room.

3.1 Related Tools

Computer-mediated communication has a long history in computer supported collaborative work (CSCW) and Human Computer Interaction (HCI) research, including for educational purposes. For instance as early as the eighties, IBM started to experiment with student response systems (SRSs) [29] to improve traditional classroom teaching by increasing student activity, communication and learning desire [29]. Conventional SRSs are for instance *clickers*, where every student typically has a small remote control to select one of the answers on a multiple choice question projected by the teacher. Afterwards, the teacher can also display an overview of all answers for the audience. Several studies have investigated the use and benefits of SRSs [11], [22], [50], [57]. Their main outcomes are that students perceive the SRSs as positive and often want to continue using SRSs. Additionally, student interactivity and participation increases. Compared to SpeakUp, most clicker-based SRSs only allow the student to choose a predefined answer option and do not allow to enter free text. Furthermore, most SRSs do not allow to rate messages of others, which could be very handy for peer instruction [17]. SRSs make it simple to aggregate all student responses, however it is hard for the teacher to really create student interaction since students cannot communicate freely what and to whom they want with clickers. Given that interaction is considered by many researchers as a conditio sine qua non for learning [21], [33], other CSCL systems have been developed to enable broader student interaction [43], [49]. Such tools allow to multiplex communication channels and allow multiple students to speak (post) at the same time. A recent large systematic review of the literature suggests that using such systems in

the classroom has overall a positive effect on learning [53]. Nevertheless, the multitasking that it introduces, especially if a large amount of off-task interaction occurs, could negatively affect the outcome [45]. Furthermore, engaging students in such interactions in CSCL systems is often difficult [33], [49].

3.1.1 Messaging Tools

There are a variety of messaging tools. For instance, TXT-2-LRN [47] is an early attempt to introduce live digital channels using mobile devices. Students can send free-form SMSs with their mobile phones to the teacher's phone, which is connected to a computer that aggregates poll results, questions and messages and displays them on the screen. The teacher can also reply to the students. TXT-2-LRN supports neither a rating mechanism nor audience-to-audience interaction and provides no anonymity since the student's phone number is known.

The Fragmented Social Mirror [7] allows students to post anonymous messages using icons to indicate the intent of the message (e.g., 'I have a question', 'I have info', 'Yes', 'No' or 'Slow down'). These icons should allow the teacher to quickly take action while scanning the messages. There is, however, no rating mechanism.

TodaysMeet[2] allows to create temporary chat rooms without message rating, accessible from the web. Users join the room using a unique URL and write messages under a nickname, which could potentially reveal the author's identity.

3.1.2 Messaging Tools with Social Features

ClassCommons [19] allows students to post multimedia messages, comment and positively vote. Sorting based on 'likes' is not possible. Students provide a nickname known to the teacher.

Pigeonhole Live [24] provides the possibility to join rooms anonymously or use your Twitter handle for those who prefer being identified. Pigeonhole Live only allows upvotes, but comes with several interesting features such as integration with slides and multiple choice questions. However, it is not freely available online and solely targets organizations.

Another option is the Backchan.nl web application [26], with which lecturers can create rooms and the audience can post and rate messages. The rooms are identified by unique URLs and one cannot specify the lifetime of a room. To create a room, the lecturer needs to create an account, but the audience just needs to enter a nickname to access the room. Backchan.nl employs an advanced message ranking system that takes into account both time and votes. Backchan.nl was evaluated in the context of conferences to foster multilateral interaction.

HotSeat [1] allows to post and vote on messages using Twitter and text messages during and after class. It was evaluated by over 2000 students and results show that it increases student engagement and is used more often by higher-performing students.

Widespread, mainstream social media, such as Twitter [40], [42] and Reddit, are also popular to foster interaction between speakers and their audience in both conferences and classrooms. However, most platforms require the participants to sign up and are not anonymous, even though Reddit promotes nicknames as opposed to real names. Twitter can typically be sorted over time, not by relevance as there is no up- or downvoting, only retweeting and favoriting, which can make it hard to select the most popular messages. Reddit on the other hand supports up- and downvotes. Messages on Reddit are public and not temporary, which might discourage people who prefer the privacy of the classroom.

3.1.3 Overview

In general, all these tools are designed for easy access and simplicity, even though many of them still require a login and some require a certain amount of administrative work before the system can be used in class. Furthermore, most tools provide a certain degree of anonymity, whether by the usage of nicknames or through full anonymity. Many tools also confine the discussion or collaboration to a closed group to provide some privacy and to reduce the level of exposure of a message thus lowering the cost of posting a message. This privacy is enhanced when systems are fully anonymous and temporary. The latter feature is very marginal, as most systems do not support temporary messages.

Most of the tools discussed above have also been evaluated in research studies. The results often conclude that students perceive such systems as positive and that they increase interactivity [2], [7], [22], [26], [47]. Furthermore, students often prefer to use a digital channel to interact over raising their hand [47]. However, Du et al. in their evaluation of ClassCommons [19] identified that the role of the teacher is critical in influencing student adoption. Furthermore, they found that a key requirement for students is that instructors pay attention to the digital backchannel. This implies that instructors adapt part of their lectures and that system designers provide a discrete notification scheme to attract the teacher's attention to relevant messages. Moreover, teachers find that content relevance is more important than just participation, because irrelevant contributions can lead to a loss of interest in the technology. To curb off-task interactions, certain authors encourage instructors to lift anonymity and encourage students to post using their real names [19]. In contrast, Retelny et al. found that students did not use public Twitter communication as a backchannel to interact among each other because students did not want to discuss publicly [42]. This could suggest that classroom interaction might require a more confined or private setting. Although SpeakUp was designed for anonymous use, instructors could ask their students to sign each message with their real name or nickname. It should be emphasized that these apps are not used in a vacuum. As a socio-technical artefact, their usage is influenced by task design, i.e., the pedagogical scenario followed by the teahcer.

3.2 Beyond Classroom Communication Tools

Blending face-to-face and digital interaction in the classroom is not limited to messaging apps. GroupScribble [14] is a tool to jointly complete a learning task. Chen et al. indicate that face-to-face and digital interaction are complementary, rather than supplementary to each other. The authors believe that when the two interaction forms are combined, students are more motivated to learn from others and are more willing to polish and refine their answers because

2. TodaysMeet, https://todaysmeet.com

TABLE 1
Overview of the Courses Involved in Study 2

Code	Course name	Students	Semester	Lectures	Hours	Msgs	Votes	Remarks
IS12	Introduction Information System (B)	300	F-2012	5	20	267	4354	survey, etiquette, censorship
PM13	Principes de Marketing (B)	300	F-2013	5	20	430	1238	controlled experiment, survey, nudge, etiquette
SM14	Social Media (M)	50	S-2014	12	12	144	1588	student presentation
CM14	Cross-cultural management (M)	100	S-2014	8	32	37	150	non-anonymous, feedback in the next course
CO14	Global Issues in Communication (B)	150	S-2014	6	12	1159	9436	@prof tags, etiquette, survey, multiple choice
IP14	Introduction to Psychology (B)	350	F-2014	1	1	2	278	only clicker style
PP14	Perspectives and Projects in Psychology (B)	50	S-2014	12	24	63	159	no remarks
NS14	Nervous system in locomotion (B)	600	S-2014	4	8	29	2303	detailed answers with slides
AM14	Analysis, Modeling and Design in IS (M)	50	S-2014	1	3	119	1206	student presentation
MS14	Social and Responsible Marketing (M)	35	S-2014	3	12	16	50	etiquette, small group, little interaction
CS14	Basic Concepts of Computer Science (B)	40	S-2014	4	12	245	819	student presentation
	Total	**2025**		**61**	**156**	**2511**	**21581**	

B = Bachelor level, M = Master level. S = Spring, F= Fall.

they know others will access their answers. The Classroom Feedback System (CFS) [2] allows to leave annotations on the teacher's slides with predefined words (e.g., more explanation). In CFS evaluations, potential design guidelines were identified, which included non-verbal communication, anonymity, aggregated feedback, closure (when something has been addressed), and simple interfaces (little cognitive efforts to disturb as little as possible).

More broadly, systems providing a live digital channel to support f2f interaction are related to CSCW [46]. Some CSCW examples beyond education include an SMS-based system that allows users to interact via posted SMS messages displayed on on-stage public display screens at music festivals [35], a cheer-meter that can measure the crowd's engagement at rap competitions [5], and technology that can trigger interaction in football stadiums [39].

However, the success of such tools also often depends on how they are integrated in the physical activity. For instance in the classroom, the teacher should takes care to adequately integrate the tools in the lecture (e.g., by integrating interactive Q&A sessions, or providing feedback and discussion moments (as also noted by [19]). On some occasions, such tools can trigger a teacher to redefine the course itself. For instance, the teaching can be reoriented more towards peer instruction [17] and the *Flipped classroom* [8].

3.3 Group Interaction

Many-to-many interaction is pervasive on the web (e.g., through social media applications and fora). Such interactions can lead to various positive outcomes such as developers helping each other out on fora like Stack Overflow[3] [59] or photographers finding an audience and recognition on mobile apps such as Instagram.[4] However, group interactions on fora and social media also have a darker side with the rise of cyberbullying [48], revenge porn and such. For instance the Reddit discussion forum was home of the *fatpeoplehate* discussion thread until it was removed alongside other hateful threads in June 2015 [60]. Research shows that interactions on well-functioning sites such as Stack Overflow are generally the result of a small number of content producers and many content consumers [59]. In general it is assumed that, in social media, 1 percent produces content, 10 percent interacts with it, and 89 percent views it [3]. This indicates that it is a challenge to raise the level of contributions above a few percentage points.

One way to potentially raise these numbers is through anonymity, which can reduce login friction [30] as well as provide a sense of privacy [30] and make users more comfortable about expressing their views [30]. This added comfort combined with the safety of hiding in the crowd [30] can unfortunately lead to *toxic disinhibition* with harsh comments and threats [52]. These behaviors can lead to the growing issue of cyber-aggression (a single act) [48] and cyberbullying [32], [48] (repeated acts), which is experienced by as many as 75 percent of school-age children at least once over a one year period [32]. Several strategies to cope with such cyber-harassment have been identified [34], [48].

Another recent study [15], comparing anonymous (Whisper[5]) to non-anonymous (Twitter[6]) social media, found that anonymity implies more personal information, more negative emotions (anger and sadness) and more messages about wants and needs. To encourage pro-social behaviors in an anonymous setting, online communities should develop specific pro-social norms [30]. This is what online fora attempt to do through their online etiquette.

Participation and pro-social behavior can also be encouraged by providing users with status and recognition [30]. For instance, [54] found that reputation was a motivator in an online math community, even though self reports list it as the lowest motivation.

4 Method

For this study we adopted a mixed method approach combining quantitative and qualitative data [16] further detailed below. To answer the two research questions, we conducted two studies:

To answer RQ1 (*How is co-located social media linked to interaction in classroom audiences?*) we performed an in situ controlled experiment in Study 1 in the PM13 course (see Table 1) over 6 weeks with 300 students (one control group, one treatment group). This setup allowed us to define and test a set of specific hypotheses and test them through quantitative (1) f2f interaction data, (2) digital interaction data and (3) student surveys. Furthermore, we conducted a follow-up qualitative content analysis of the interaction

3. Stack Overflow, http://stackoverflow.com/
4. Instagram, https://instagram.com/
5. Whisper, https://whisper.sh/
6. Twitter, https://twitter.com

TABLE 2
Examples of Messages of the PM13 Course (Translated from French)

	Category	Message example	Score
On-task	Content	I don't understand the differentiation by product compared to the conformity .. ?	35
	Organization	Watch out for the background color of the slides, the text was sometimes hard to read. Thanks.	5
	SpeakUp	Does the app work on Android	−2
Off-task	Lecture-related	Look for the sickest Marlboro commercial ever	1
	Fun	Chuck Norris is the biggest blood donor, but it's never his	3
	Miscellaneous	Stop	−3
	Social	Pez, do you wanna marry me?	2
	News	We're qualified	−43
		We have been qualified for a month already	29

data as well as additional student surveys in the CO14 course (see Table 1) to further understand this interaction.

To answer RQ2 (*How can co-located social media be designed for the synergy between digital and face-to-face interaction?*) Study 2 reports on 11 case studies with instructors from several countries and continents (see Table 1) who used SpeakUp during their classes and answered teacher surveys.

4.1 Hypotheses

Since low usability can affect the evaluation results, we considered it as a *sine qua non* for evaluating SpeakUp, leading to our first hypothesis:

H1. The co-located social media app is usable.

Through the controlled field experiment performed in Study 1, we want to test the following hypotheses about the behavior and attitude differences in the control and treatment groups:

H2. Using co-located social media is associated with increased interaction compared to the control group.

H3. Using co-located social media is associated with increased perceived learning outcomes compared to the control group.

Apart from these hypotheses we want to test whether two main features (anonymity and temporariness), improve interaction. To that effect we put forth the following hypotheses:

H4. Anonymity in co-located social media is associated with increased interaction.

H4′. Anonymity in co-located social media is associated with increased intention-to-use.

H5. Co-located social media users favor temporary messages over persistent messages.

H5′. There is a difference in the attitude of users and non-users of co-located social media towards message persistence.

4.2 Digital Interaction Data

We recorded the digital interaction data (log data) during the classes. To obtain qualitative information about the interactions, we (three course experts and the teacher) coded the content in three on-task categories (i.e., content-related, organization-related, and SpeakUp-related) and a broad off-task category (i.e., messages not relevant to the lecturer). We discussed inconsistencies together to to resolve them. These categories are related to those defined by McCarthy et al. [37] who identify three main categories: work (content-related), logistics (organisation and SpeakUp-related), and other (off-task messages). We further categorized the off-task messages into five categories: (1) lecture-related, (2) fun, (3) social, (4) news, and (5) miscellaneous. Table 2 gives examples of each category. Note that the score column shows the actual score of the message (i.e., number of upvotes minus number of downvotes).

TABLE 3
Overview of the Surveys

Survey	Who	N	Courses	Questions	Results
Survey 1.1	S	59	PM13	System Usability Scale (SUS), Usability feedback	Section 5.2
Survey 1.2	S	157	PM13	Anonymity, Temporariness	Figure 8, 9 Section 5.5, 5.6
Survey 1.3	S	219	PM13	Student Evaluation of Teaching (perceived learning outcome)	Section 5.4
Survey 1.4	S	93	CO14	Backchannel, Anonymity, Off-task messages	Figure 6, Section 5.3.1
Survey 2.1	T	11	All	Experience blending interaction with SpeakUp	Section 6

S = Students, T = Teachers.

4.3 F2F Interaction Data

We recorded F2F interaction in the classroom by writing down student questions as they occurred. The f2f interaction was also coded according to the same coding scheme as the digital interaction.

4.4 Student Surveys

Table 3 gives an overview of the surveys conducted in the study with descriptions of the topics and links to the figures and paragraphs where the results are discussed. We administered surveys in the PM13 course to gather information about student attitudes on usability (Survey 1.1), and attitudes towards anonymity and temporariness (Survey 1.2). To measure the learning outcome, the ideal solution would be to have a precise metric (e.g., grade exam) for the control and the experimental group. The PM course, however, contained a single final exam for both the treatment and the control group, where it was not possible to determine which student belonged to which group. We were able however to collect perceived learning outcome through the results of a Student Evaluation of Teaching (SET) survey [56]. SETs are the most used method to get student feedback on a course and are standard practice at the university where PM13 took place (Survey 1.3). In this questionnaire, there is one item asking students about perceived learning outcomes which we focus on in this study. Finally, we conducted a follow-up survey in another course (CO14) to get further insights into student attitudes towards the different types of interactions in the classroom (Survey 1.4).

4.5 Teacher Surveys

We conducted a survey with 11 instructors to get insights into how they used and perceived the usage of a co-located social media app in their classes (see Table 3 Survey 2.1).

TABLE 4
Hypothesis and Result Overview

	Hypothesis	Data	Test
H1	The co-located social media is usable.	A System Usability Scale test survey showed an average score of 82 for SpeakUp. A single sample Wilcoxon test showed that the median (Mdn = 85) was significantly greater than 73 which is considered the limit of Good usability. H1 is supported.	Wilcoxon W = 4.63 $p < 0.01$
H2	Using co-located social media is associated with increased interaction compared to the control group.	Based on digital and f2f interaction logs, looking only at relevant content (the strictest condition) we find that there is significantly more interaction in the treatment condition (Mdn = 18) than in the control group (Mdn = 5.5). H2 is supported.	Mann-Whitney U = 2, n1 = 6, n2 = 5, $p < 0.01$
H3	Using co-located social media is associated with increased perceived learning outcome compared to the control group.	Based on a student evaluation of the teaching survey, a Mann-Whitney test showed that the treatment group estimated that they learnt more (Mdn = 4) during the class than students in the class that did not integrate SpeakUp (Mdn = 3). H3 is supported.	Mann-Whitney U = 4447, $p < .01$
H4	Anonymity in co-located social media is associated with increased intention-to-use.	A survey asked if users thought anonymity would increase their contributions. A one-sample Wilcoxon test was conducted to evaluate whether the median (Mdn = 4) was different from 3, the neutral response. H4 is supported.	Wilcoxon W = 1501, $p < .01$
H4′	There is a difference in how users and non-users of co-located social media perceive the influence of anonymity on interaction.	A Mann-Whitney test show that control group (Mdn = 2), vs treatment group (Mdn = 4) have different attitudes toward anonymity. H4′ is supported.	Mann-Whitney U = 604, n1 = 60, n2 = 67, $p < 0.01$
H5	Co-located social media users favor temporary messages over persistent messages.	A survey asked how long users wanted to keep messages (1) day, (2) week, (3) year, (4) for ever). A significant majority of students (72%) wanted short term traces (1 or 2). H5 is supported.	χ^2 (1, N = 87) = 17.48 $p < 0.01$
H5′	There is a difference in the attitude of users and non-users of co-located social media towards message persistence.	A chi square test shows that control group vs treatment group have different attitudes toward temporariness. H5′ is supported.	χ^2 (3, N = 151) = 47.46 $p < 0.01$

5 Study 1

Study 1 aims to provide insights into how co-located social media can affect interaction in classroom audiences (RQ 1). To do so, we evaluated SpeakUp in the 'Principles of Marketing' course (PM13) at HEC Lausanne for 5 lectures during the 2013 fall semester with 300 bachelor students. This evaluation was conducted to assess whether SpeakUp creates more interaction and what kind, and to better understand the difference between f2f and digital interaction. The students were split into two groups due to their large number, but both groups were taught the same material by the same professor. The students were assigned to each group based on the first letter of their last name by the administration. Even though they were supposed to stick with their initial group, students were allowed to change groups for organizational reasons (depending on their other classes). The Control Group (CG, 100 students) did not use SpeakUp. The Treatment Group (TG, 200 students) used SpeakUp from the second lecture onwards. SpeakUp was used by 159 TG students of which 66 posted messages. Typically, students used SpeakUp during the lecture. The teacher would check SpeakUp interaction during the break and answer the relevant questions afterwards. For both CG and TG, the f2f interactions between students and the instructor were recorded and all SpeakUp user interaction was tracked and messages categories were first created using a deductive coding method (e.g., 'off-task', 'content-related', 'organisational'). We then allowed the code set to grow and integrated all the additional categories that emerged from the actual data. As a consequence, all messages were recoded based on the new extended set of categories Through this quasi-experiment, we were able to conduct a study that kept as many parameters stable as possible in both groups (e.g., teacher, content, course format, time period, student background and age range), so we could study the differences in interaction with and without SpeakUp. However, some other factors could not be controlled (e.g., time of day and week of the lectures, group size and group composition). Hereafter, we present the results of the hypotheses that we tested and our follow up investigations for the nature of the digital interactions.

5.1 Testing Hypotheses

To test the hypotheses, a log analysis and three voluntary surveys were conducted during the PM13 course: Survey 1.1 on the third week was completed by 59 students of TG, Survey 1.2 in the last week with 157 students (72 from CG, and 85 from TG), Survey 1.3 was also completed at the end of the semester by 219 students (79 from CG, and 141 from TG). Table 4 presents an overview of the hypotheses tested and their results.

5.2 SpeakUp Provides Good Usability (H1)

We conducted a usability evaluation with the well researched and widely used [25] System Usability Scale (SUS) [4]. This scale ranges from 0 (worst) to 100 (best). Our results indicated an average SUS score of 82 for SpeakUp, which is considered between Good and Excellent usability [4]. Compared to other mobile apps, it is comparable to the usability of top of the charts (top 10) iPhone and Android apps [31]. The median (85) was significantly greater than 73 which is considered the limit of Good usability. These results convey the fact that the usability of SpeakUp is not an issue.

5.3 SpeakUp and Increased Interaction (H2)

Since CG and TG differ in group size, Fig. 2 provides a relative view, illustrating the number of messages per 100

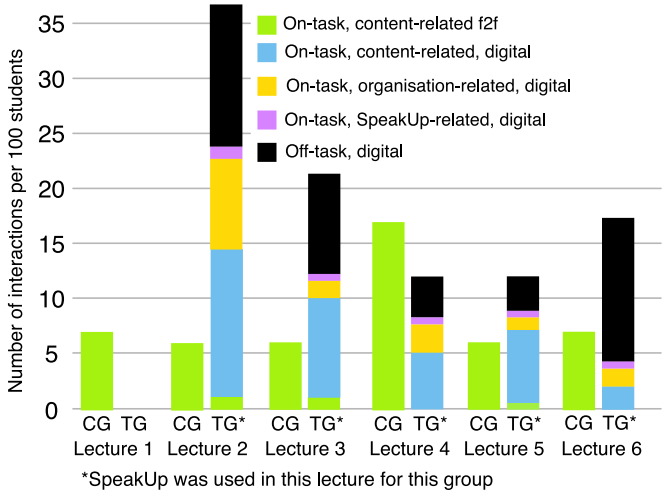

Fig. 2. The categorized messages per lecture and group of PM13 (messages per 100 students per lecture and group of PM13).

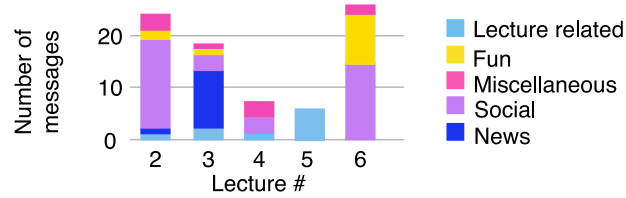

Fig. 3. The categorized off-task messages of PM13.

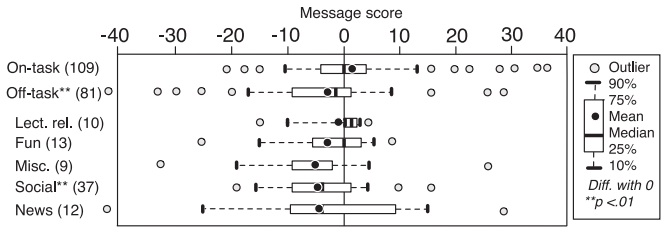

Fig. 4. The score of messages in PM13 per category.

students per category and lecture. The results show that students in the treatment group (TG) interacted more and almost exclusively digitally, although there were many off-task messages (i.e., 47 percent of TG interaction). The interaction is less focused on the course content and there seems to be a novelty factor. In comparison, the control group (CG) only asked content-related questions. The initial PM13 lectures have more SpeakUp interaction, indicating a novelty factor, especially for off-task messages, which decrease in each lecture, apart from lecture 6. This was the last lecture of the fall semester and many holiday-related messages were posted. Such a potential novelty factor was also observed in another course [28] and also in other applications, for example Backchan.nl [26]. Lecture 4 has a higher number of questions in CG, which may be related to a small difference in content. Half of these questions (8/17) were asked during the presentation by an external speaker. Contrary to TG, there was another external speaker (giving the same lecture) who did not trigger any questions. One might expect (in Fig. 2) that more people would create more interaction. However, Blatchford et al. [10] show that there is a significant negative effect of class size on the amount of face-to-face student-teacher interactions. This result explains that there were less f2f interactions in TG than in CG. This is interesting, since we added the digital channel in a condition where student participation (f2f) was lower. Based on digital and f2f interaction logs, looking only at on-task content (the strictest condition) there is significantly more interaction in the treatment condition than in the control group. Note that running the statistical tests on normalized data does not change the results.

A large part of SpeakUp interaction (43 percent) seems to be off-task messages. To gain a better understanding of the motivation behind these messages, they were coded based on their content and purpose into five extra categories: (1) lecture-related, (2) fun and jokes, (3) miscellaneous, (4) social (e.g., small talk) and (5) news-related messages (see Fig. 3 and Table 2 for examples).

Fig. 3 shows a lot of social interactions. Examples are often to thank people or related to flirting, for example 'Happy birthday, Julie!' and 'Carl is too handsome'. The day before lecture 3 the French soccer team got qualified for the World Cup, which triggered a flow of messages (see the news messages in Table 2). Quite a few jokes were posted, especially during the last PM13 lecture right before the Christmas break. Examples include: 'Chuck Norris kills two stones with one bird' and 'What's the color of the white horse of Henry IV?'. In our previous work [27], [28] such messages were labeled as 'spam', but closer investigation in this section shows that the reality is much more nuanced. To assess if messages labeled as 'off-task' by experts are still considered useful for students, Fig. 4 compares the score ($\#thumbsup - \#thumbsdown$) of the messages for each category of Fig. 3. Overall there is a statistically significant difference in the score of on-task (M = 1.04, SD = 10.06) versus off-task (M = -3.56, SD = 11.28) messages (Mann-Whitney U = 5442, p = .01) and off-task messages are generally scored negatively. However, the filtering mechanism does not allow to decisively filter out off-task messages, as many are voted positively and half of the on-task messages are not scored positively. For example, one 'miscellaneous' outlier inquires about the name of the lecturer's newborn baby, which interested many. 75% of the social messages score negative, while news-related messages are the most contended, due to the very engaging soccer comments in lecture 3 (see Table 2 for examples). Some off-task messages may have been triggered because of SpeakUp's simple ranking system that students can game. For instance, a highly rated funny message might cause other users to write more jokes to get the same 'recognition'.

5.3.1 Backchannel

It is important to note that some messages which were off-task, are still related to the lecture (e.g., 'Searching the sickest Marlboro commercial ever' and 'You have to watch until the end with sound!'). These messages are actually addressed to fellow students and are examples of the usage of SpeakUp as a backchannel. To understand how SpeakUp is used as a backchannel we classified all messages into two categories. We define a *backchannel* message as communication directed to the audience and not the teacher, while a *frontchannel* message is directed to the teacher. In general, 59% of the messages are on the backchannel. Fig. 5 summarizes this categorization for the off-task and on-task digital messages ('on-task' consists of the 'content', 'organization' & 'SpeakUp' categories of Fig. 2).

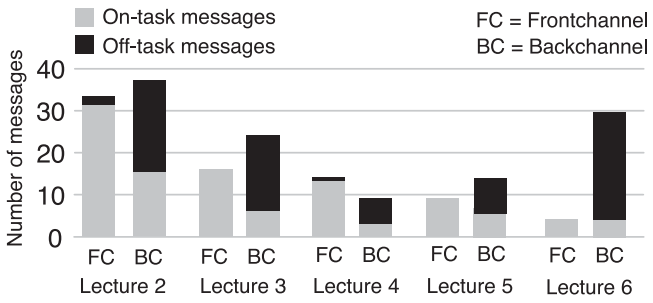

Fig. 5. All messages of PM13 categorized as on-task and off-task to the lecturer and as back- and frontchannel.

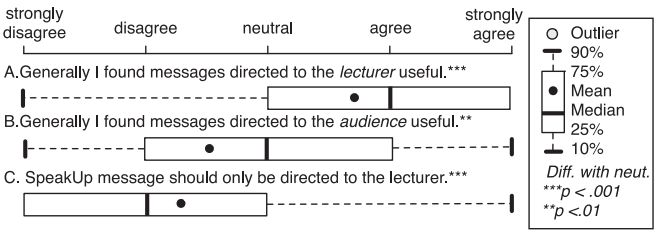

Fig. 6. CO14 survey results.

Most off-task messages occur in the backchannel (i.e., only 3 off-task messages are frontchannel). One third of on-task messages are backchannel info (32 percent). Most messages are comments (74) and 67 percent of the student answers are on the backchannel. These results show that SpeakUp is not only used for audience-to-teacher interaction, but the backchannel also enables audience-to-audience messaging. Moreover, SpeakUp is used for peer tutoring. However, the amount of off-task messages is left unchecked and could discourage people from using SpeakUp due to information overload. Since most off-task messages occur in the backchannel (see Fig. 5), we have assessed the impact of the backchannel further in CO14. To increase awareness of the front- and backchannel, we instructed the students to tag their messages with `@prof` if they were targeting the lecturer (frontchannel). As the results in Fig. 6 show, students found the frontchannel messages generally useful (A), but half of the students perceived the backchannel messages as useful and the other half perceived it as useless (B). Furthermore, when asked whether they would only prefer frontchannel messages, most students preferred to keep the backchannel (C).

5.3.2 Moderating Content

To reduce the number of off-task messages (and maybe handle potential information overload issues), various approaches could be considered. One way could be to blacklist the authors of such messages. Fig. 7 summarizes the students who wrote off-task messages according to the lecturer (37 out of 67 authors) and compares the number of on-task versus off-task messages. Due to overlap in the scatter plot, the bubble size indicates the number of students that wrote the same amount of on-task and off-task messages. Fig. 7 shows that most students wrote less than three messages, which in total is much more interaction than in CG without SpeakUp. Several students who wrote off-task messages actually contributed also with many on-task messages. For instance, the student in the upper right corner contributed most of the on-task messages of all students. The trend

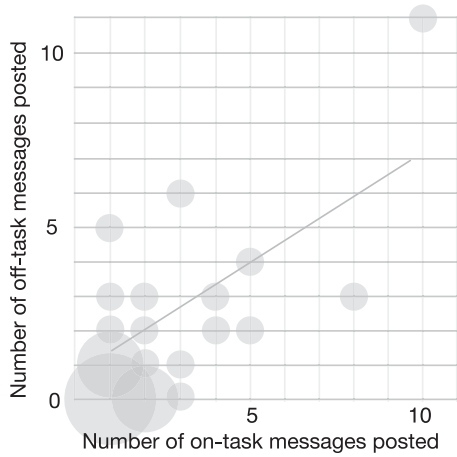

Fig. 7. Comparing off-task and on-task messages written by the PM13 students. The size of the bubbles represents the number of students with the same number of on-task and off-task messages (min = 1, max = 10).

line indicates that the students who wrote off-task messages also contributed almost as much with on-task questions or comments. Therefore, blocking students who write off-task messages will also reduce the number of on-task messages.

In a previous experiment [28], a moderator deleted the messages he considered irrelevant, which resulted in even more off-task messages. In the future we want to experiment with social spam reporting, which might be better perceived than a centralized censor. We also plan to investigate more complex ranking mechanisms that take other parameters into account (e.g., time) as done by Harry et al. [26]. We now know that removing the off-task messages can have an impact on the on-task messages, but we do not know whether keeping those off-task messages has an impact on the user experience, for example, due to information overload.

5.4 SpeakUp and Increased Perceived Learning (H3)

The anonymous SET questionnaire (Survey 1.3) was a combined open-closed instrument, consisting of 27 closed questions split into four sections assessing (1) general quality of the course, (2) course presentation quality, (3) complementary work, and (4) course structure. In the general quality of the course section there was one item on perceived learning outcomes: "in this course I learn a lot". The group using SpeakUp estimated that they learnt slighty more during the class than students in the class that did not integrate SpeakUp.

5.5 SpeakUp User Value Anonymity (H4 and H4')

One of our premises was that anonymity can increase interaction but can also cause spam. Although SpeakUp is associated with increased interaction, its causes are unknown. Therefore, we inquired about this in a student survey. Both PM13 groups were required to indicate whether they ask more questions when they are anonymous (Fig. 8A). The participants in the treatement group responded positively (Median = 4). Whereas the the participants in the control group responded negatively (Median = 2). Furthermore, the difference between both groups is statistically significant. For a better understanding, we inquired whether students would prefer identity in cases where ownership/authorship could be important. They are not really interested in knowing who authored a message (Fig. 8B). Additionally here it

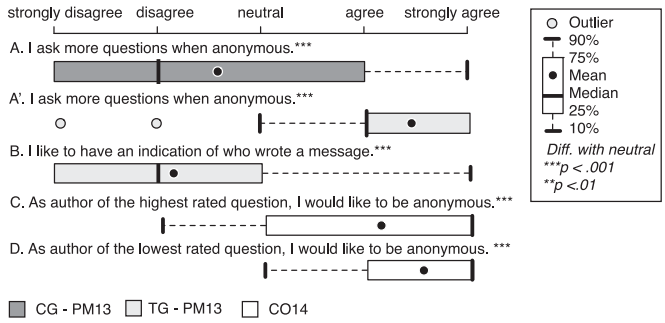

Fig. 8. Anonymity survey results boxplot.

seems that anonymity is in general preferred over identity, both when they were the author of the highest rated question and the lowest rated question (Figs. 8C and 8D).

5.6 SpeakUp User Value Temporariness (H5 and H5')

Temporary social media have recently come into the spotlight.[7] In such systems, messages are only kept for a limited time (at least from the user's perspective), which *"could enhance the privacy [...] and make people feel freer to be spontaneous."*[8] To evaluate if the time dimension of SpeakUp's *here & now* philosophy is important, we asked both CG and TG how long they prefer to keep the interaction traces (for CG: given that they would have access to such a tool). A survey (see Fig. 9) asked how long users wanted to keep messages (1) day, (2) week, (3) year, (4) for ever). A significant majority of students wanted short term traces (1 or 2). Surprisingly, the control group did not show a preference for short lived messages and there is a significant difference between the two groups.

6 Study 2

Study 2 aims to provide insights into how SpeakUp is used to interact and how a synergy between co-located digital and f2f interaction can be created by investigating how SpeakUp is used in different case studies. In Study 2, we discuss 11 case studies of university courses where SpeakUp was used (see Fig. 1) and compare how SpeakUp was used to blend digital and f2f interaction, and digital and f2f integration strategies. The 11 university instructors that used SpeakUp participated in a survey with open questions. Note that the instructors were shown how the app worked, but did not receive specific training on how to integrate it in their lectures. The survey inquired about their experience with SpeakUp, how they integrated SpeakUp in their course and how they inter-weaved the digital and f2f communication. The nature of the courses varied from economics to engineering, computer science, management, medicine and psychology, exposing SpeakUp to a wide audience. Fig. 1 summarizes the courses.

6.1 Introducing the Digital Channel

In all courses SpeakUp was introduced either by the teacher or the SpeakUp video.[8] Subsequently the teacher explained

7. MIT Technology Review – 10 Breakthrough Technologies 2013, http://www.technologyreview.com/featuredstory/513731/temporary-social-media/

8. The SpeakUp video is available at http://www.speakup.info.

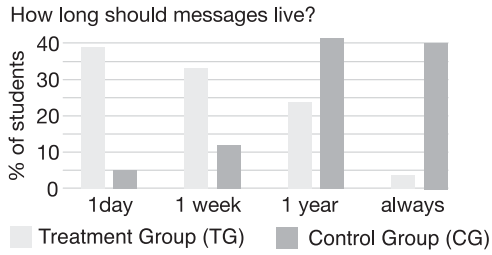

Fig. 9. PM13 student preferences in the duration of data retention for SpeakUp. N = 157 (72 in CG and 85 in TG).

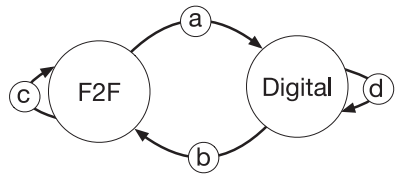

Fig. 10. F2F - Digital transitions: (a) an instructor initiates a poll or explicitly asks students to post messages on the digital channel, (b) instructors address digital posts orally, (c) students and instructors interact orally, and (d) students vote on each other's posts or answer each other's questions.

how SpeakUp would be used based on the scenarios described above. However in some courses, behavioral rules or etiquette on how to act courteously were introduced (IS12, PM13, CO14, IP14 & MS14). In IS12 and PM13, etiquette was only introduced in the third lecture to reduce the number of off-task messages, after which the interaction became more focused on the course (e.g., see Fig. 2). Another mechanism used in PM13, was a small nudge where the teacher told students how others had used SpeakUp and how he would use it. A nudge is an intervention that alters the user's choices in a predictable way without restricting options or changing incentives significantly [55].

An interesting social media mechanism was applied in CO14 to filter information due to the very intensive interaction (1159 messages), namely an `@prof` tag was added to address the teacher. Some courses with smaller numbers of students (most around 50) did not introduce any etiquette. Etiquette was mainly introduced in large courses ($>$150 students) with many messages (except for IP14, which needed to establish a strict protocol for the clicker-style interaction, and MS14, which was a small group with very little digital or f2f interaction).

Additionally, the CM14 teacher asked students to reveal their identity by signing their messages with their name, since part of the grade was for f2f and digital participation. According to the teacher, students would then typically sign their message for content related messages, but would remain anonymous for more organisation related messages.

6.2 Blending the Lecture

SpeakUp was used in various blended interaction scenarios transitioning between the f2f channel and the digital channel. Fig. 10 shows a model of the transitions between these channels that emerged from the survey.

6.2.1 *From f2f to Digital (a)*

Arrow (a) illustrates the transition from the f2f to the digital channel. A typical scenario includes a tutor who initiates a poll or explicitly asks students to post messages on the

digital channel (IP14, CO14). Another example comes from PM13, where the instructor talks about a researcher in the field. A student did not get the full name and posted "Martin, what is his last name please?". In IP14, SpeakUp was used like a clicker. The teacher posted two statements and students used the rating mechanism to agree or disagree (thumb up / thumb down). Similarly in CO14, several messages were used to ask multiple choice questions. Several instructors suggested blending the open text functionality of SpeakUp with clicker-style interaction to "support multiple choice questions during class".[9]

6.2.2 From Digital to f2f (b)

Arrow (b) illustrates the transition from the digital to the f2f channel. A typical scenario includes tutors addressing digital posts orally. This was the most predominant transition (in IS12, SM14, PM13, CM14, CO14, PP14, NS14 & MS14), nevertheless there were differences in terms of transition synchronicity from almost immediate (CO14, SM14) to more asynchronous (e.g., CM14). In SM14 and CO14, which had multiple instructors, the instructors that were not teaching would answer SpeakUp questions and potentially interrupt the speaker to ask a relevant question or address a relevant comment. In some cases, like PM13, the teacher would allocate a few minutes at the end of an hour to address digital questions (e.g., "Can co-branding and cannibalisation phenomena co-exist?") and in other cases (e.g., CM14) questions would be addressed the following week. In some IS12 and PM13 lectures, SpeakUp messages were projected on a public display next to the teacher's slides to raise audience awareness of digital activity. Previous research was unable to find any different interaction behavior with and without public displays [27], [28] and the teacher of PM13 reported that he did not find the experience compelling since there was sometimes noise from the audience (e.g., laughter) related to the activity in SpeakUp visible on the screen. Several instructors noted that there should be awareness features to make this transition easier such as "visual alerts when there are important messages". Moreover, instructors would like "archiving for later reuse" of digital content. Typically saving the logs would allow instructors to analyze the interaction offline to improve the lecture.

6.2.3 Staying f2f or Digital (c, d)

Arrows (c) and (d) illustrate activity on one channel. In all surveyed courses, the f2f channel was always open for students and instructors to interact orally since these lectures took place in a shared classroom. In some cases, the interaction mainly occurred on the digital channel where students vote on each other's posts or answer each other's questions. For instance in PM 13, after a student asked about the last name of a researcher, another student replied "Martin Lindstrom". It should be noted that students can initiate the digital state in the absence of an instructor prompt. In CO14 for instance, students were instructed to post questions or comments they had at any point during the lecture. For instance, SM14, AM14 and CS14 used SpeakUp for commenting on student presentations. In SM14, the Q&A for each student group presentation was completely conducted on SpeakUp. Group members replied while one team member was presenting to maximize presentation and Q&A time. In CS14, the presenting students would often monitor SpeakUp interaction to answer immediately or in the Q&A session afterwards. Instructors suggested to "add replies" to better structure the digital interactions.

9. The multiple choice feature has been implemented since.

7 Design Principles

Similar to Yardi's guidelines to integrate backchannels in the classroom [61], we provide guidelines based on the evaluation results and case studies, for co-located social media app designers, instructors working with such apps and researchers, who can potentially use these guidelines for future research.

7.1 Design for First Use

Guideline 1 – Lower Access Barriers

Providing no (or very simple) registration and authentication will ease adoption with co-located audiences. This is especially true for co-located social media since it is often used for events with large audiences so effortless access enables the audience to focus on the interaction and collaboration. The deployment time should be kept low so the setup of a digital channel does not obstruct f2f interaction. Typical solutions should be free for students, not require sign up or log in, and be available on a wide range of devices. Such simple access schemes foster quick deployment in the field. For instance in the IP14 course, SpeakUp was deployed briefly to assess an opinion via voting on just two statements. As an example of the number of people online, in the first lecture of the CO14 course, analytics recorded 153 users online. Since this course is taken by 150 students and taught by 3 lecturers, it is close to the 100 percent adoption rate.[10] Kang et al.'s research results also indicate that anonymity can facilitate effortless logins [30]. However, being identified can also have benefits as elaborated in Guidelines 3 and 4. In some cases, access barriers are lowered by using widespread social media which most participants already use (e.g., conferences often use Twitter or Facebook as their backchannel [40]). In general, providing effortless access schemes can increase deployment speed, and will make users employ co-located social media apps more spontaneously.

Guideline 2 – Design for Simplicity

In a co-located setting there is often no time for users to climb a steep learning curve to execute tasks. They must be operational within minutes. The confidence of the lecturer/organizer that the audience can easily execute tasks will be correlated with the probability that she adopts the system. High learnability is a known usability principle in HCI. However, it is especially important in the educational context, where instructors must make sure their students can all immediately be proficient with the tool (see Guideline 1). Designers should design for a very short learning time, for example, by ensuring good usability and focusing to excel at a limited set of essential tasks that can support various use cases.

10. We cannot be definitive, since some students might have more than one device and there might have been non-registered students in the classroom.

7.2 Design for More Digital Interaction

Guideline 3 – Provide Concealed Identity

By providing a form of anonymity for access and interaction, users might be more eager to interact freely, as this reduces the threshold for involvement, especially when those users are introverted and shy. In social media platforms, the representation of user identity can have a great effect on user behavior. Our results convey the fact that users are more inclined to contribute when anonymous (see A in Fig. 8 and H4). Anonymity can also foster inclusion (e.g., females often want to be confident about their work before attaching their names to it, while males say they mind less to reveal their identity [18]). However, when hiding under the anonymity umbrella users can act in a less responsible way [30], while having identified users can create a closer emotional connection between users and build trust [30]. Digital anonymity is also coupled with f2f anonymity (e.g., in a small group it will be much harder to ensure digital anonymity than in a course with 500 students). Harry et al. [26] argue that a range of identity options should be offered to increase the cost of changing identity. Guideline 3 concurs, but proposes to keep anonymity within these offered options. A soft identity can be added to an anonymous system, as examplified by the CM14 teacher who asked students to sign each message with their real name.

Guideline 4 – Make the Interaction Traces Temporary

To further enhance privacy, user interaction traces can be made temporary. Supporting temporal data volatility can increase participation, as it can lead to user trust, since user activity will be bound to the event's time span. Our results show that the temporary nature of social media can be highly appreciated in the classroom context (see Fig. 9 and H5). On the other hand, several instructors wanted to be able to archive a report of the posted messages. Some users might be comfortable with sharing their opinions and interactions publicly for an undetermined time span (like on Twitter), however others might be intimidated by this prospect and may avoid participation (see Guideline 8). Therefore, limited data retention can be useful to nourish adoption by a large group.

Guideline 5 – Design for Privacy

By providing proper privacy, some users can feel more at ease and thus be more willing to participate and interact. Recently, there has been more attention to include privacy features in the early stages of software design and development [12]. Additionally, anonymity (Guideline 3) and data transience (Guideline 4) further privacy feature can be provided, such as restricting messages to a group (e.g., the class) instead of making them publicly accessible. By providing such privacy features, users can feel comfortable and free to express their opinions because conversations are private [30].

7.3 Design for Richer Interaction

Guideline 6 – Make use of f2f Etiquette

To blend digital and f2f interaction, the audience often needs awareness cues and rules on how the system will be used collectively. Additionally, positive reinforcement [55] can create non-forced compliance to guide audience interaction. Yardi also recognizes the need for etiquette in backchannels, and defines that etiquette should be contextual and grow, based on its users, the environment and the requirements [61]. Within the environment and context of the combination of digital and f2f interaction, such etiquette could be designed and evolve on the spot fulfilling the needs of the moment. In the different lectures of Fig. 1, various strategies to guide interaction were used. For instance, some instructors discussed with the students how to use SpeakUp courteously, while others tried using social norms so as to guide students to act respectfully. Such f2f etiquette appears to be quite effective to curb off-task messages according to instructors who have used it. As discussed for the PM13 case, descriptive norms (e.g., *the majority of students post very on-task messages*) can be better motivators than standard appeals [23].

Guideline 7 – Embrace the Backchannel

The backchannel can sometimes be seen by users as a source of information overload. However, for other audience members such interaction is important and it can ignite lively discussions that can positively contribute to the f2f interaction. Although backchannel messages can distract from the content-focused digital and f2f interaction, they can also provide additional benefits for many. For instance, in the CO14 survey most students wanted to keep the backchannel messages (see C in Fig. 6) and some found the backchannel useful (see B). Eliminating the backchannel might result in removing useful content and discouraging active contributors. Furthermore, a significant amount of backchannel messages are still on-task as shown in Fig. 5. For instance, removing the authors of off-task messages in PM13 also results in eliminating the most active contributors of on-task content, as demonstrated in Fig. 7. Other research supports and elaborates on the various benefits of backchannels, (e.g., [19], [26], [61]). Hence, designers should not discard the backchannel, but integrate it. However, features for filtering or sorting the backchannel information should be considered since information overload could impact the user experience. Further research should investigate how it is possible to further improve the relevance of backchannel messages and possibly contribute to peer instruction. Additionally, research should further understand the types of students who post frequent off-task messages and understand the relation with their learning outcomes.

7.4 Design for Digital-f2f Transitions

Guideline 8 – Design for Awareness & Reflection

Providing support for lecturers to know what happens on the digital channel while they deliver their lecture is a key issue. Research on learning analytics investigating the issue is becoming more and more prominent [20]. Awareness can be supported both by software features (e.g., the highest rated and most recent messages, or a public display) and via the f2f interaction and protocol. In SpeakUp case studies, this issue has been addressed in different ways. In some lectures the transition from f2f to digital was more guided, where instructors asked questions orally and posted a digital message and students replied either by providing a comment or a vote. In general, most lecturers adopted an asynchronous approach where the digital channel was

consulted at the end of the lecture. In C014 and SM14, the lectures were co-taught, which allowed the teaching staff not presenting to read SpeakUp posts and answer when their turn came. Additionally they sometimes acted as a moderator, interrupting the speaker with a question or a comment from the audience when it was appropriate. We also experimented with a public display in PM13, but instead of raising awareness subtly, it tended to increase the teacher's disconnect with the digital channel. Further, allowing instructors to export information for subsequent analysis can improve usefulness from the lecturer's perspective. In SpeakUp this can be done by printing the content of the room. However, future research could investigate what kind of learning analytics dashboards could prove useful for instructors in that context.

8 Discussion and Conclusion

This paper investigated how co-located social media is linked to interaction in the classroom (RQ1) and how such co-located social media can be designed to blend digital and f2f interaction (RQ2). In this research, we have designed temporary SpeakUp location-bound chat rooms where students can anonymously post and rate messages. SpeakUp was extensively evaluated in 61 lectures and with over 2000 students, which is one of the largest studies the authors are aware of in the computer-mediated communication research field. SpeakUp was evaluated on two different levels: (1) digital and f2f interaction was analyzed with a quasi-experiment in one course, and (2) 11 case studies illustrated SpeakUp's integration in the course. From these results, eight design guidelines were derived that can be useful to design co-located social media.

8.1 How can Co-Located Social Media Affect Interaction in Classroom Audiences?

To answer RQ1, we have analyzed the SpeakUp interaction of a quasi experiment in one course. SpeakUp is not solely used for teacher-audience interaction, but is also extensively used as a communication backchannel that, in our study, empowered students and resulted in richer interactions than without SpeakUp. Often, this backchannel was used by the audience to comment on the lecture and answer peer questions. Such peer tutoring is often not possible in large traditional classrooms. Although backchannel messages can appear off-task and irrelevant to the teacher, students use this backchannel for several reasons. Notwithstanding that the backchannel can lead to information overload, a majority of students do not want to get rid of these messages. To curb the off-task messages, we investigated moderation and blacklisting of authors of such messages, but both techniques were ineffective. In the future, we plan to investigate social flagging mechanisms, and the impact of etiquette rules and nudges to filter out the most irrelevant messages. One might argue that the substantial quantity of off-task messages is due to the user's concealed identity because of the SpeakUp privacy, anonymity and temporariness settings. Our survey showed that SpeakUp's private and anonymous setup makes students more willing to participate and that they do not really want to identify themselves. However, this concealed identity and temporariness can lead to lower accountability of students for their actions. From our quasi experiment, we learned that user opinion on system features can differ considerably when users actually used the system compared to when we just inquired about a hypothetical system. This difference is in itself important given that many studies are based on perceived attitudes. For instance, SpeakUp users valued data transience and anonymity, whereas the other group did not. This finding may suggest that message transience could be appreciated in other social media, but users might only value it once they have experienced it. Last but not least, we found preliminary indications that the design and enactment of the lectures which integrate SpeakUp could lead to increased learning. Through an anonymous SET questionnaire, the perceived learning outcome was significantly higher for students using SpeakUp, than for students without SpeakUp.

8.2 How to Design for a Synergy between Digital and Face-to-Face Interaction?

On a macro-level, the 11 case studies showed that SpeakUp is generally applicable in multiple scenarios without providing dedicated features. The interviewed instructors also applied various strategies to synchronize the digital and f2f interaction. In most cases, dedicated synchronization points during the lecture were chosen, for example, during a break. In active and large classes, a form of etiquette on how to use SpeakUp was often discussed with the students and social media techniques were introduced to filter the front—and backchannel. In general, we found that a co-located social media app such as SpeakUp increases interaction beyond asking questions and that such simple apps can be used for a variety of scenarios. However, some new issues such as information overload and distraction can potentially be introduced with such apps. Based on our research results and the different case study scenarios, we created eight design guidelines for co-located social media apps that aim at seamlessly blending the digital with the f2f channels, by including more users (design for first use), fostering more contributions (design for more digital interaction), while encouraging quality (design for richer digital interaction) and providing support to move from one channel to the other (design for digital-f2f transition). It should be noted that the teaching scenarios described in this research are non exhaustive. Finding adequate teaching scenarios to take advantage of the added channel is an open research question. Teaching scenarios that could be further investigated include an open-ended variation of the poll scenario. In such an open-ended version, the instructor asks an open-ended question to the students (e.g., "Give an example of a privacy issue online"). The students are instructed to discuss in small groups and post their answer digitally. Then they read the others' answers and vote on them to show whether they agree. The instructor can then have a very fast overview of the opinions of all. Such a scenario could be a rich combination of F2F and digital interactions.

8.3 Beyond SpeakUp and the Classroom

Recently, several innovative teaching methods, often supported by technology, have popped up (e.g., Massive Open Online Courses (MOOC) [36] and Flipped Classrooms [6],

[36]). SpeakUp does not compete with those, but can rather complement interaction in these situations. For instance, we used SpeakUp for a live Q&A session in Coursera's *Unethical Decision Making in Organizations* MOOC in 2014 to add a here & now feeling to the course. The result was quite positive with 92 messages and 148 replies posted (we introduced replies in the app for this course) and 609 votes. Interestingly, in this context there were mostly on-task messages about the content (e.g., "When I'm not in the management but only a team member, what can I practically do to bring the new ethical thinking into the organization?") and remarks about the course (e.g., "I just regret that this wonderful course is just 7 weeks long"). The 128 users (out of the MOOC's 40,000 registered users) who made the effort to join the live session were also possibly interested in contributing positively. This paper has focused on one specific co-located social media app and in one specific setting. However, we believe that SpeakUp can be applied easily beyond the classroom. For example, to foster interaction at conferences or Q&A sessions such as the one described above. In the workplace, SpeakUp could increase interaction in meetings or inclusion in brainstorming sessions through anonymity.

8.4 Limitations to Our Research

There are several limitations to the present research, which we discuss below. Even though our case studies covered 11 different courses across several countries and continents, we cannot draw definite conclusions from our findings. Designing a UI is frequently based on several hand-picked guidelines and patterns that are, although based on research, often not written in stone. For instance, guidelines can be incompatible or conflicting. Our guidelines are not meant to be hard rules to obey, but rather to steer the design. Furthermore, such guidelines might differ with user age and culture (e.g., the perception of privacy might differ between the USA, Europe and Asia). Controlled experiments in the real world are not perfect. Although we tried to control as many parameters as possible, it was impossible to control the group size and group composition, for instance. The latter might be important for interaction (e.g., an extrovert group of friends might distort the overall interaction). To better understand the PM13 survey results, it could be interesting to contrast the results with detailed SpeakUp user behavior.

8.5 Future Work

In the future, we want to experiment with ways to guide the behavior of users in computer-mediated communication where f2f and digital interaction collide. One way to reduce off-task messages could be to apply a reputation score to each user based on her contributions (e.g., using positively rated messages and number of comments received). Such a reputation score could be used to filter important and off-task messages. It could even be possible to restrict people who want to game the system by not allowing users with a low reputation to send new messages. Furthermore, if the reputation score would be visible in SpeakUp's UI, it could provide the backchannel users with a level of author trust. Hence, the reputation score could provide a nudge for users to behave well, without dictating an etiquette. To evaluate the idea, we plan to set up A/B testing by assigning different reputation mechanisms to different users and assess how they can affect interaction. Additionally, we want to further evaluate the guidelines. One way of doing this (as done by [41]) would be to conduct a between subject experimental design with two groups of participants. One group of designers would be asked to design a (mockup) social media app using the guidelines and another not using the guidelines. The resulting (mockup) apps would then be evaluated with users and HCI experts and a common survey would be used to investigate whether the designs result in different user experience and behavior. Finally, we want to further evaluate the potential learning impact of SpeakUp. To do this, we want to once again work with a control group and to further improve on the stability of the learning conditions (e.g., controlling the uniformity of the group formation and learning content).

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Sten Govaerts is a research associate with the Ecole Polytechnique Fédérale de Lausanne (EPFL). His research interests include user experience design, information visualization, and findability applied to both the technology-enhanced learning domain and contextualized music. He worked on the ROLE project (http://www.role-project.eu) and the Go-Lab project (http://www.go-lab-project.eu/).

Adrian Holzer received the PhD degree in information systems from the University of Lausanne. He is a professor of management information systems with the University of Neuchâtel. He was a research associate with EPFL and a research fellow with Polytechnique Montréal. His main research interests include digital transformation in organizational, learning, and humanitarian contexts.

Bruno Kocher is an assistant professor of marketing with the Faculty of Business and Economics (HEC), University of Lausanne. He was a research fellow with Baruch College, CUNY, and an assistant professor with HEC Paris. His research interests include consumer behavior, luxury consumption, branding, and e-learning.

Andrii Vozniuk is a postdoctoral researcher with the Coordination and Interaction Systems group (REACT), Swiss Federal Institute of Technology in Lausanne (EPFL). His research and software engineering activities focus on the development of approaches and tools supporting knowledge sharing in the educational and the humanitarian domains.

Benoît Garbinato contributed to the emerging research trend on distributed object systems in the 1990s. He led the software engineering group of UBS's research lab (Ubilab) and later worked for Sun Microsystems as a senior software architect. Since his return to academia in 2004, his research has focused on emerging distributed architectures such as context-aware mobile systems.

Denis Gillet is a faculty member with EPFL. His main research interests include learning technologies and coordination systems, human computer interactions, and cyber physical systems. He is a former associate editor of the *IEEE Transactions on Learning Technologies (TLT)* and a current associate editor for the *International Journal of Technology Enhanced Learning*.