



Cultivating a Space for Learning: A Study of Note-Taking and Sharing on a Video-Sharing Platform Bilibili

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Abstract. Video-sharing platforms such as YouTube are popular today, not only for entertainment but also for learning, e.g., for understanding lecture content or acquiring everyday skills. Some platforms, like Bilibili, a popular video-sharing platform in China, even introduced note-taking and sharing features to further foster such learning practices. While note-taking and sharing have been extensively explored in environments specifically for learning, their use around these social media platforms such as YouTube and Bilibili remains under-studied. In this paper, we present a qualitative study with 15 participants who have used the note-taking and sharing feature called BNote launched on Bilibili. Our study reveals how note-taking and sharing are used as a way to cultivate a space for learning on such a general video-sharing platform by structuring, supplementing, and substituting user-generated videos and by leveraging social forces for motivation, self-discipline, and organization for learning. We end by discussing our findings and providing design recommendations to better support a learning space on social media platforms.

Key Words: Video-sharing platform, Note-taking and sharing, User-generated video, Cultivating a space for learning

1. Introduction

Nowadays, more and more people are drawn to video-sharing platforms, such as YouTube and Bilibili (a popular video-sharing platform in China), not only for entertainment but also for learning (Nishioka 2021; bilibili.com 2024; Wang and Chen 2020), e.g., for understanding lecture content or acquiring everyday skills such as cooking. Unlike platforms specifically designed for learning, such as MOOCs, these video-sharing platforms are based on videos generated by non-professional users and lack instructors to facilitate the learning process, and yet they have attracted numerous users leveraging them for learning purposes. For example, a 2023 annual report (bilibili.com 2023a) shows that 243 million people have been

watching videos for learning, e.g. programming languages, science knowledge, and presentation skills, on Bilibili. To further support learning, some platforms like Bilibili even launched a note-taking and sharing feature called BNote (at the end of April 2021), allowing users to create, store, and even share notes while watching videos without the need to switch screens (bilibili.com 2021). By the middle of May 2023, over 2.5 million users had posted more than 6 million notes using BNote on the platform, with over 3000 shared notes from more than 2,000 users per day.

Note-taking and sharing have been extensively studied in specialized learning settings, such as classroom lecturing and MOOCs, and more recently on live-streaming platforms (Ain et al. 2022; Fang et al. 2021; Cao et al. 2022; Deb and Bhattacharya 2017; Glassman et al. 2015; Almahmoud et al. 2022). Past research has shown that notes are taken to record important moments or points, provide feedback, and create works together during the livestreaming (Yang et al. 2020; Lu et al. 2018, 2021). That note-taking can facilitate the cognitive aspects of learning (Deb and Bhattacharya 2017; Wong and Lim 2021; Grahame 2016; Khan et al. 2022), by triggering active construction and processing of knowledge (Fang et al. 2022; Lu et al. 2018; Hartley and Marshall 1974; Fang et al. 2022), is well recorded. Note-taking has also been found effective in facilitating the learning process by recording important points and identifying weaknesses (Kiewra 1989; Fang et al. 2022; Cao et al. 2022). Moreover, it is also commonly reported that collaborative note-taking and sharing can facilitate learners' a sense of community and social learning (Faust and Paulson 1998; Fang et al. 2021; Kam et al. 2005; Lu et al. 2018).

However, note-taking and sharing in today's general video-sharing platforms remain under-studied. Unlike specialized learning settings, such as MOOCs, classroom lecturing, and live-streaming teaching, where instructors or streamers facilitate the learning process (Zhu 2022; Celina et al. 2016; Lu et al. 2018; Wohn 2019), users on video-sharing platforms fully rely on themselves for learning (Lee et al. 2017; Wang and Chen 2020). In addition, these platforms feature non-professional users who freely create, upload, and share videos¹ (Ding et al. 2022; Xia et al. 2022), whose structure may not be as evident as that of professionally produced ones. Moreover, the videos on these platforms serve various purposes with broader topics, not necessarily made with learning in mind. These differences make learning on video-sharing platforms quite distinct, as are the practices around note-taking and sharing in an environment that is dominated by entertainment and socialization.

To better understand note-taking and sharing and to inform design in such a new video-sharing context, we performed a qualitative study of practices around BNote on Bilibili. We are interested in what motivates users to take and share notes on Bilibili and how, and what roles note-taking and sharing play on such a platform.

¹ On video-sharing platforms, some video creators/uploaders have become micro-celebrities by professionalizing their content.

Based on semi-structured interviews with 15 participants who have taken notes and posted them on the platform using BNote, we highlight how note-taking and sharing were drawn on as a way to cultivate a space for learning in such a social media environment. We illustrate how notes were taken to structure, supplement, and sometimes substitute the user-generated video for learning, shared to provide a social force to be better motivated and self-disciplined, and collectively made to foster a community for quality note production and learning experiences, all of which are very critical in such an environment where videos are user-generated, learning is self-driven, and entertainment is dominant.

Our work yields three contributions:

- a first study of note-taking and sharing practices on today's popular and general video-sharing platform, differing from specialized and teacher/instructor-facilitated learning settings.
- new empirical findings of the roles note-taking and sharing play in a video-sharing environment. Specifically, we reveal that note-taking and sharing are drawn on as a way to cultivate a space for learning, by surfacing a layer of structure for user-generated videos, and scaffolding a social force to stimulate self-disciplined and organized learning in a social media environment.
- new design implications for how to better build a learning space in informal environments such as video-sharing platforms, e.g. leveraging social forces for learning, and facilitating collective note co-production.

2. Related work

2.1. Note-taking and digital note-taking

Note-taking² has long been recognized as playing an important role in learning. For instance, it is taken as an encoding in external storage (Kiewra 1989; Bauer and Koedinger 2006; Mueller and Oppenheimer 2016), through which users internalize learning materials via the encoding process and are able to review notes with its storage benefits (Bauer and Koedinger 2006). Moreover, note-taking, or annotation, on documents can help highlight important content, track reading progress, record interpretations, and serve as an active learning strategy (Roy et al. 2021) to help concentrate and capture thoughts (Yoon et al. 2013; Romat et al. 2019). By taking notes on a document, people are better able to monitor their understanding of the material and regulate their study tasks (Khan et al. 2022).

Nowadays, it is increasingly common for people to take notes digitally (Witherby and Tauber 2019; sohu.com 2017; tech.huanqiu.com 2014). Digital note-taking has several advantages over traditional handwritten ones such as reduced encoding workload (Bui et al. 2013), higher flexibility (Willett et al. 2015), better portability (Fernández Camporro and Marquardt 2020), and easier sharing (Mueller and

² In this paper, note-taking (or note, for short) is denoted as the act, artifact, or process of taking notes.

Oppenheimer 2014). A range of digital note-taking tools are available in the market, like Evernote³, OneNote⁴, GoodNotes⁵, and ColorNote⁶ for daily use on the computer, iPad, and mobile contexts.

Existing studies have extensively explored new practices of taking notes with digital technologies. For instance, (Chen et al. 2021a) compared audio and text note-taking behaviors in mobile settings, finding that audio notes were taken by users in personal language to capture unfamiliar content and improvised thoughts, while users taking text notes had better accuracy and deeper reflection experiences via modification. Han et al. (2014) showed that pictures can supplement text notes by providing additional information, e.g., the objects and contexts to which the text refers. Wang et al. (2022) demonstrated that AI-enabled note-taking techniques, such as handwriting and speech recognition, can enhance information capture during clinical visits while preserving patient-clinician interactions in hospital environments. Haliburton et al. (2023) demonstrated that automated note-taking techniques, i.e., voice recording and transcription, in mobile work environments can foster task focus, create a shared understanding between users, and generate more useful notes (e.g., including important points for post-processing and follow-up actions) using a one-click highlighting button. Zheng et al. examined the note's core components as well as its dimensions of design space, and discussed design suggestions to simplify repetitive note-taking tasks, furnish flexible generating processes, and lower entry barriers (Zheng et al. 2021). Others have explored intervention strategies to develop learners' note-taking skills. For example, Thaleia et al. designed an educational game, which was verified to create an engaging and entertaining learning atmosphere to cultivate note-taking skills for students in academic and professional settings (Deniozou et al. 2020).

2.2. Collaborative note-taking and sharing

Collaborative note-taking and sharing are commonly studied in existing studies. They support learners to exchange their thoughts and ideas with peers, contributing to better learning engagement (Silvestre et al. 2014) and social learning (Valtonen et al. 2011). Prior work has shown that collaborative note-taking and sharing can enable learners to make more accurate and comprehensive descriptions of the material (Faust and Paulson 1998), and can also aid comprehension of learning content, confirmation of ideas, and communication with diverse perspectives (Kalir et al. 2020; Fanguy et al. 2023; Costley and Fanguy 2021). For example, (Almahmoud et al. 2022) showed that sharing annotation and highlighting some of them on shared documents can enhance learners' attention to informative or stimulative

³ <http://www.evernote.com>

⁴ <http://office.microsoft.com/onenote>

⁵ <https://www.goodnotes.com/zh-cn>

⁶ <https://www.colornote.com>

annotation, and provide those whose work being spotlighted with a sense of approval and pride. Users' attitudes and practices of sharing notes with others have also been reported in the existing literature. Willett et al. reported that participants are reluctant to share notes in the raw form, because of feeling uneasy about their notes' structure and writing style and worrying about forcing others to read overloaded or irrelevant content (Willett et al. 2015; Goffin et al. 2015). As a result, people probably prune, reformat, and edit their work before note-sharing or take notes more prudently if they know them to be shared (Willett et al. 2015), some of whom even give up their personal tones to increase the note's readability (Marshall and Bernheim Brush 2004).

2.3. Video-based note-taking and sharing

With video-based learning becoming more popular, note-taking for video-based learning, in the form of video annotations or more traditional notes, has also been commonly explored (Rodrigues et al. 2021; Fang et al. 2022). Video annotation means attaching comments, marks, and ideas to the video, and is found to provide a simple way to add extra explanations, highlight points of interest, and pose questions for watchers (Kleftodimos and Evangelidis 2016), which can promote reflection and provoke discussion (Glassman et al. 2015; Pardo et al. 2015; Mirriahi et al. 2018; Rodrigues et al. 2021). Traditional notes are often used to extract and summarize the video content to reflect viewers' understanding of learning material (Fang et al. 2022).

In the video-based learning setting, in addition to cognitive or social functions, annotations or notes can also be used for navigation by building connections or references between the notes and video. For example, based on timestamps coming with notes (Fu et al. 2006; Mu 2010), a two-way navigation method can be established: upon clicking on a note, learners see the video segment that corresponds with the note's timestamps; the note keeps highlighted as the video plays between the start and end timestamp (Chatti et al. 2016). As such, it can help learners find places where certain concepts are explained, and review parts of the material they have already viewed (Monserrat et al. 2013).

For video-based learning, we can distinguish between asynchronous and synchronous forms where note-taking and sharing play quite distinct roles. Asynchronous forms means people watch pre-recorded videos for learning. For instance, in MOOCs, learners can access a wide range of pre-recorded videos to learn at their convenience (Xiao and Wang 2017). Often, MOOCs also provide discussion forums for learners to pose and reply to course-related questions (Gamage 2021; Almatrafi and Johri 2018; Coetzee et al. 2014). Several approaches have been explored to promote social interaction in such a context. Chen et al. (2017) introduced and embedded notes and discussions anchored to the video's timeline, and found it can stimulate more thinking and collaborative learning, help learners develop a sense of company, and create a lively atmosphere to attract learners.

NoteCoStruct (Fang et al. 2022) was designed to support a three-phase structured note-taking process (i.e., transcript highlighting, commenting, and notes finalization), with each phase presenting learning traces left by previous learners of the video. This system was found to foster learners' a sense of belonging to the learning community and enhance the quality of their notes in both completeness and usefulness. There are also repositories such as Notion⁷ and GitHub⁸, which can embed video content from various platforms such as YouTube and are often used in specialized learning settings, such as classrooms (Zagalsky et al. 2015; Glassey 2019; Tu et al. 2022). Researchers have explored the potential of these repositories as collaborative learning platforms for education. For example, (Zagalsky et al. 2015) found that educators used GitHub to reuse and share course materials and check students' work, while students used it to submit notes and assignments, seek help from teachers, and engage in peer discussions.

In synchronous video-based learning settings, such as online classroom lecturing or live-streaming, note-taking and sharing have been found to stimulate interactions among learners and between learners and instructors. For example, Mudslide (Glassman et al. 2015), which supports annotating confusion points spatially anchored in lectures, was discovered to provide a meaningful way for students to give feedback, and meanwhile, for teachers to gather and reflect on this feedback. Livenotes (Kam et al. 2005) supports group members to cooperatively take notes during lectures, and it has been found that students engaged in cooperative note-taking create more comprehensive sets of lecture notes (i.e., with more coverage of lecture information) and attend a higher degree of group conversation than those taking notes individually. In recent years, live-streaming based learning, another synchronous form, has become popular on some platforms (e.g., Twitch⁹), resembling online teacher-facilitated learning. On these platforms, streamers broadcast their work activities (e.g., creating artifacts, computer programming, cultural practices) to viewers, who concurrently watch the live streams and post comments in the chat (Lu et al. 2018; Chen et al. 2021b; Lu et al. 2019). Viewers are also found to collaboratively mentor each other by offering answers and advice in the text-based communication channels (Faas et al. 2018). Multi-modal methods beyond text-based chat have also been actively explored to enrich interactions and engagement among viewers and between streamers and viewers (Yang et al. 2020; Lu et al. 2021; Yen et al. 2023; Hamilton et al. 2018; Chen et al. 2019). Examples include annotating the screenshot with simple shapes (Yang et al. 2020), using free-form sketches on the screen (Lu et al. 2021), collaborative note-taking on annotation cards (Lu et al. 2018), and integration of multimedia such as text, audio, video, and image (Hamilton et al. 2018; Chen et al. 2019). Research has shown that learners use these multi-modal methods to create improvised works for collaborative

⁷ <https://www.notion.so>

⁸ <https://education.github.com>

⁹ <https://www.twitch.tv>

creation and providing feedback, highlight the whole stream's structure and key points, and enable easy navigation of archived video.

Overall, research on video-based note-taking and sharing has mainly been explored in specialized learning settings such as MOOCs, online classroom lecturing or live-streaming teaching. What has been under-explored are note-taking and sharing on video-sharing platforms that feature user-generated videos mainly designed for socialization and entertainment, like Bilibili. In this paper, we address this gap by exploring how note-taking and sharing are used in this new context.

3. Bilibili and BNote

Our study is based on Bilibili, one of the most popular video-sharing platforms in China. The number of daily active users has reached 100 million (bilibili.com 2024), with nearly 80% aged under 24 (bilibili.com 2023b). Similar to mainstream video-sharing platforms such as YouTube, Bilibili is a UGC (User Generated Content) platform, whose video creators/uploaders are mostly ordinary users. Unlike specialized learning oriented video platforms such as MOOCs, Bilibili supports both learning and entertainment. In contrast to other popular video-sharing platforms such as Douyin (the Chinese version of TikTok), whose feature is short-form videos lasting 15 seconds to a few minutes, Bilibili supports longer videos with even hours. Different from live-streaming platforms (e.g., Twitch) that feature synchronous interaction and engagement, Bilibili supports asynchronous sharing, communication, and creation. With distinct social features such as Danmu¹⁰ and Virtual Coin¹¹, as well as terms, rules, and symbolic language embedded in the video contents and comments, Bilibili has developed a community with rich social interactions.

BNote, the note-taking and sharing feature on Bilibili, was officially deployed in April 2021 (bilibili.com 2021). It was conceived with the rise of pan-knowledge, a concept that encompasses various forms of content for enhancing personal knowledge and skills, contributing to daily life (ciavc.com 2021). Since June 2020, Bilibili has launched a first-level section named “Knowledge Zone”, which is integrated and upgraded from the original Science and Technology Zone. This section is dominated by sharing knowledge, experience, skills, viewpoints, and humanities. In a short time, pan-knowledge content has become a windfall for this platform, accounting for 45% of the total broadcast volume (ciavc.com 2021). At present, the pan-knowledge content of Bilibili has spanned eight categories: Popular Science, Social Science & Law & Psychology, Humanities & History, Finance & Business, Campus Learning, Workplace, Design & Creativity, and Wild Skills. As such, the

¹⁰ A video commentary system that allows viewers to post comments directly onto the video, with comments appearing on the screen as written texts in synchronization with the video's timeline.

¹¹ A kind of virtual currency donated by viewers to the video uploaders for thanking their contribution.

increasing focus on learning and pan-knowledge makes Bilibili ideal for us to understand video-based learning practices.

BNote was initially positioned to target pan-knowledge types of UGC videos. As a part of this video ecology, BNote is designed to serve as an auxiliary tool for video watching and learning. Like BNote, certain video comments can also assist viewers to understand key points of a video by summarizing its content (Monserrat et al. 2014; Yarmand et al. 2019). Nevertheless, video comments are applied to broadly discuss knowledge, opinions, and thoughts with others in the common form of short texts¹² (Madden et al. 2013; Dubovi and Tabak 2020; Zhang et al. 2023), while BNote is intended to be created and shared around the video itself, such as summarizing video contents through longer texts and images¹³. Besides, only a few of the comments provide a summary of the video's content, and these comments are often overwhelmed in other comments placed below the video, making them easily overlooked (Monserrat et al. 2014). In contrast, BNote serves as a separate and easily recognizable component for both video watchers and note creators. Therefore, we specifically focus on BNote as our research subject.

In terms of functionality, BNote is quite easy to use, which follows one essential guideline for the design of social software: keeping the interface and function as simple as possible (Vassileva 2008). Beyond the basic functions commonly found in note-taking products on the market, BNote is enhanced with two unique features (Box A and B in Figure 1, respectively): screenshot (the camera-like button) and time-tag (the flag-like button) to create a strong binding with the video. As seen in two examples of Figure 1, with one screenshot click, the video frame at current moment of operation is captured; when a time-tag is clicked, the time moment of the video playing is recorded, and users can directly jump to the corresponding video frame through this time-tag. It is also the original purpose of BNote to associate notes with videos in lightweight ways, rather than developing elaborate note-taking features, which differentiates it from existing commercial and design tools, such as OneNote, VideoSticker (Cao et al. 2022), etc.

To use BNote, users just open a video on the platform, and a “Notes” button appears at the bottom right corner of the video (Box A in Figure 2). After clicking it, users are able to view, if any, all the notes about this video (Box B in Figure 2). To create a note, users simply click the “Take a Note” button (Box C in Figure 2). The interface then switches to the note-taking interface as shown in Figure 1. The note content is saved automatically three seconds after the users stop typing, and they can also manually click the “Save” button (Box C in Figure 1). The note's current saved status can be seen at the top of the BNote editor. If users want to share the note, after completing it, they can do so by pressing the “Public Release”

¹² The content limit of video comments on Bilibili ranges from 2 to 2,000 words.

¹³ The content limit of BNote ranges from 200 to 20,000 words during our study and the minimum limit was decreased to 100 words afterwards.

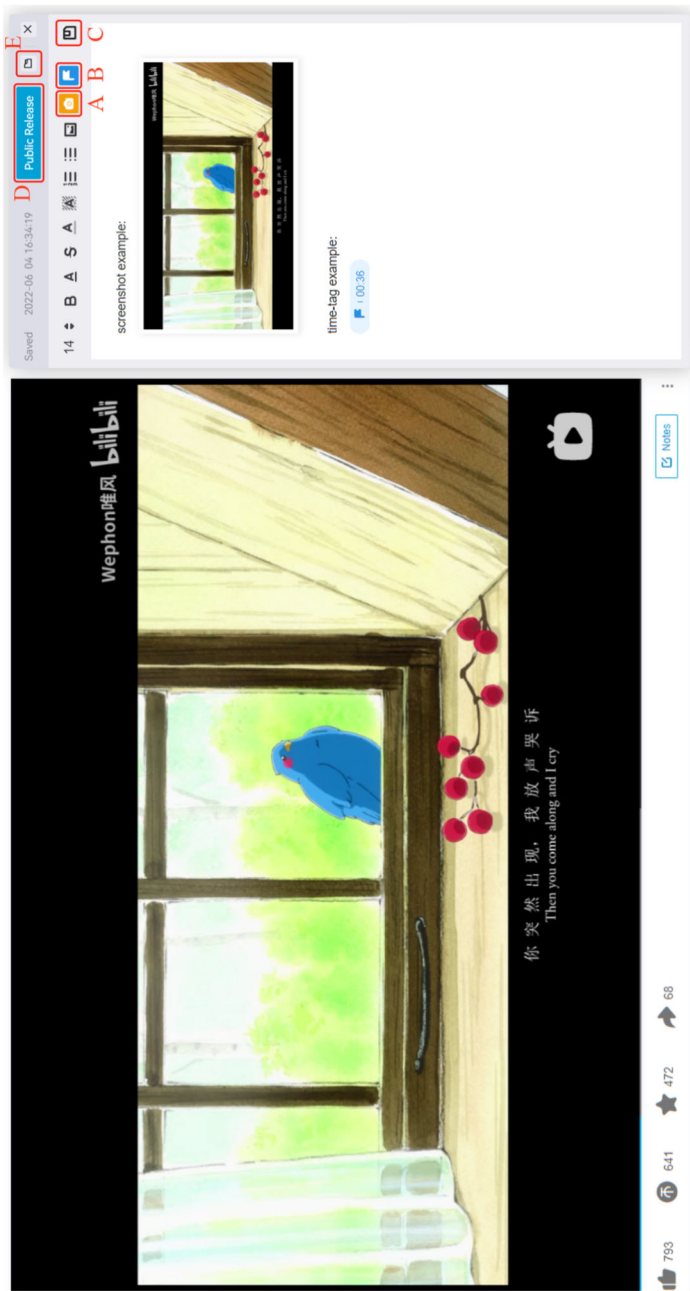


Figure 1. The BNNote taking interface (right): (A) the screenshot function (with one click, the video frame at current moment of operation is captured), (B) the time-tag function (with one click, the time moment of the video playing is captured, and users can directly jump to the corresponding video frame through this time-tag), (C) the “Save” button, (D) the “Public Release” button, and (E) the “My Notes” button.



Figure 2. The BNote list interface (right): (A) the “Notes” button, (B) the users’ note list, and (C) the “Take a Note” button.



Figure 3. Screenshots of shared notes as shown in users' respective personal spaces (left top: P6's note, left bottom: P11's note, right: P8's note; these notes can be accessed and viewed by others via the users' public profiles; the practices shown can be corresponded to related quotes in subsequent Section 5.2).

button (Box D in Figure 1). Once the note passes manual moderation,¹⁴ it will be made public on the platform. By clicking the “My Notes” button (Box E in Figure 1), users can jump to their personal spaces to review or refine all their past notes. Shared notes are separately listed in the user’s personal space. Others can access and view these shared notes via the user’s public profile. Figure 3 shows screenshots of shared notes from three participants, as displayed in their respective spaces. Moreover, others can also see these shared notes in the note list and the comments area of the corresponding video, and can click to view details, as shown in Figure 4.

By the middle of May 2023, more than 6 million notes from over 2.5 million users had been released on this platform, with 3000+ public notes per day. Amongst them, shared notes accounted for 2% of the total, with about 50% coming from PCs. To expand the publicity, Bilibili has launched multiple note-related clock-in activities¹⁵ to date, aimed to encourage users to create and share more notes, thus fostering a healthy and vibrant ecosystem of note-taking and sharing for learning on the platform.

This study aims to explore how people use BNote to take and share notes on Bilibili, identify the roles note-taking and sharing play in learning, and offer design implications to support learning in such an informal environment. We believe such a study is highly important, particularly as video-sharing platforms like Bilibili have become increasingly adopted for learning.

4. Method

4.1. Participants

We conducted a qualitative study to better understand note-taking and sharing related practices on Bilibili. The only screening criteria was that participants had shared at least one note using BNote, given the emerging nature of the BNote feature during our study. We designed a recruitment flyer that describes the purpose, procedure and qualification of the study, and sent it to qualified users through Bilibili’s messaging system. First, we chose random qualified users to send interview invitations, and recruited P1 and P2 this way. Then, we made deliberate efforts to recruit active note users who could provide richer experiences, by contacting the platform’s top-30 note users ranked by the number of comments, and recruited P3, P4, P7, and P8. P8 recommended P5 who was a product manager of Bilibili, and P5 recommended P9 and P11 whose notes were related to course learning. We also contacted 6 prize winners of Bilibili’s initial note clock-in activities and recruited

¹⁴ The content of user notes is moderated in accordance with that of the columns on Bilibili, see: <https://www.bilibili.com/read/cv2>.

¹⁵ An open activity organized by Bilibili, which requires participants to write and publish notes that meet the requirements within a specified period, and rewards the winners who made the highest-quality notes with prizes or virtual currencies.

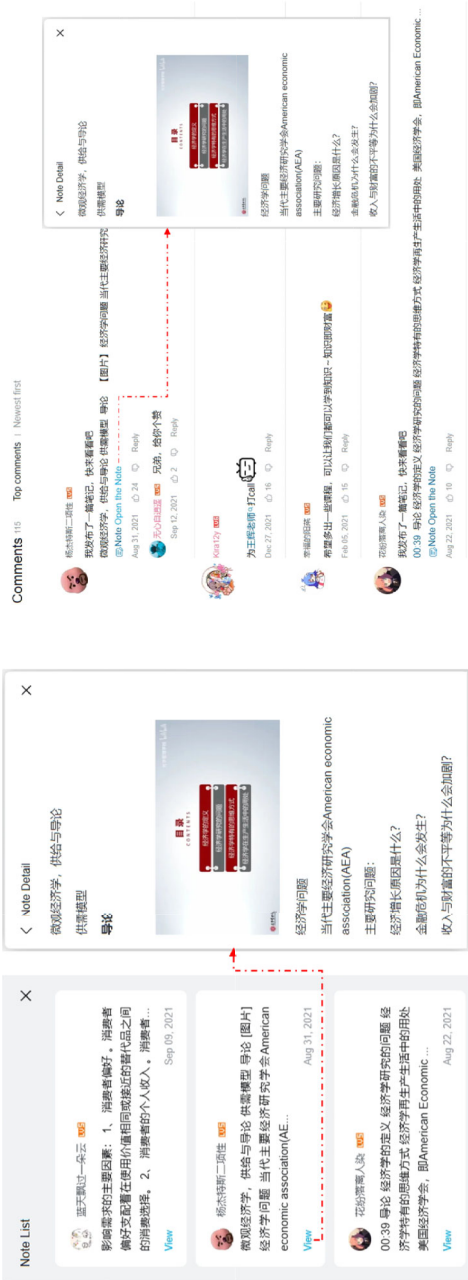


Figure 4. Screenshot of shared notes as shown in the note list and comments area of the corresponding video: (A) In the note list of the video, all shared notes are sorted by newest first, and users can view the details of any note by clicking the “View” button; (B) In the comments area of the video, each shared note is specifically marked with the word “Note” and a note-taking icon. Notes are sorted by top comments or newest first, and users can click the “Open the Note” button to see the details.

Table 1. Demographics of participants.

ID	Gender	Age	Occupation	City (Province)	No. of Shared Notes (Total Notes)
P1	F	22	Postgraduate	Wuhan (Hubei)	2 (3)
P2	F	18	Senior School Student	Fuzhou (Fujian)	1 (17)
P3	F	21	Undergraduate	Unknown (Anhui)	2 (2)
P4	F	15	Senior School Student	Jinhua (Guangdong)	1 (3)
P5	M	24	Bilibili Product Manager (Master)	Shanghai	1 (1)
P6	M	26	Postgraduate	Zhengzhou (Henan)	1 (1)
P7	M	17	Senior School Student	Unknown (Anhui)	2 (2)
P8	M	21	Taobao Shopkeeper	Wuhan (Hubei)	24 (31)
P9	M	17	Senior School Student	Haerbin (Heilongjiang)	8 (8)
P10	F	22	Nurse (Bachelor)	Jiaozuo (Henan)	1 (1)
P11	F	17	Senior School Student	Baoji (Shanxi)	1 (1)
P12	F	20	Undergraduate	Wuhan (Hubei)	9 (18)
P13	F	23	Accountant (Bachelor)	Jiangmen (Guangdong)	13 (21)
P14	M	24	Undergraduate	Shenyang (Liaoning)	17 (19)
P15	M	17	Senior School Student	Shenyang (Liaoning)	15 (24)

P12–P15 (P8 was also in the list of prize winners). We stopped when data saturation was reached (Malterud et al. 2016). In the end, we recruited a total of 15 users as our participants, with varied levels of engagement, including those who had merely taken one note (but read others' many times) as well as who had shared multiple notes. This offered us a rich perspective covering various levels of note-taking and sharing practices, from the near-lurkers to the active contributors.

Participants' demographic information is shown in Table 1. These 15 participants, 7 male and 8 female, aged 15–26 years (average age of 20.3), were distributed across nine different provinces in China. The number of notes shared by participants and their total number of notes were based on data available at the time of our interview. As seen from Table 1, even P8, who was deemed by the platform as one of the most active note-takers, as well as P15, the champion of a note clock-in activity, only took notes in the dozens (e.g., the maximum is 31). This could be because, at the time of our study, the BNote feature had only been officially published and propagated for a few months and participants had not yet produced so many notes. Several participants have since made and shared more notes. Unlike the other participants who took notes on the videos they consumed, P6's note was for a video he created himself. Although we tried our best to balance the age and occupation distribution using different recruitment strategies (e.g., random, focused, recommended), the majority of participants were school students and young people who had recently entered society, consistent with Bilibili's user population of people mostly in their 20s (bilibili.com 2023b).

4.2. Procedure

Due to the dispersed distribution of our participants, we conducted semi-structured interviews primarily by voice calls on WeChat¹⁶, from late July to early October 2021. Specially, under-age participants were interviewed at home with the permission and presence of their parents. Our interview questions covered participants' experiences and details about their concrete note-taking and sharing cases, including: how they noticed the BNote feature, the context in which they took their first note, their most impressive or latest note-taking experience, why they chose to share their notes, any concerns they had about sharing notes, their note reading and learning experiences on Bilibili, and so on. When we discovered intriguing or illustrative points, some participants also agreed to share specific screenshots with us. Despite using the same interview guideline for all participants, we refined our questions or adjusted the inquiry order based on their answers to ensure a natural conversational flow and collect data as richly as possible from each individual's unique experience, until saturation was reached.

Each interview lasted around 60–90 minutes in Mandarin Chinese, and each participant was compensated with 50 RMB (about \$7) through WeChat transfer for their contribution to the study. Our study was approved by the authors' institution. Prior to each interview, we clearly stated our intentions and offered information about the study. All data were audio-recorded and then transcribed with the permission of our participants, and were anonymized for analysis in this paper.

4.3. Data analysis

A thematic analysis (Braun and Clarke 2006) was performed on the 16-hour interview transcript. First, the first two authors independently open-coded the transcript using Google Docs¹⁷. The two coders went through the transcript line by line for multiple rounds, making comments with descriptive words and then coding the data using higher-level keywords, such as “making the video more structured”, “being more motivated and self-disciplined by sharing notes”, and “taking notes as an organized whole”. Second, through an axial coding conducted with iterative discussions among all the authors, we attempted to find links between the codes, sorted and grouped them into sub-categories and further into categories using a ProcessOn¹⁸ board. Finally, with the selective coding, we identified a few categories that represented the remaining sub-themes as recurrent and central themes, including “structuring and complementing videos ” and “scaffolding a social process for learning ”. As the analysis process progressed, we gradually finalized a

¹⁶ A popular instant messaging APP in China, which is also commonly applied to other purposes such as paying bills.

¹⁷ <https://docs.google.com/document>

¹⁸ <https://www.processon.com>

central theme, i.e., note-taking and sharing were drawn on to cultivate a space for learning in such a general video-sharing platform. During the coding phases, any inconsistencies, such as those related to concepts and conclusions, were discussed through regular weekly meetings until a consensus was reached within the whole research team. In these meetings, the coders explained their reasoning behind the coding, and specific examples from the transcript were reviewed by all team members to resolve disagreements. Representative quotes were translated into English from Mandarin and used as illustrations in this paper, which we will explain further in the following section.

5. Findings

5.1. Overview

On Bilibili, participants mainly used pre-recorded videos for learning, viewing them as an informal way of knowledge creation, sharing, and communication. This approach is quite different from synchronous live-streaming and classroom lecturing, which are more formal and similar to traditional teacher-based learning. From our data, we learned that adult participants took notes for a wide variety of videos (e.g., popular science, cooking, drawing), depending on their individual interests or needs to improve skills. In contrast, under-age participants predominately watched lecture related videos from the “Campus Learning” Subzone—one of the eight categories in the platform’s “Knowledge Zone”, to supplement their school learning. This phenomenon could be related to the particular social context where study is highly emphasized for Chinese adolescent students, so social media is also drawn on for learning outside the classroom.

The majority of participants (9 out of 15) were inspired to write their first note after seeing others’ notes, consistent with the social learning theory (Rumjaun and Narod 2020). For example, P11 was motivated by seeing others’ well-detailed notes, showing much effort put into learning. P6 was influenced by the uploaders he was following: “I saw [that] an uploader I follow was using BNote to publish a note this year, so I thought I could use it too.” In addition, the aforementioned clock-in activity designed by the platform to encourage note-taking and sharing also played a role here. For instance, although P15 was fully aware of the BNote feature after seeing many notes left in the videos’ comments area, he did not decide to take one himself until a timely push of the platform’s clock-in activity.

All participants performed varied degrees of editing works to make their notes more readable before sharing, consistent with findings from previous work (Willett et al. 2015; Marshall and Bernheim Brush 2004). Moreover, all participants have kept their shared notes, regarding them as a means of tracking what they have learned. However, the private notes (i.e., notes not shared) were fragmented, scribble-like, and consisted of few words. The majority of private notes were used as

temporary storage and later deleted by participants, aligning well with the lifecycle of formal and informal notes mentioned in existing studies (Lin et al. 2004).

Now we will turn to elaborate on how note-taking and sharing are drawn on to cultivate a space for learning in the social media environment, including using the note forms to compensate and complement user-generated videos, as well as drawing on the social means for motivation and self-discipline, and co-learning (Figure 5).

5.2. Structuring and complementing videos

Videos contain rich and vivid information in audible and pictorial forms, and have become increasingly popular resources for learning (Cao et al. 2022). However, videos on social media are mostly generated by ordinary users (Ding et al. 2022; Lu Jia et al. 2019), and not necessarily specialized for learning as well. So, the structure of these videos is often not as evident as that of professionally produced ones for learning, making it time-consuming to watch and learn from these videos (Shoufan 2019; Cao et al. 2022). From our study, we found that note-taking and sharing were not simply to cognitively facilitate learning, but many times, to compensate for the various disadvantages of learning on video-sharing platforms, particularly in terms of structuring, supplementing, and substituting the video on this platform.

5.2.1. *To structure the video*

In addition to the less obvious structure the video has on social media, video is essentially a temporal stream of data containing both audio and pictures, making it difficult to quickly see the structure and get an overview. As such, its structure, if any, is less intuitive than that of other media forms such as pictures and texts that unfold in the visual space. P12 compares it with text this way:

“The video is a stream. I have to drag the progress bar if I want to go to view something. It is extremely troublesome this way. It is very unlike the text, which is so clear at a glance.”

Here, with note-taking using BNote, it offers users a way to add a layer of structure to the video stream. First, it is through the two functions of BNote, i.e., time-tag and screenshot, which are perceived by 11 of 15 participants as the most useful, as they can be used to not only externalize the structure contained in the video but also to tightly correlate with particular video segments. For instance, P13 described how she used the time-tag function in a note on popular science regarding common cold:

“On a certain video frame, the speaker usually said what he would discuss next, and then I would click [the time-tag button to add it to my note] right away ...”

Similarly, adding the time-tag makes it easier to see different video segments, as P14 explained:

“This video [on cities and cultural heritage] is segmented. The first and second episodes, for example, are an introduction. Just like the previous video on gram-

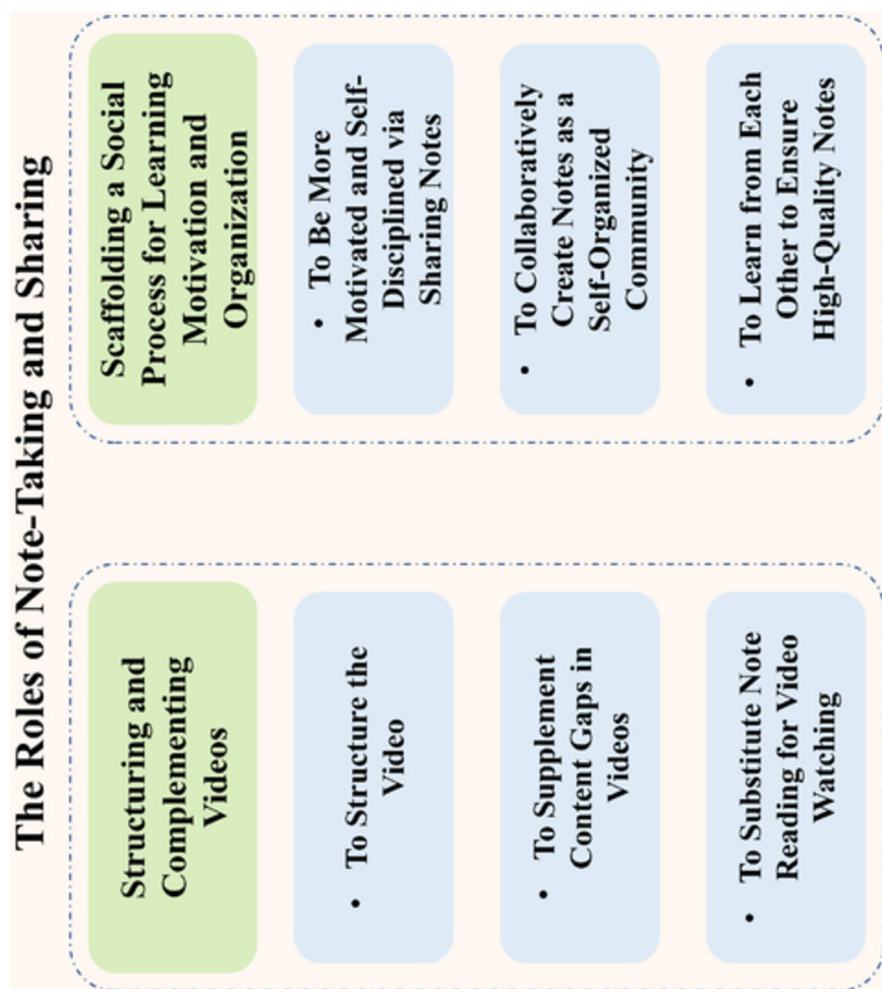


Figure 5. Overview of the main research theme.

matical tenses, it (this video) contains several episodes, each of which has different content. So, it is expressed more clearly by adding the time-tag [that corresponds to the video segment] like this.”

Moreover, with the time-tag function of BNote, participants can quickly locate specific points in the video, making it more convenient and intuitive to navigate, serving a purpose similar to the timestamp in video annotation (Fu et al. 2006; Mu 2010). Our participants commented that BNote made it easier not only to see the video’s structure but also to quickly jump to the part they wanted to see. P1 described this way:

“It (time-tag) is equivalent to a quick index. For example, in the beauty makeup [video], the first part is about the lipstick, and the second part is about the foundation. [In this case], I can quickly go to where I desire with these time markers. That is, if I want to learn more about a certain part, I can click [the time-tag] and find the corresponding part that I want to see.”

At the same time, participants also often use BNote’s screenshot function to make their notes more illustrative and visually appealing. This is different from the screenshot feature used during livestreaming, which is used to refer to a part of artwork, provide suggestions on it, or capture milestone events (Yang et al. 2020). For example, in addition to using the time-tag, P11 also made the subheadings more eye-catching by adding screenshots alongside them. Similarly, some screenshots serve as a quick summary of the video’s topics, as P9 explained:

“They mostly reflect the key contents of this video [about organelle]. That is, the key points of this video are these [screenshots]. For example, [from the first screenshot], we can see that the biological membrane system is divided into nuclear and cell membranes, which are both highly important.”

P13 utilized screenshots to extract representative examples from the video to illustrate significant topics. P11 described a case in which she used the screenshot and time-tag functions together to mark a specific story (“Kuaifu Chased the Sun”), closely associated with a video’s topic of interpreting classic Chinese literature from various perspectives.

What is more, users also utilized BNote’s various textual features, such as font color, background color, and font size, to make the video’s structure more visible by externalizing certain core pieces of information, such as topics, highlights, and more. For example, P9 used font and background colors to distinguish different levels of content in the video:

“The red font is to determine whether it is vector or scalar, which is the focus of this video [about physics concepts]. The blue font is to express an explanation of these concepts. The green font means a subheading ... [By doing so], you can tell which is more important, right? ... The fonts with yellow backgrounds are key points, such as, “the timeline doesn’t have a negative half-axis” is a relatively important thing ... Yes, these fonts with red backgrounds are the most important.”

P1, on the other hand, used boldness to highlight what is important in the video on popular science about diarrhea:

“These bold fonts are the [video’s] highlights, which allow me to rapidly recognize that “diarrhea” belongs to “visceral abdominal pain”. Further, what is “visceral abdominal pain”? That is, it’s “stomach + intestine”, and something in the intestine triggers the pain receptors, that’s why I feel pain. By doing so, I can see the focus at a glance ... Other unmarked contents are secondary knowledge that can be considered common sense, and hence there is no need to mark them.”

P12 also detailed how font-color or font-size of BNote can be used to distinguish video’s concepts, e.g. using cyan font to make a glossary of important concepts, and small gray font for explanations of the concepts. These strategies above can be called “spotlighting”, i.e., using different visual cues (e.g., color highlights) to emphasize information, which has been proven to improve the salience of informative or stimulative content in a document (Almahmoud et al. 2022). As such, this form of textual notes makes the structure of video more visible.

In summary, users were able to surface the video’s structure by using a variety of BNote techniques. That is, the textual note, combined with BNote’s functions such as screenshot and time-tag, provides an easy and visually appealing way to see the structure and navigate the video. Although video annotations (Monserrat et al. 2013; Klefodimos and Evangelidis 2016; Lu et al. 2018) and timestamp-based navigation (Fu et al. 2006; Mu 2010) can structure and navigate the video to some extent by highlighting key points, they are usually incomplete, scattered, and intertwined with the video.

5.2.2. *To supplement content gaps in videos*

Videos on social media are mostly generated by ordinary users, and as a result, their content may not be as clearly presented as professionally produced videos specialized for learning. In this context, not merely to transcribe what is said from a video, note-taking is also commonly drawn on to complement the video stream in a way to make it more organized and complete. We discovered that users spontaneously endeavored to improve, replenish, and expand content that the video lacks, through a variety of source avenues, supplementary methods, and screening strategies.

Very often, participants attempted to supplement the video content with more detailed textual descriptions using BNote’s textual functions, as shown in the case of P10’s cooking note:

“In preparing dishes, for example, the speaker didn’t say how to cut onions. She didn’t say anything and just started cutting. So, I wrote how to cut it in the note. Also, the whole process of frying vegetables was not fully described, [or] she might [only] describe a part of it. Anyway, I followed the steps in the video and added a text description to it.”

P9, who was watching physics videos to prepare for the upcoming semester, sometimes utilized BNote’s image uploading function to provide his own example when the video lecturer did not provide one or provided an example that was not easily understood.

Nearly half of participants reported leveraging relevant comments from the video's comments section as a source for complementary materials. P8 explained why he included two creatures not mentioned in a popular science biology video in his note:

"Someone in the comments area made memes about these two creatures, so I added them. In this video, Guan Chenchen (the Tokyo 2020 Olympic champion in balance beam) joked that XiaoLiang (the video uploader) looked like a "Tibetan Rat", and well, then a lot of people started commenting "Tibetan Rat", "Tibetan Rat", ... So, I added "Tibetan hamster" and "Moupin Pika" (both sound similar to "Tibetan Rat" in Chinese), which weren't mentioned in the video."

P11 detailed how she gleaned information from the comments to list evidence for a particular viewpoint not mentioned in a video analyzing "The Peach Colony", a very famous classical Chinese work:

"The No. 1 (reason why utopian ghost stories are untrustworthy) is that I saw a hot comment, saying he/she had read "The Peach Colony", "Doraemon", and other works, and believed these very good classics had been maliciously interpreted. So, for this classical Chinese work [analyzed in this video], malicious interpretation also seems to be a plausible reason ..."

In one popular science medical video, P15 noticed a comment with references provided by the video uploader himself, so he added these references to his note. Of course, there are inevitably comments with fake or misleading information (Zhang et al. 2023). We found that when integrating comments (i.e., collecting scattered comments and organizing them within the note), participants employed screening strategies to exclude low-quality comments. For example, P2 usually filtered out those with advertising feelings, or those simply for fun. On the other hand, P12 exhaustively collected the comments of one "summary representative"¹⁹ who had provided detailed summaries of a video on "Aesthetic Principle" but distributed them in scattered comments.

In addition to using video comments, participants also often complemented the video's content by locating pertinent information online. For example, P8 added information from the Internet that wasn't covered in detail in the video:

"The speaker didn't mention the features and other details of a creature (in this popular science biology video), so I went to Baidu to find relevant contents. For example, for the second creature ("indigo fruit"), the speaker discussed what it is, [but] he didn't talk in detail, so I looked up its related features on the Internet ... The video explained the reasons and principles of "Kangaroo bending waist", and I found the information on the introduction and origin [of Kangaroo] in the Baidu encyclopedia."

P15 added correlative contents from searching the articles of WeChat Official Accounts in his note on how to solve insomnia. In P14's note about cities and

¹⁹ Someone who is acknowledged by others as a video's summary representative, because he/she is skilled at summarizing the content of the video, in the form of comments or notes.

cultural heritage, he provided pertinent materials from his school's website that corresponded to the video's theme, including content about the history and growth of a city called Panlongcheng. P11 reported a case of how he combined Danmu and search engine to add materials:

"On Danmu, someone recommended that we read the "Peach Blossom Source Poems", so I went to find the hyperlink and posted it to my note ... The Baidu encyclopedia and links to this ancient poetry were added at the end ..."

Users even used BNote to complement the video by sharing their personal experiences and thoughts. For example, P6 is an anime fan and utilized BNote to share his experience behind the AMV (Animated Music Video) production he uploaded:

"In order to let the audience better understand the ideas behind my video creation, or what I wanted to express ... I wrote this note mainly for sharing my own experience, and my understanding of animation."

Participants also included personal feelings or insights, like appreciation for the video's speaker, or a desire for encouragement and discussion. For example, at the start of a note on "Aesthetic Principle", P12 stated:

"The speaker explains the course in a simple and understandable way, and I feel quite rewarded. If you like my note, you can collect it from my column. If you have any questions, I will be excited to discuss them."

To sum up, participants tried to fill in any content gaps in the video as much as possible. Not only did they do so using readily available information from the platform, such as video comments, or adding their personal opinions and thoughts, but they also proactively sought out and added materials from other online avenue they could think of, developing their own strategies to filter and gather additional information during the process.

5.2.3. *To substitute note reading for video watching*

Compared with a video stream, the note is seen as a media that can convey knowledge in a more concise form, which at times provides a more selective way of viewing by substituting video watching. P10 commented that a note combining screenshots and words was very intuitive to view:

"It looks quite intuitive. For example, to prepare the ingredients [for cooking], this picture can exactly depict the container containing ingredients as well as the spoon. [In this way], with picture and text together, it looks so intuitive ... Just like I said, how big is this spoon? It's something that could be difficult to explain in words. For example, I can't say it's a round spoon with a diameter of 3~5 cm, right? With the screenshot, [together with the text], I see the information intuitively."

P12 said, instead of watching the video, she could directly read pivotal information from the textual note, since "It (the note) is equivalent to translating the video to text, representing the knowledge in a more condensed form." P7 mentioned that the note was especially valuable to those who found it inconvenient, or were unable to watch the video. As such, with a mixture of picture and text in a static,

condensed, and spatial form, the note can be often utilized as a more lightweight way to replace video watching.

When review is concerned, while the video also works as a carrier of knowledge, reviewing notes is considered more efficient than re-watching the video again. When participants were asked how they reviewed the materials covered in the video, they answered that they often just reviewed the note directly instead of re-watching the video. P2 shared her experience:

“Almost always, when I saw something and thought it was useful, I used the screenshot function of BNote to put it inside the [private] notes. This way, if I need something [relevant], I can just look at my notes [that contains screenshots] without having to watch that video again.”

P9 reported that he went over his notes several times, instead of watching the video repeatedly to memorize something:

“I reviewed it (the note) several times and then remembered the important points. I mean, I got the important parts of the note into my head ... instead of watching the video again and again.”

While the cognitive effects of notes on knowledge review has been commonly reported (Bauer and Koedinger 2006; Lu et al. 2018), in the context of video-sharing platforms, we also found that participants commonly drew on the note as a shortcut to preview the video so help them decide whether to watch the entire video or not. As videos generated by users on social media span a wide range of topics (Rosenthal 2018; Tang et al. 2021), the note helps learners make efficient video choices on such a platform this way. For example, P13 reported that she usually read notes to decide whether or how to watch the video:

“It may take some time to watch a video, but if you can see the notes, it will be clear which part you want to watch the most. Then, you can focus on that part only [by clicking the corresponding time-tag in the note], so you can spend less time understanding what the video is about ...”

Meanwhile, P13 mentioned that she usually browsed the overall structure of other’s notes, and then decided to view the video if there were any points that interest her.

Also, although BNote was designed as a way to bind the note with the video, our participants deemed that the note could exist as a material for the video and yet independent of it, which is different from video annotation (Kleifodimos and Evangelidis 2016; Mu 2010; Lu et al. 2018). P3 said: “One advantage of BNote is that even if the original video disappears, the note I wrote can still remain.” BNote also works well as a memory aid (Lin et al. 2004) that is convenient to carry when participants need to put the video’s knowledge into practice. For example, P4 was practicing singing and dancing. A note with lyrics was helpful for her to practice singing, and movement screenshots helped her to practice dancing:

“I wrote down [the lyrics of this song] because it’s convenient for me to look at the lyrics and practice singing it out on my own ... I learn dancing on the platform,

and when I came across the repetitive movement like this, I saved it as a screenshot [and thus used it] to follow the movements.”

Similarly, P10, who is interested in cooking, relied on her note whenever she wanted to cook the dish made in the video, instead of watching it again.

From the above cases, we can see that in many situations, including knowledge review, practicing knowledge from the video, and making watching decisions, participants often used the “easy to glance” and portability (Fernández Camporro and Marquardt 2020) nature of the note to replace actual viewing. In this way, although both the video and the note can work as knowledge carriers, the note, as a lightweight alternative for the video, is often preferred, which provides a more selective way of viewing and learning knowledge on social media.

5.3. Scaffolding a social process for learning motivation and organization

Bilibili is essentially an online community (Lu et al. 2017), where members come to together to watch and learn from videos (Wang and Zhang 2021; CCTV.com 2019; Lee et al. 2021). That is, video watching and learning are not in isolated forms, but rather, embedded within the social process of the community. Our study also revealed the social function of note-taking and sharing, in which participants’ note-taking and sharing practices are similarly shaped by the social process in multiple ways. Specifically, note-taking and sharing scaffold a sharing and collaborative creation process for users to get more motivated and self-disciplined, and more organized in their learning, by sharing notes with the community, collectively creating notes, and communally augmenting their note-taking abilities.

5.3.1. *To be more motivated and self-disciplined via sharing notes*

On a platform dominated by entertainment and socialization, like Bilibili, it is especially important for learners to use the power of the other members (i.e., their peers) within the community to stimulate their learning, as they lack supervisory support from outsiders (e.g., instructors, streamers). Here, we noticed that note-sharing enabled them to use this social force. Specifically, the community members who shared their notes on the platform served as role models, motivating other users to start note-sharing as well. After having been motivated by other members’ notes to take and share their first note, our participants had it in mind that their notes were also to be shared and seen by others, and perhaps, in turn, to be regarded by someone else as role models too. This then gave them an extra incentive to be more self-disciplined and accountable (Willett et al. 2015). For example, P1 made a conscious effort to use the platform’s public audience as a force to push herself to ensure the quality of her own notes and to be more focused on learning Go Language programming:

“I hoped I could be more focused when watching the video for learning ... I felt using BNote to take notes for the public gave me a sense of being monitored, which made me take it more seriously. While writing this note, I had envisaged making

it public, so I felt more responsibility for my note, and I couldn't just scribble anything. In a sense, note-sharing served as a function of monitoring, with which I was forced to take it more seriously during the whole process."

The note clock-in activity organized by the platform was also used to help participants be more engaged in learning. For instance, P13 described how the activity helped her stay focused and engaged in studying drawing, which she had always meant to do but had yet to truly begin:

"I shared notes not only to win this clock-in prize, but also to get myself moving, learning, and finding my life goals ... Yes, it's true, I was so lost after graduation that I didn't know what to do. I wanted to study, but I wasn't motivated enough. So I participated in the clock-in activity to keep myself engaged ... It did get me started and making progress ... Right! I've been relying on the activity to force myself to watch tutorials and learn drawing, and I haven't watched any entertainment videos since then."

Moreover, the approval of shared notes received from others was the most common motive (mentioned by 9 participants) for the continued learning and contribution of notes, more than the economic benefits as mentioned in existing studies (Ding et al. 2022). For example, P7 saw others' positive comments as an affirmation of the quality of his hard work, which then pushed him to keep studying English and sharing his English notes during the summer break:

"Yeah, this is my [greatest] motivation to continue writing [and sharing] this note and learning [English words] ... When I saw someone find it very useful, or someone urged me when to update my note, I felt quite worthwhile. The comments made me feel motivated to memorize, write down, and share these English words every day."

Similarly, P8, who is quite interested in popular science, said his motivation for sharing notes was to gain community acknowledgement and this acknowledgement further motivated him to share more quality notes:

"My main motivation is to get more people's attention, and for that, I have made a big effort to take and share notes ... [Through sharing quality notes], now I have a lot of people following me, and they often send me private messages or mention me in the video comments area, calling on me to take notes for some [popular science] videos. It feels like more and more people are recognizing me. Look, I was mentioned and praised by LuoXiang (a famous law science uploader) in his latest video ... Recently, the platform also granted me an outstanding note-taker certification, which was truly an honor for me."

As shown here, BNote, together with the clock-in activity organized by the platform, was consciously utilized by learners as a social force to keep themselves more motivated, focused, and engaged in learning on social media by sharing quality and regular notes.

5.3.2. *To collaboratively create notes as a self-organized community*

We found that note-taking was also a collective, not merely individual activity, in that people worked together to make the shared notes better and more complete, as similarly found in previous work (Kam et al. 2005; Silvestre et al. 2014). In particular, if learners noticed that someone had taken a note for a video, and if the note was an excellent one, they just made use of it instead of creating a new one. On the other hand, if they found that a video was worth note-taking, yet no note had been taken or if something was missing from the existing notes, they would supplement it by creating a new note or adding new information on their own. From the study, it appears, these are the tacit rules users follow, and it is these rules that prompt them to spontaneously and collectively complete and improve notes in an organized manner. P10, who often watched popular science videos, described such a situation:

“For example, I watched popular science videos, such as those uploaded by XiaoLiang (a famous biological science uploader) and TuBaGe (a famous medical science uploader). I might watch them after the video had probably been uploaded two or three days. In this case, someone else usually had taken notes, and it was nice for me to simply view or collect these notes. I didn’t have to do it myself anymore in this case.”

P11 similarly said that if there were already detailed notes provided, she would just read them instead of creating new ones.

So it is a common practice that before taking notes themselves, participants check whether there are any shared already, and how complete they are. P11 even checked whether there were any good comments before she started to make a note:

“When I saw this video [on “The Peach Colony”], I first turned to the comments section to see if there were any high-quality comments, if anyone had summarized it, or if there were any representatives’ comments. After seeing no one had made relevant comments, I opened the note list, and found no one had made any notes either ... After a quick browse of the video, I thought it was clearly stated. So, I started taking notes right away ...”

In one of her notes on literary theory, P12 reported that she added some content that she believed was important but had not yet been included in others’ notes:

“In the first half of the video, the speaker talks about some cutting-edge content [before starting the formal introduction], but I noticed that no one had documented this segment. Others began taking notes directly from the introduction, so I decided to write it down as the starting point of the course.”

When seeing that others had made simple notes with merely a outline, P12 decided to supplement them by providing more content:

“Take the [outlined] note for “Aesthetic Principle” as an example. If we didn’t understand what the video speaker explained beforehand, it would be difficult to read. So, based on that, I supplemented it ... That is, I added crucial contents, examples, and logical transitions from the video [in my note] based on the outline.”

For many, using others' notes and making notes for others are a form of mutual help in the community. P9 explicitly said that because he derived value from others' notes, he also made notes for others:

"I started watching the video (about physics science) from the first chapter, but only started making notes later, as someone else had made notes for the first few chapters. So, I didn't need to repeat it ... If there are notes already, I needn't take my own note and can just use their notes to memorize things. At the same time, the notes I took could also help others in this way."

P3 used the textual feature of BNote to transcribe the lyrics of songs to share mainly for her singing friend:

"It was mainly because I knew a friend who often uploads singing videos, and I was actually helping her to transcribe this song. This way, she didn't need to do it [and could sing this song by simply reading my note]. That was just a help between friends."

As seen from the cases above, note-taking on the platform was such a collective practice, where users spontaneously and collaboratively created and improved notes in a self-organized manner within the community.

5.3.3. To learn from each other to ensure high-quality notes

By using others' notes and sharing their own, users have developed a social process in which they learn from each other about note-taking. This can be viewed as a more cost-effective way to cultivate note-taking skills, when compared to specifically designed gamification techniques (Deniozou et al. 2020). People learn by practicing and reproducing the observed models' behaviors (Rumjaun and Narod 2020), in this social media context, means people can use others' shared notes (especially high-quality ones) to enhance their own note-taking abilities. More specifically, participants paid attention to others' notes, compared the difference, e.g. in quality, with theirs, then self-reflected and adjusted their notes, thus learning and internalizing the note-taking skills from others to strengthen their own.

When asked why they viewed others' notes, 12 of 15 participants said that it was for learning—learning note-taking skills in addition to the video's materials. This is not exactly the same as peer learning during the livestreaming, where note-takers view others' notes mainly to facilitate their understanding of the video (Lu et al. 2018). P14 described it this way:

"I learned [from] others' note-taking skills, including what content was written down, what content was added, or other similar skills like this. I liked to see how they took notes, or the skills they used to make the notes more understandable, and then tried to master these skills myself."

P11 also tried to scrutinize others' notes to improve her own:

"If others had taken notes, I usually looked at theirs to see what differences there were between their notes and mine, whether there were any points to learn, and what [I] could use to improve it."

Similarly, P9 drew on others' notes to see whether there was anything missing, such as structure and organization, in his notes, and gradually improved these skills so the notes he took could be more acceptable to others:

"I learned from them (others' notes on the knowledge of different subjects) to improve my own notes, such as the focus, labeling, and layout. By doing so, I can gradually align myself with the public interest."

To pick up note-taking skills, participants used different strategies. Some viewed others' entire notes, examining the structure, focus, and details, as P13 did: "First, I scanned the overall content. Then, I looked closely at the content that arouse my interest." P1, on the other hand, assumed that all she needed to do was locate the content she needed:

"I only needed to take in the information that was beneficial to me [and added it in my note], right? Once I found what I wanted, I wouldn't pay attention to any extra information."

Others (9 of 15 participants) went out of their way to find high-quality notes from which to learn, e.g. how to better organize their own. They regarded viewing high-quality notes as an effective way to enrich their note-taking abilities. While our participants had diverse perspectives on the criteria for measuring note quality, they all agreed that the number of Likes was enough to reflect a note's quality, and most adopted the "Like" feature as the preferred way to rate others' notes. For example, P8 relied on the number of Likes to identify high-quality notes:

"I'd go to see who has recently released notes based on the number of Likes. I'd see how well others wrote ... For example, I viewed what forms others used, such as how the title was written."

P13 marked the time segments correlating with knowledge points at the beginning of a note for a video on common cold, so to make her note's contents clearer. She applied this strategy because it was used by a popular note-taker she was particularly following (P8 actually), who was a "summary representative" on the platform:

"Because I've used others' good notes for reference, and saw one note was taken like that ... It was from a "summary representative", who seems to have written a lot of good notes [with lots of Likes] and taken them very seriously ..."

P2 expressed her desire to obtain more high-quality notes for reference, but did not find many of them.

From the above quotes, we can see that users consciously paid attention to role models (i.e., good note-takers), whose work (i.e., note-taking) was highly evaluated by other members in the community through social feedback, such as Likes. By referencing and reproducing these role models' note-taking patterns (e.g., structure, organization), they improved the quality of their own notes.

Taken together, note-taking and sharing have been collaboratively and spontaneously carried out by the community of members. Through note-taking and sharing on the platform, it provides a note sharing and collaborative creation process to inspire self-discipline and organization for learning.

6. Discussions and implications

In the preceding sections, we identified emerging practices around note-taking and sharing on Bilibili, especially in their surfacing the structure of user-generated videos for learning and scaffolding a social means for self-disciplined and organized learning (Figure 5), indicating the potential of note-taking and sharing to cultivate a learning space in such informal and general video-sharing environments. Below, we will discuss our findings in relation to prior literature, and design implications for building an effective online learning space.

6.1. The new roles of note-taking and sharing

This research inquires into the roles note-taking and sharing play in learning on video-sharing platforms. While note-taking and sharing have been extensively examined, they are mainly explored in a context specialized for learning, e.g., classroom lecturing, MOOCs, and recently live-streaming based online teaching. In this paper, by focusing on video-sharing platforms, we uncovered new roles note-taking and sharing play in a context not dedicated for learning. As seen in our study, in this particular context, note-taking and sharing are in many ways drawn on to alleviate the shortages and at the same time take advantage of the platform to cultivate a space for learning, by providing a structure to the less structured video stream, as well as by leveraging the social forces to enable more motivated, self-disciplined, and organized ways of learning.

While the video can present the learning materials in a more vivid and rich form, it suffers from the relative invisibility of structure, which note-taking is used to alleviate. According to (Zacks et al. 2001; Truong et al. 2021), people mentally perceive the video as being composed of hierarchical structures. Through note-taking using BNote, users are able to externalize the perceived structure of the video, and identify and supplement the missing information in the structure, making it easy for people, including note-takers, to comprehend and use the externalized structure to facilitate their learning processes. Unlike note-taking on repositories such as GitHub (Zagalsky et al. 2015; Glassey 2019), which host video content from external platforms such as YouTube, BNote is embedded within Bilibili. BNote makes it easy to seamlessly integrate with other features such as annotations or comments on the platform. At the same time, while video annotations and comments can also structure the video by highlighting key points (Ain et al. 2022; Kim et al. 2014; Mirriahi et al. 2018; Lu et al. 2018; Yang et al. 2020; He et al. 2021; Yarmand et al. 2019; Dubovi and Tabak 2020), they are often short and even scattered, or tightly intertwined with the video, or related to dialogues such as discussion, emotional expression, and socialization (Zhang et al. 2023; Lee et al. 2017; Dubovi and Tabak 2020). However, the note, taken using BNote, typically contains long, complete, and coherent content combining texts and pictures, more so than multi-media contents created in a reactive manner during live-streaming based learning (Lu et al.

2018, 2021; Zhou and Farzan 2021). It can work as a new form of user creation that exist independently of the video to substitute video watching for learning. The existence of this integrated, independent, and coherent form is valuable for video-based learning, e.g., as a preview to the video, as a form that is easy to carry and review, and as an alternative for video watching. Here, both the videos and the notes serve as recordings of knowledge on the platform; yet, the role of note-taking is not merely about the recording or storage as one of the main needs in traditional learning settings (Kiewra 1989; Exposito et al. 2017), but also provides a spatial visual form to make the structure of video more visible and to complement video watching.

Moreover, note-sharing is also used to turn a social media platform, into a learning environment by leveraging social forces for motivation and self-discipline, and socially organized note production. Unlike specialized learning contexts such as MOOCs (Zhu 2022; Celina et al. 2016), video-sharing platforms, like Bilibili, were not originally designed for learning, but mainly for entertainment and socialization. Learners can easily become distracted by the various relaxation options provided on these platforms (Rosenthal 2018; Tang et al. 2021). Additionally, users on these video-sharing platforms usually learn at their own pace, with video creators/uploaders acting more as knowledge “sharers” than “facilitators” (e.g., instructors or streamers) involved in teaching, support, and guidance. With little external support, these learners especially need self-discipline (Wang and Zhang 2021; Lee et al. 2021). As such, conducting learning in this social media context poses more challenges for users to keep focused and self-disciplined, as the use of social media itself can be easily distracting. However, as shown in the study, by viewing others’ notes and sharing their own, our participants made the learning activity more visible, and invited extra social forces to keep them more engaged, beyond the mutual observation and imitation mentioned in existing studies (Rumjaun and Narod 2020; Gautam et al. 2023).

To some extent, with BNote, learning-oriented communities of practice (CoP) (Wenger 1999; Blackmore 2010) emerged in such a video-sharing environment, where people share notes and engage in collective learning around their note-taking and sharing practices. Here, we witnessed that participants were inspired to share quality notes by observing and following the behaviors of other note-takers, particularly those they regarded as role models through social recognition such as Likes and positive comments. In such video-sharing contexts, note-taking and sharing help learners form, affirm, and invest their social identity—engaging with each other, motivating one another, and being mutually accountable for learning. By generating and sharing notes as a new way of participating in communal activities, a new identity emerges and is shared, acting as a social force to further inspire them to be more focused on learning. This new function of note-sharing differs from that on live-streaming platforms, where people used the shared notes mainly for recording important stream moments, providing feedback, and collaborative creation (Lu et al. 2021; Yang et al. 2020; Lu et al. 2018). Nor is it the same as those

on platforms such as GitHub for educational purposes, where users shared notes and other materials as a way to submit assignments, gain help from teachers, and join discussions with peers (Zagalsky et al. 2015). By contrast, this motivating and identity-forming role of note-sharing would likely be less significant in specialized learning contexts, where learning is more taken for granted.

CoP highlights that members' actions are shaped by self-organized collaboration, characterized by shared practices, collective engagement, and peer support, rather than external directives (Wenger 1999; Blackmore 2010). Such self-organizing behaviors are most clearly seen in how participants spontaneously engaged in collective note-taking and sharing on Bilibili, without external agencies dividing and organizing the work. The majority of users initially noticed the BNote feature and were motivated to take notes after seeing other members' notes shared on the platform, not through the platform's official notice. Throughout the note-taking and sharing process, participants naturally distributed their efforts in contributing original notes, utilizing peer power to commit to note-taking and sharing, improving their notes upon others, or directly making use of others' notes, as such to ensure each video that is worth note-taking has good notes associated with it.

This dynamic process is not unlike the classical example of "soap bubble" in Gestalt theory (Wertheimer 2010). According to Gestalt theory, most acts unfold dynamically through an internally determined organization, from forces originating inside, much like the "soap bubble" (Wertheimer 2010): it starts as a deformed membrane and then, following the interaction law, reacts to local forces via soap particles, thus rendering the whole structure into a spheroid. The final form of the soap is the result of dynamic self-distribution, not of artificial constraints, which guarantees the thickness of the membrane is uniformly distributed throughout the entire structure. These dynamics of forming an equilibrium driven by internal forces are manifested in the note-taking and sharing behaviors around BNote. While the initial change might be triggered by an external factor, such as the introduction of BNote or the incentives brought by the clock-in activity, it is the local forces coming from within the community that cause the largely uniform distribution of quality notes throughout the platform and form an equilibrium. This is different from the collaborative note-taking and sharing observed in synchronous learning settings, such as live-streaming and classroom lecturing, where note-taking and sharing were inspired and guided by streamers/moderators or instructors (Lu et al. 2018, 2021; Yang et al. 2020; Glassman et al. 2015; Kam et al. 2005), not in such a spontaneous and self-organizing manner to achieve note coherence and equilibrium.

6.2. Implications for design

Supporting Efficient Note-Taking and Video-Based Learning For video-based learning as shown in our study, notes serve as a spatial form to complement videos by providing a structure to the stream and thus support more selective learning. This is due to the way people naturally perceive the observed video as being segmented

into hierarchical structures (Zacks et al. 2001; Truong et al. 2021). It suggests that for video-based learning, particularly in settings where the video's structure is not obvious, we can help facilitate such a process by automatically extracting the structures from the video to provide users with a foundation to start with when taking notes, e.g., automatically extracting a video's structural elements through video transcript analysis. Also, based on the observation that users draw on content from video comments or other sources for note enrichment, we could facilitate such a process as well. For example, we could display special badges for both quality and unreliable comments, allowing users to quickly identify the high-quality comments and, meanwhile, avoid integrating false or misleading comments into notes. In addition, we can use the notes, in addition to conventional video metadata, such as titles, tags, and profiles, to help search for videos as learning materials, since the notes can better reflect the overall structure and richer content of the video. Finally, while the note is a separate and independent existence from the video, we can still provide a means to integrate it with the video to better combine the benefits of both if needed, e.g. by adopting forms similar to annotation-based navigation (Chatti et al. 2016) or Danmu/time-anchored comments (He et al. (2021); Yarmand et al. (2019); Lee et al. (2015)).

Leveraging Social Forces for Learning What we see here is that in informal environments like video-sharing platforms, where no instructors/streamers or other facilitators are involved, it is especially important to have communal support for members to inspire each other. As such, it is important to make their learning activities more visible and trackable (McMillan and Chavis 1986; Sun et al. 2018; Fang et al. 2021; Rong et al. 2023), as a way for peers to motivate and hold accountable to each other. Besides the notes themselves, we can track and make more visible members' note-taking efforts and their contributions to the community, such as by displaying "how many notes you have taken", "how many people have referred to this note", or "how many people have recommended this note", and so on. Moreover, the platform could consider allowing viewers to give labeled feedback on shared notes, such as "complete", "elaborated", and "organized". This way, users could better track their efforts, become more aware of each other's work, receive digital feedback for their efforts, and thus get more motivated and engaged in learning.

Facilitating Collective Note Co-Production From this study, we learn that members spontaneously and mutually help, complement, and build on each other's work. Other similar spontaneous behaviors were also observed in such social media contexts. For example, existing studies have found that users voluntarily supplement and regulate information of videos (He et al. 2021), offer answers and suggestions to help other learners (Lee et al. 2017), and provide feedback to content creators (Ding et al. 2022) using video comments on video-sharing platforms such as YouTube and Bilibili. These behaviors stem from the "participatory culture"

on social media (Zhang et al. 2023; Wu et al. 2018; Lee et al. 2017), where users have a collaborative spirit as contributors, rather than being passive consumers of videos as in specialized learning settings. Therefore, we can further facilitate such a process, e.g. by allowing members to indicate which videos they want notes on but probably do not have time to do yet, and making it easier for the members to see what notes are highly wanted in their area, in the form of dashboard or others, so that they can contribute when they have time. In addition, apart from sharing notes, we can offer mechanisms to support the collaborative creation process, e.g. by providing permission for users to co-edit a note, and showing who contributed in what way so members will be appropriately credited. Finally, we can facilitate the social approaches for members to learn from others' notes in a cost-effective way, such as sorting all shared notes by the frequency of their references/recommendations, not just by the notes' release time. In this way, it can reduce the time peers spend seeking out high-quality notes as templates to improve their note-taking skills.

7. Limitations and future work

While we reported our findings from the interview with a variety of participants who took and shared notes on Bilibili, this study has several limitations.

First, the vast majority of our participants were young students or recent graduates. While young students or recent graduates are the main user population on the platform, it would still be valuable to cover populations of other ages, occupations, and influence. Second, due to our sampling strategy, we could only find participants who had shared notes. We were unable to locate those who just read notes but never took one and those who had taken notes but never shared them. The note-taking and sharing practices of these people might significantly differ from our samples. In our study, we had participants who had only made one note but read others' multiple times and those who took many notes but only shared one, which could allow us to have a glimpse of these users, although more such users might be valuable. Third, our interviews with participants occurred during the early stage (less than 6 months) of the BNote feature's official deployment. As a result, the number of notes made by participants was relatively small. Within such a short duration, some of the note-taking and sharing interactions and practices might not have become regular or stabilized yet. In the future, it would be helpful to study for longer periods of time (e.g., more than 6 months) to observe any differences. Finally, our qualitative study was based on only one video-sharing platform. Future research could look into other platforms to see how some of the findings could be generalized broadly.

All of the aforementioned limitations may produce biased samples. Interview studies with more varied samples or large-scale surveys could be expected to avoid these limitations, help corroborate our findings, and further generalize them to all video-sharing platforms dominated by entertainment and socialization. To get a

more holistic understanding of digital note-taking and sharing practices on Bilibili and social media in general, future work could investigate the note-taking and sharing practices across diverse age ranges, social statuses, and degrees of practice.

8. Conclusions

In recent years, video-sharing platforms have been increasingly used to support learning, and the note-taking and sharing feature is one such example that makes the platform support for this practice more explicit. In this paper, we were interested in why and how users take and share notes and what roles note-taking and sharing play in this social media environment. To this goal, we conducted a qualitative study based on Bilibili, which had launched its note-taking and sharing feature, BNote. The finding revealed that note-taking and sharing are used to cultivate a space for learning on the platform, by structuring, supplementing, and substituting the user-generated video as well as through the sharing and collaborative creation process collectively carried out by the community. We highlighted the distinct roles note-taking and sharing play in learning on video-sharing platforms—different from specialized and teacher/instructor-facilitated learning settings, e.g., making the structure of user-generated videos more visible, and scaffolding the social forces for motivation and self-discipline. On this basis, we further understood such spontaneous, dynamic, and self-organizing nature of note-taking and sharing practices on social media. We ended by providing several implications to better support a learning space, including supporting efficient note-taking and video-based learning, leveraging social forces for learning, and facilitating collective note co-production. Through these means, we hope we can maximize the potential of note-taking and sharing in cultivating a learning space on informal environments such as video-sharing platforms.

Author Contributions

Fangyu Yu was responsible for design of the work, data collection, data analysis, and writing the main manuscript. Xianghua (Sharon) Ding critically guided and revised the whole process. Peng Zhang made suggestions of the manuscript. Tun Lu and Ning Gu approved the version to be published. All authors reviewed the manuscript.

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Availability of Data and Materials

Not applicable.

Declarations

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

Not applicable.

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