

Student Perceptions of Bullet Screens in Pre-Clinical Pharmacology: Acceptability, Effectiveness, and Entertainment Value

Sanne J. de Vries^{1*}, Mark L. van Dijk¹

¹Department of Clinical Pharmacy and Pharmacotherapy, Faculty of Science, Utrecht University, Utrecht, Netherlands.

*E-mail ✉ sanne.devries@gmail.com

Abstract

Insufficient interaction and communication in pharmacology instruction—particularly after the outbreak of coronavirus disease 2019 (COVID-19), which forced rapid transitions to online teaching in medical schools—have resulted in suboptimal educational outcomes. To enhance learner engagement and interaction in both distance learning and face-to-face settings, innovative and interactive teaching strategies are urgently needed. Bullet screens were incorporated into pharmacology classes. Subsequently, a questionnaire survey was administered to first-, second-, and third-year pre-clinical undergraduate medical and nursing students at Shanghai Jiao Tong University School of Medicine between November 2020 and March 2022. The core characteristics, pedagogical effectiveness, and entertainment aspects of bullet screens were assessed. Responses to both structured and open-ended items regarding perceived advantages, limitations, and overall impressions were coded and analyzed, with comparisons conducted between medical and nursing student groups. Regarding fundamental attributes, bullet screens showed strong student acceptance, and this innovative format effectively facilitated classroom interaction. From the perspective of teaching effectiveness, bullet screens appeared to encourage deeper cognitive engagement. At the same time, students more often used bullet-screen messages to show agreement or support rather than to contribute new ideas or express dissenting opinions. The entertainment component of bullet screens was prominent. Differences observed between medical and nursing students may have been related to variability in idea generation, suggesting that appropriate guidance on bullet-screen usage is necessary. Bullet screens have the potential to be widely adopted as a supplementary instructional method to strengthen teacher–student interaction in both in-person classes and remote learning environments. They represent an engaging and useful aid in pharmacology education; however, several aspects of this tool require refinement before large-scale implementation.

Keywords: Bullet screen, Pharmacology education, Pre-clinical undergraduate, Survey study

Introduction

Pharmacology education serves multiple disciplines, such as clinical medicine, nursing, dentistry, and pharmacy. Within medical training, a solid grasp of pharmacology is essential for appropriate pharmacotherapy and accurate prescribing practices [1]. Nevertheless, pharmacology is a challenging subject that encompasses extensive theoretical content, including

mechanisms of drug action, clinical indications, and adverse effects. The curriculum is dense and conceptually abstract, and medical students have reported a need for increased pharmacology instruction [2, 3]. Similarly, pharmacology education in nursing programs has been described as inadequate [4, 5]. Consequently, existing approaches to pharmacology teaching require optimization to improve learning effectiveness. Active instructional methods combined with collaborative learning have been shown to promote idea exchange and yield superior educational outcomes compared with conventional lecture-based teaching [6]. In this study, we explored the introduction of bullet screens into classroom teaching to enhance interaction and thereby improve student learning.

Access this article online

<https://smerpub.com/>

Received: 08 September 2024; Accepted: 07 December 2024

Copyright CC BY-NC-SA 4.0

How to cite this article: de Vries SJ, van Dijk ML. Student Perceptions of Bullet Screens in Pre-Clinical Pharmacology: Acceptability, Effectiveness, and Entertainment Value. *Ann Pharm Educ Saf Public Health Advocacy*. 2024;4:210-8. <https://doi.org/10.51847/qa9bnzgATq>

A bullet screen is a digital function that enables viewers' real-time comments to scroll across a display like projectiles. Most Chinese university students favor media content accompanied by bullet-screen comments due to their subcultural appeal, simplicity, immediacy, and, notably, their "social viewing" nature [7]. For young learners, bullet screens facilitate self-expression and identity formation. These features align closely with the objectives of contemporary educational reform [8, 9]. Despite this, the application of bullet-screen technology in medical education has been limited. When submitting bullet-screen messages, students often experience a sense of simultaneous participation with peers. Through the WeChat platform, bullet screens can be activated by scanning a Quick-Response code and sending text, which then appears instantly over presentation slides. Student anonymity is preserved, encouraging participation. As a supplementary teaching instrument, bullet screens are easy to use and can increase learner involvement. We hypothesized that their use would enhance student interaction, potentially exerting a positive influence on learning, consistent with evidence supporting active learning strategies [10-12].

In our pharmacology course, bullet screens were employed as an interactive medium to pose engaging and reflective questions to medical students. Clinical case scenarios were integrated to prompt consideration of patient conditions and rational medication use. Questions addressing key concepts and common pitfalls were included, along with prompts encouraging exploration of advanced pharmacological knowledge. Multiple-choice questions were also used for reinforcement. To assess student acceptance, perceptions, and the influence of bullet screens on teaching quality and classroom dynamics, we conducted this survey study. Differences in application and perception between nursing and clinical medicine students were also examined. Based on the findings, recommendations were proposed to further optimize the use of bullet screens in pharmacology education.

Materials and Methods

Study population

This research was performed at Shanghai Jiao Tong University School of Medicine. Participants were medical and nursing undergraduates enrolled in their first, second, or third academic year during the period from November 2020 to March 2022. Teaching activities

were delivered through both online platforms and conventional on-site classrooms. Ethical approval for the study was granted by the Ethics Committee of Shanghai Jiao Tong University School of Medicine. An online questionnaire was developed using the www.wjx.cn platform (questionnaire created on November 10th 2020), and access to the survey was provided via a link embedded in the lecture PowerPoint slides. Students were invited to complete the questionnaire once, immediately after their first experience with a bullet-screen-assisted class. Participation was entirely voluntary. A total of 310 medical students and 70 nursing students attended classes using the bullet screen. Of these, 127 questionnaires were returned; responses from 16 students were excluded because they had not used the bullet-screen function. The final response rate was 33.4%.

Survey design and implementation

The questionnaire comprised 17 items, with only one response permitted per item. A five-point Likert scale was applied, assigning 5 points for "strongly agree," 4 points for "agree," 3 points for "neutral," 2 points for "disagree," and 1 point for "strongly disagree." Mean values were calculated to obtain the predicted score for each item. The evaluation focused on three domains of bullet-screen use: basic characteristics, educational impact, and entertainment value.

Statistical analyses

Expected scores for individual questions were derived from average values. Descriptive analyses were presented as means with standard deviations or as frequencies and percentages, depending on the data type, using IBM SPSS Statistics software (version 22.0; IBM Corp., Armonk, NY, USA). Internal consistency of the structured Likert-scale items was assessed by computing Cronbach's alpha, also using IBM SPSS Statistics software (version 22.0; IBM Corp., Armonk, NY, USA). Statistical testing procedures and the construction of percent stacked bar charts were conducted with R version 4.1.3 (<http://www.r-project.org/>).

Ethical considerations

Two key strategies were adopted to ensure that students could provide honest feedback without fear of negative consequences. First, the survey was conducted anonymously, and no personal identifiers or names were collected. Second, participation was optional. Individuals

responsible for data collection were unable to identify which students completed the survey. At the time of dissemination, students were clearly informed that the questionnaire was anonymous, voluntary, and that their responses would not be associated with their identities or academic evaluations.

Results and Discussion

Between November 2020 and March 2022, 111 students participated in classes incorporating bullet screens. The survey demonstrated strong psychometric properties, with a Cronbach's alpha of 0.85 (95% confidence

interval 0.8 to 0.9) and a Kaiser–Meyer–Olkin (KMO) value of 0.81 ($P < 0.001$), indicating high reliability and validity. Among respondents, 25 were male (22.5%), and 86 were female (77.5%). Demographic characteristics are summarized in **Table 1**. Of the participants, 55 students (49.6%) were enrolled in clinical medicine programs, while 56 students (50.5%) were nursing majors. The sample included 4 first-year students (3.6%), 81 second-year students (73.0%), and 26 third-year students (23.4%). Most respondents (88 students, 79.3%) were aged 18–20 years, whereas the remaining participants were between 21 and 23 years old.

Table 1. Demographic characteristics of participants

Characteristic	Total Participants	Clinical Medicine Majors	Nursing Majors
Total	111	55 (49.6%)	56 (50.5%)
Gender			
Male	25 (22.5%)	22 (19.8%)	3 (2.7%)
Female	86 (77.5%)	33 (29.7%)	53 (47.8%)
Age Group (years)			
18–20	88 (79.3%)	32 (28.8%)	56 (50.5%)
21–23	23 (20.7%)	23 (20.7%)	0 (0.0%)
Academic Year			
Year 1	4 (3.6%)	4 (3.6%)	0 (0.0%)
Year 2	81 (73.0%)	25 (22.5%)	56 (50.5%)
Year 3	26 (23.4%)	26 (23.4%)	0 (0.0%)

Perceived overall advantages of the bullet-screen classroom

Study findings indicated that the bullet-screen classroom was well accepted by the 111 pre-clinical students, and that this innovative instructional approach was associated with enhanced classroom interaction (**Figure 1**). Given the widespread familiarity of bullet-screen technology among Chinese university students, nearly all respondents (107/111, 96.4%) agreed or strongly agreed that operating the bullet screen during class was easy, and 92 students (82.9%) reported that it was convenient. The majority of participants (96/111, 86.5%) considered the approach beneficial. The interactive experience provided

by the bullet screen was rated as highly engaging by 98 students (88.3%). In total, 95 students (86.5%) agreed or strongly agreed that bullet-screen use increased classroom participation. Additionally, 84 students (75.7%) felt that bullet-screen comments were an effective means of self-expression during lessons. Furthermore, 83 students (74.8%) agreed or strongly agreed that interaction through bullet screens promoted deeper cognitive engagement. These seven indicators were averaged to represent the positive dimensions, all of which achieved mean scores exceeding 4 (**Table 2**). Overall, the results suggest that bullet screens have strong potential for widespread adoption and application.

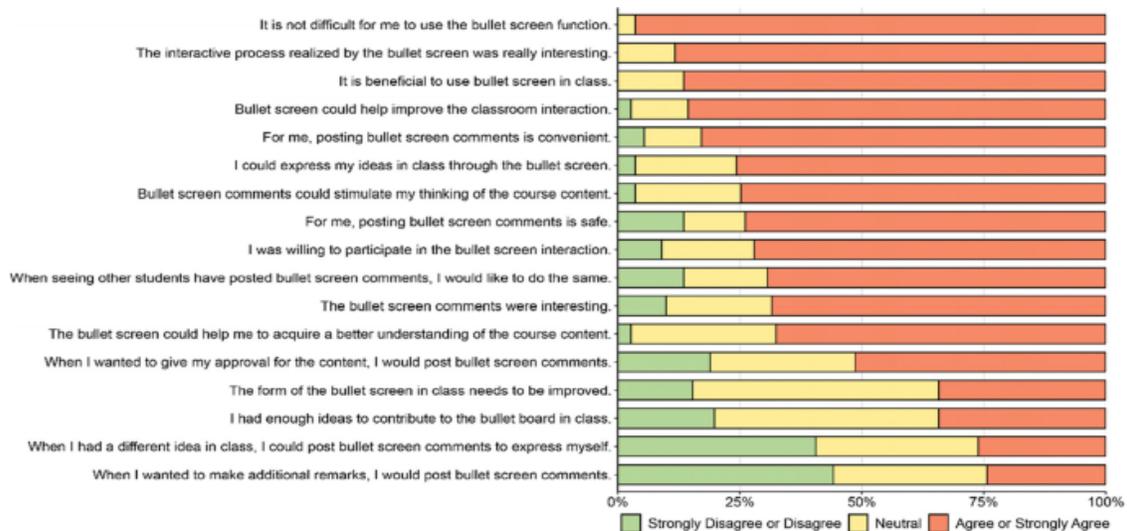


Figure 1. Student perceptions of bullet-screen value among pre-clinical students at Shanghai Jiao Tong University School of Medicine. Participants rated their agreement with 17 statements, with one response allowed per item.

Table 2. Overall scores for each survey item, ranked by score

Questionnaire Item	Score (Mean \pm s.d.)*
Using the bullet screen function is not difficult for me.	4.6 \pm 0.6
The interaction enabled by the bullet screen was truly engaging.	4.3 \pm 0.7
The bullet screen can enhance classroom interaction.	4.2 \pm 0.7
Utilizing the bullet screen during class is advantageous.	4.1 \pm 0.6
Posting bullet screen comments is convenient for me.	4.1 \pm 0.8
I was able to convey my thoughts in class via the bullet screen.	4.1 \pm 0.8
Bullet screen comments helped stimulate my thinking about the course material.	4.0 \pm 0.8
Posting bullet screen comments feels privacy-protecting to me.	3.8 \pm 1.0
I was eager to engage in bullet screen interactions.	3.8 \pm 0.9
Seeing other students post bullet screen comments made me want to do the same.	3.8 \pm 1.1
The bullet screen comments were enjoyable.	3.9 \pm 0.9
The bullet screen assisted me in gaining a deeper understanding of the course content.	3.9 \pm 0.9
When I wished to show agreement with the content, I would post bullet screen comments.	3.5 \pm 1.0
The format of the bullet screen used in class requires improvement.	3.3 \pm 0.8
I had sufficient ideas to share on the bullet screen during class.	3.3 \pm 1.0
When I held a differing opinion in class, I could use bullet screen comments to voice it.	2.9 \pm 1.0
When I wanted to add extra comments, I would post bullet screen comments.	2.9 \pm 1.0

Items with scores ≥ 4 were classified as positive attributes, while all other items were categorized as neutral or negative.

Responses to the remaining ten items reflected neutral or unfavorable perceptions among the 111 students. Concerns about privacy related to bullet-screen use were reported by 15 students (13.5%). Despite observing peers using the bullet screen, 31 students (31.5%) indicated neutral or negative willingness to engage with it themselves. Approximately 32% of respondents (35/111, 31.5%) believed that bullet-screen content was neither entertaining nor helpful for learning. Only 38 students (34.23%) agreed that they had sufficient ideas to

contribute to bullet-screen discussions. When holding alternative viewpoints during class, 29 students (26.13%) reported that they would express them via bullet-screen comments. Similarly, when wishing to add further remarks, only 27 students (24.32%) indicated that they would use the bullet screen to do so.

Perspectives on the basic properties of bullet-screen interaction in medical and nursing students

Pharmacology education is equally essential for nursing students; however, instructional approaches in this discipline are frequently overlooked [13, 14]. Insufficient teaching and the resulting weak grasp of scientific foundations have led many nurses to struggle with medication management and with effectively conveying drug-related information to patients [14]. For this reason, we implemented the bullet-screen tool among nursing majors to assess its educational impact. Furthermore, earlier research has shown that nursing students demonstrate lower average scores than medical students in several learning strategies, including peer collaboration, critical thinking, and management of study time and learning environments [15]. Accordingly, we aimed to examine learning outcomes associated with bullet-screen use among nursing students and to compare these findings with those of medical students, thereby identifying areas requiring further improvement.

Our findings indicated that nursing students were less inclined to post bullet-screen comments than students majoring in clinical medicine (3.7 ± 0.9 Vs. 4.1 ± 0.9 , $P = 0.02$) (Table 3). In addition, classroom dynamics appeared less active in nursing cohorts. When observing peers submitting bullet-screen messages, fewer nursing

students expressed willingness to participate in the same way (3.6 ± 1.2 Vs. 4.1 ± 0.9 , $P = 0.01$) (Table 3). Although students generally valued the opportunity to express themselves via the message board, we observed that both nursing and clinical medicine students lacked sufficient ideas to contribute during class discussions, with this limitation being more pronounced among nursing students (Nursing 3.0 ± 0.9 Vs. Clinical medicine 3.5 ± 0.9 , $P = 0.003$) (Table 3). For instance, instructors posed open-ended questions such as how to optimize insulin use, whether angiotensin-converting enzyme inhibitors might affect the prognosis of COVID-19 infection, and whether porcine heart transplantation could address end-stage heart failure. Some students were unable to independently formulate and articulate their own viewpoints. Compared with nursing students, those majoring in clinical medicine offered a greater number of perspectives. Additionally, many participants expressed concerns regarding bullet-screen privacy (Table 3). This issue may be related to limitations of the current bullet-screen software, which did not obscure profile images. Exposure of personal profile photos led some students to feel identifiable, as classmates could infer the commenter's identity from these images.

Table 3. Perspectives on the basic properties of bullet-screen interaction in medical and nursing students

Major	Number	Mean \pm s.d.	P value
Using the bullet screen function is not difficult for me.			
Clinical medicine	55	4.8 ± 0.5	0.13
Nursing	56	4.6 ± 0.6	
Posting bullet screen comments is convenient for me.			
Clinical medicine	55	4.2 ± 0.7	0.12
Nursing	56	4.0 ± 0.9	
Utilizing the bullet screen in class is advantageous.			
Clinical medicine	55	4.2 ± 0.6	0.20
Nursing	56	4.0 ± 0.6	
I was able to share my thoughts in class via the bullet screen.			
Clinical medicine	55	4.1 ± 0.9	0.82
Nursing	56	4.1 ± 0.8	
I was eager to engage in bullet screen interactions.			
Clinical medicine	55	4.1 ± 0.9	0.02
Nursing	56	3.7 ± 0.9	
Observing other students post bullet screen comments motivated me to do likewise.			
Clinical medicine	55	4.1 ± 0.9	0.01
Nursing	56	3.6 ± 1.2	
Posting bullet screen comments feels privacy-protecting to me.			
Clinical medicine	55	3.8 ± 1.0	0.86
Nursing	56	3.8 ± 1.0	
I had adequate ideas to share on the bullet screen during class.			
Clinical medicine	55	3.5 ± 0.9	0.003

Nursing	56	3.0 ± 0.9
---------	----	-----------

Perspectives on the educational properties of bullet-screen interaction in medical and nursing students

We next assessed the contribution of bullet screens to learning enhancement in face-to-face classroom settings. Nearly three-quarters of participants (83/111, 74.8%) (Table 4) agreed that bullet-screen interaction encouraged deeper thinking during class. However, this cognitive stimulation was less pronounced among

nursing students (Nursing 3.8 ± 0.9 Vs. Clinical medicine 4.2 ± 0.7, P = 0.01) (Table 4). Overall, approximately 32% of students reported that bullet-screen content did not support their learning (Table 4). Pre-clinical students were more likely to view bullet-screen comments as a means of signaling agreement rather than as a platform for extending discussion or presenting alternative viewpoints.

Table 4. Perspectives on the educational properties of bullet-screen interaction in medical or nursing students

Questionnaire Item	Major	Number	Mean ± s.d.	P value
Bullet screen comments helped stimulate my thinking about the course content.				
	Clinical medicine	55	4.2 ± 0.7	0.01
	Nursing	56	3.8 ± 0.9	
The bullet screen assisted me in gaining a deeper understanding of the course content.				
	Clinical medicine	55	4.1 ± 0.8	0.12
	Nursing	56	3.8 ± 0.9	
When I wished to show agreement with the content, I would post bullet screen comments.				
	Clinical medicine	55	3.4 ± 1.0	0.61
	Nursing	56	3.5 ± 1.0	
When I wanted to add extra comments, I would post bullet screen comments.				
	Clinical medicine	55	2.9 ± 1.1	0.54
	Nursing	56	2.8 ± 1.0	
When I held a differing opinion in class, I could use bullet screen comments to voice it.				
	Clinical medicine	55	2.9 ± 1.0	0.48
	Nursing	56	3.0 ± 1.1	

Perspectives on the interactive or entertainment properties of bullet-screen interaction in medical or nursing students

Blending educational content with entertainment is widely used in teaching formats, as it increases engagement and enhances students' motivation to listen and participate [16, 17]. Consequently, we also evaluated the interactive and entertainment dimensions of bullet-screen use. A total of 98 students (88.9%) reported that the bullet-screen format itself was interesting.

Nevertheless, only 76 students (68.5%) found the bullet-screen comments enjoyable. This outcome may reflect the relatively serious tone of the classroom environment. In addition, limited idea generation related to the course material may have contributed to repetitive or monotonous bullet-screen content. The perceived improvement in classroom interaction was greater among clinical medicine students (4.3 ± 0.7) than among nursing students (3.9 ± 0.7) (P = 0.003) (Table 5).

Table 5. Perspectives on the interactive or entertainment properties of bullet-screen interaction in medical or nursing students

Questionnaire Item	Major	Number	Mean ± s.d.	P value
The interaction enabled by the bullet screen was truly engaging.				

	Clinical medicine	55	4.4 ± 0.8	0.96
	Nursing	56	4.4 ± 0.6	
The bullet screen can enhance classroom interaction.				
	Clinical medicine	55	4.3 ± 0.7	0.003
	Nursing	56	3.9 ± 0.7	
The bullet screen comments were enjoyable.				
	Clinical medicine	55	4.0 ± 1.0	0.37
	Nursing	56	3.8 ± 0.9	

In the present investigation, 111 pre-clinical students participated in classes incorporating bullet-screen technology. Among them, 55 were enrolled in clinical medicine programs, and 56 were nursing majors. Within the context of medical education, we assessed the core characteristics, pedagogical effectiveness, and entertainment-related attributes of bullet screens, while also examining how students' academic specialty influenced these parameters. The findings indicated that bullet screens have potential value in pharmacology teaching. Consistent with observations from Chinese social surveys, students perceived the interactive process enabled by bullet screens as engaging (4.3 ± 0.7) and were able to express their perspectives on theoretical content immediately through this medium (4.1 ± 0.8). Consequently, bullet screens effectively enhanced classroom interaction (4.2 ± 0.7) and promoted deeper cognitive engagement (3.9 ± 0.9). Nevertheless, many students reported limited ideas for participation, highlighting the need for further development of critical thinking skills. This lack of active involvement was even more evident among nursing students. These outcomes suggest that more carefully structured course design is required to better stimulate student engagement and reflective thinking. Overall, students responded positively to the bullet-screen classroom, which appeared to enhance participation and support self-expression. Given its benefits and strong acceptance, bullet-screen technology may be extended to a broader range of courses. At the same time, we identified several areas where improvements could facilitate more effective classroom integration.

During the coronavirus disease 2019 (COVID-19) pandemic, numerous digital teaching platforms were introduced. Zoom has become a commonly used videoconferencing tool [18], while Microsoft Teams offers functions such as quizzes, assignment management, feedback provision, and group organization through teams and channels [19]. Online questionnaires are frequently used to assess student

learning outcomes. Although bullet screens are currently used mainly in China and Japan, they can be seamlessly combined with conventional Zoom-based teaching. After scanning a QR code at the start of a session, students are able to submit bullet-screen comments at any time while attending a Zoom lecture. In this way, bullet screens integrate smoothly with existing online platforms while offering greater flexibility and immediacy: comments can be posted freely, displayed instantly across the screen, and noticed without delay; teachers are not required to prepare additional questionnaires; and students can provide real-time feedback on course material. Moreover, the COVID-19 pandemic has disrupted routine teaching practices. The sudden shift to online instruction—often characterized by reduced interaction and communication—has posed significant challenges for educators [20]. From the students' perspective, insufficient planning, monitoring, and interaction may reduce motivation for home-based learning [21]. Feelings of isolation and disconnection from peers can further hinder the effectiveness of remote education [22]. Bullet screens may support self-expression and a sense of identity among students, and whether this auxiliary tool can alleviate isolation and anxiety associated with online learning warrants further study.

Current problems and room for improvement in bullet-screen classrooms

Although the introduction of bullet screens enhanced classroom interaction, the overall level of interaction remained limited. While bullet screens have the potential to encourage deeper thinking, their effectiveness depends heavily on teachers' guidance and the design of discussion questions. This requires instructors to possess substantial subject knowledge and strong improvisational skills. Conversely, unrestricted use of bullet screens may disrupt teaching flow and compromise instructional objectives. Therefore, instructors must carefully balance the use of this tool, recognizing both its strengths and

limitations. As a result, bullet-screen-based teaching may demand additional preparation and effort from educators.

The applicability of bullet-screen classrooms is also context dependent. They may be less suitable for courses dominated by dense theoretical content that require detailed explanation and leave minimal room for open discussion. In contrast, bullet screens may be more valuable in flipped classrooms or massive open online courses (MOOCs), where students can independently explore, supplement, and critique content [14]. Furthermore, in courses involving narrative elements, uncertainty, or exploration—such as drug design and development—bullet screens may maximally stimulate creativity and support inquiry into unknown topics. Whether bullet screens are better suited to these emerging instructional formats in pharmacology education remains an open question.

Several software-related modifications are also needed. Traditional bullet-screen platforms are popular among young users largely because of anonymity, which allows individuals to express opinions freely without fear of judgment. However, the classroom bullet-screen software used in this study displayed students' profile pictures alongside comments, which caused discomfort for some participants who preferred not to be identifiable. In addition, the operating procedures should be simplified to improve usability. Concerns have also been raised regarding content safety, such as the potential for inappropriate remarks. This issue could be addressed by implementing background filters to block sensitive or abusive language. Although removing profile images would preserve anonymity among peers, instructors could still identify commenters through the backend system if inappropriate content is submitted.

Limitations

Several limitations should be considered when interpreting these findings. First, this was a single-centre study, which restricts the generalizability of the results to other educational settings. As Shanghai Jiao Tong University School of Medicine is among the leading medical institutions in China, the effectiveness of bullet screens in less well-resourced colleges remains uncertain. Second, the sample size was relatively small, preventing subgroup analyses based on variables such as age, gender, academic year, or learning format (online versus face-to-face). Our comparisons were limited to differences by specialty, which constrains insight into

how diverse student groups may respond. Finally, this study focused primarily on student perspectives and did not sufficiently consider instructors' views. While bullet screens are popular among younger users, further research is needed to determine whether faculty members—particularly older instructors—can readily adopt and adapt to this technology. As teachers play a central role in guiding classroom learning, their evaluations are essential for refining this instructional model.

Conclusion

Bullet-screen technology was implemented in pharmacology education, and its impact was systematically assessed. Students responded favorably to this approach, which effectively enhanced classroom interaction. From an instructional standpoint, bullet screens showed potential to promote deeper thinking, while from an entertainment perspective, the interactive process was perceived as engaging. Variations between medical and nursing students may be partly attributable to differences in idea generation, underscoring the importance of appropriate instructional guidance and thoughtful application of bullet screens. Overall, bullet screens may be promoted as a supplementary teaching strategy to enhance interaction in both traditional curricula and remote learning environments. Further research is needed to explore broader implementation and to compare experiences between online and in-person participants.

Acknowledgments: The authors are grateful to the participants and the fundings that supported this study.

Conflict of Interest: None

Financial Support: This work was supported by the National Natural Science Foundation of China (grant numbers 82171358, 81973272, 92068111), Shanghai Science and Technology Committee (19410710100, 21XD1422200), Shanghai Science and Technology Development Funds (22QA1405000).

Ethics Statement: None

References

1. Engels F. Pharmacology education: reflections and challenges. *Eur J Pharmacol.* 2018;833:392–5.

2. Miles S, Kellett J, Leinster SJ. Medical graduates' preparedness to practice: a comparison of undergraduate medical school training. *BMC Med Educ.* 2017;17(1):33.
3. Heaton A, Webb DJ, Maxwell SR. Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. *Br J Clin Pharmacol.* 2008;66(1):128–34.
4. Manias E. Pharmacology content in undergraduate nursing programs: is there enough to support nurses in providing safe and effective care? *Int J Nurs Stud.* 2009;46(1):1–3.
5. Simonsen BO, Daehlin GK, Johansson I, Farup PG. Differences in medication knowledge and risk of errors between graduating nursing students and working registered nurses: comparative study. *BMC Health Serv Res.* 2014;14:580.
6. Khan A, Egbue O, Palkie B, Madden J. Active learning: engaging students to maximize learning in an online course. *Electronic Journal of E-Learning.* 2017;15(2):107–15.
7. Yin Y, Fung A. Youth online cultural participation and Bilibili: an alternative form of democracy in China? In: *Digital media integration for participatory democracy.* Hershey: IGI Global; 2017. p. 130–54.
8. Xu H. Research on the influence of online bullet screen interactive teaching on high school students' art learning investment. In: *2021 4th international conference on education technology management,* vol. 2021; 2021. p. 131–5.
9. Huang M, Shi Y, Yang X. Emergency remote teaching of English as a foreign language during COVID-19: perspectives from a university in China. *IJERI: Int J Educ Res Innov.* 2021;15:400–18. <https://doi.org/10.46661/ijeri.5351>.
10. Byers T, Imms W, Hartnell-Young E. Comparative analysis of the impact of traditional versus innovative learning environment on student attitudes and learning outcomes. *Stud Educ Eval.* 2018;58:167–77.
11. Deslauriers L, McCarty LS, Miller K, Callaghan K, Kestin G. Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proc Natl Acad Sci.* 2019;116(39):19251–7.
12. Theobald EJ, Hill MJ, Tran E, et al. Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proc Natl Acad Sci.* 2020;117(12):6476–83.
13. Banning M. Nurse prescribing, nurse education and related research in the United Kingdom: a review of the literature. *Nurse Educ Today.* 2004;24(6):420–7.
14. Lee K-y, Lai Y-c. Facilitating higher-order thinking with the flipped classroom model: a student teacher's experience in a Hong Kong secondary school. *Res Pract Technol Enhanc Learn.* 2017;12(1):8.
15. Salamonson Y, Everett B, Koch J, Wilson I, Davidson PM. Learning strategies of first year nursing and medical students: a comparative study. *Int J Nurs Stud.* 2009;46(12):1541–7.
16. Jarvin L. Edutainment, games, and the future of education in a digital world. *New Dir Child Adolesc Dev.* 2015;2015(147):33–40.
17. Malecki SL, Quinn KL, Zilbert N, et al. Understanding the use and perceived impact of a medical podcast: qualitative study. *JMIR Med Educ.* 2019;5(2):e12901.
18. Dash S, Samadder S, Srivastava A, Meena R, Ranjan P. Review of online teaching platforms in the current period of COVID-19 pandemic. *Indian J Surg.* 2022;84(1):12–7.
19. Pawar PN, Thorat SA. Effectiveness of online teaching in language and communication classes in engineering. *J Eng Educ Transfo.* 2022;35(Special Issue 1):285–91.
20. Naciri A, Baba MA, Achbani A, Kharbach A. Mobile learning in higher education: unavoidable alternative during COVID-19. *Aquademia.* 2020;4(1):ep20016.
21. Li Y, Zhang X, Dai DY, Hu W. Curriculum innovation in times of the COVID-19 pandemic: the thinking-based instruction theory and its application. *Front Psychol.* 2021;12:601607.
22. Shahrivini B, Baxter SL, Coffey CS, MacDonald BV, Lander L. Pre-clinical remote undergraduate medical education during the COVID-19 pandemic: a survey study. *BMC Med Educ.* 2021;21(1):13.