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# Effects of technology-mediated professional development on special education teacher collective efficacy

**Shantanu Tilak**[1,2] · **Mindy Gumpert**[1,2,3] · **Taryn A. Myers**[1,2]

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## Abstract
This mixed methods study investigates whether technology mediated collaborative practices during a professional development (PD) session led to growth in the collective efficacy of 21 special education teachers at an independent 1–12 school in Southeastern Virginia. This school specializes in individualized instruction for students with learning differences not limited to Autism Spectrum Disorder, Attention Deficit Hyperactivity Disorder, Specific Learning Disability, and their comorbidities. Teacher collective efficacy, which subsumes cohesive perceptions of classroom learning and behavior management, has been shown as strongly related to student achievement and healthy school culture. Mastery experiences with specific tasks related to teaching and learning can spur collective efficacy. Cutting-edge technologies (Vibe and Newline collaborative all-in-one hardware and software interfaces) were used to engage teachers in an interdisciplinary vision boarding activity to outline academic, social, and technological goals within and across subject areas. Teachers also engaged in a behavior management reflection exercise. Pre- and post-survey analysis was conducted using a paired samples t-test, showing overall growth in collective efficacy after the brief PD session. Regression analyses revealed that technology savvy teachers grew most in collective efficacy. Network analysis of vision board output and a descriptive analysis of the behavior management surveys showed that teachers became united in interdisciplinary goals for learning, and in strategies for behavior management through conversational practices.

**Keywords** Technology-mediated communication · Teacher collective efficacy · Professional development · K-12 · Special education

✉ Shantanu Tilak
stilak@cba-va.org

[1] Center for Educational Research and Technological Innovation, Chesapeake Bay Academy, Virginia Beach, VA, USA

[2] Virginia Wesleyan University, Virginia Beach, VA, USA

[3] Old Dominion University, Norfolk, VA, USA

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## 1 Introduction

The perceived capacity for group functioning of teachers can contribute towards joint solutions to problems and setting classroom/school-level academic goals, turning them into a well-oiled team (Durksen et al., 2017). Professional development (PD) helps teachers iteratively update their knowledge, share victories, and allows them to collectively set goals to address challenges faced in their classrooms (Kennedy, 2016). Factors contributing to teachers' learning and implementation of PD content include using evidence-based pedagogical techniques (Svendsen, 2020) and savviness with technology (Schmidt et al., 2009). Collaboration, access to resource experts, and a healthy atmosphere accounting for teacher needs all contribute to effective PD (Postholm, 2012). Additionally, Martin et al. (2010) found that in the digital age, fidelity of technology-assisted PD implementation is linked to superior curriculum design and student achievement. A deeper understanding of how to effectively use technology in teaching and learning can be valuable to educators (Glassman et al., 2023; Fernandez-Batanero et al., 2022).

Although these factors can make PD effective, what is learned in PD does not always translate into practical skill (Simonsen et al., 2019). Teachers can benefit if they see that the principles they learn from PD can be applied to classrooms (Svendsen, 2020). Additional challenges arise when designing effective PD for special education teachers. Typically, PD for special education teachers focuses on areas like reading (Dingle et al., 2011) or working with students with specific learning differences like autism spectrum disorders (Layden et al., 2023), rather than bolstering collaborative technology skills. When PD for special education teachers does include technology, it often focuses on assistive technology to address specific student needs rather than general pedagogical applications and effective digital communication (Almethen, 2017). This paucity of technology-focused PD and team-building, presents a research and practice gap in the continuing education of special education teachers (Papi, 2018).

There do exist some best practices outlined for designing PD specifically for special education teachers, as well as correlates of cohesive teacher teaming. Leko and Brownell (2009) emphasized the importance of providing content knowledge, emphasizing strategies for specific diagnostic profiles, having teachers collaborate and reflect, and using technology to efficiently communicate. However, there is a paucity of studies in special education settings focusing on whether collaborative teacher training initiatives can foster team cohesion in the Information Age. Owing to the obvious importance of collaborative technology-mediated problem-solving for all educators post-COVID-19 (Hartshorne & Baumgartner, 2020), we examine whether a technology-assisted collaborative PD initiative can increase the team cohesion of special educators; what Albert Bandura (2001) called *collective efficacy (CE).*

## 2 Theoretical framework

This study employs Bandura's (1977) theoretical framework to understand whether PD mediated by collaborative technologies and teamwork improves teachers' confidence to work cohesively. Bandura's concept of self-efficacy includes perceptions



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or "beliefs in one's capacity to organize and execute the courses of action required to produce given attainments" (Bandura, 1977, p. 3). His theory suggests that there is a three-way relationship between the way we think (cognition), the way we act (behavior), and the feedback from the environment (Glassman et al., 2021). With the proliferation of mass media, Bandura (2001) suggested that cognitive filters or thoughts of individuals interact when they engage in collaboration, creating collective level perceptions. He called these perceptions of capacity for collaborative action collective efficacy (CE; Tilak et al., 2022). Expanding Bandura's later (2001) work, educational researchers identified several kinds of efficacy beliefs impacting student achievement and classroom activity. These include a) student self-efficacy (Pajares, 1997) and CE (Khong et al., 2017) judgments, b) teacher's beliefs in their own pedagogy (Tschannen-Moran et al., 1998), c) teachers' belief about the CE of practitioners at their school (Donohoo et al., 2020; Goddard et al., 2000) and, d) CE in using online technologies (Glassman et al., 2021; Tilak et al., 2022). All efficacy beliefs are micro-oriented; they are situated in projected judgments of capability at a specific task (Bandura, 1977).

The focus of the PD initiative in the present study is *teacher CE* (Donohoo et al., 2020). For teachers, CE can relate to whether a team recognizes unity in perceptions of effective pedagogy, behavior management, and even global school culture. Simply stated, teacher CE refers to judgments teachers and faculty have regarding their joint ability to execute a course of action to initiate positive impacts for students and families.

In Hattie's (2015, 2018) two syntheses of predictors of student achievement, teacher CE ranked second and first, respectively. A cycle of improvement can be created through the association between teacher CE and achievement, with student performance enhancing the perceived capacity of teachers to succeed the subsequent year (Goddard et al., 2000). Teacher CE has been shown to be more predictive of student math achievement than students' socioeconomic backgrounds (Hoy et al., 2002). Other than student achievement, CE can also spur teachers to band together to understand how to best serve their students and learn new pedagogical techniques. Cantrell and Callaway (2008) found that teachers with high CE expended less time in internalizing literacy strategies for language development and were more successful in understanding how to apply techniques they learned. Similarly, Parks et al. (2007) found that among 314 teachers, CE was related to willingness to incorporate movement into instruction and to the importance the institution placed on movement-driven learning. Teacher CE has also been shown to be helpful in spurring community and family engagement in urban schools (Kirby & DiPaola, 2011).

Success or failure can play a large part in teacher CE; exposure to positive outcomes or mastery experiences can heighten CE over time. For example, if there is a judgment that performance of a particular task has been successful (i.e., feedback from the environment, parents of a child, or administrators), teacher efficacy beliefs are raised and there is an implication that in the future similar success can be achieved. Wilson et al. (2020) showed that mastery experiences with inclusion were associated with teacher self-efficacy in providing special education instruction. Moreover, self-efficacy formed a mediator between teacher CE and inclusive behavior. Lyons et al. (2016) showed that teachers were more willing to use inclusive practices to overcome instructional challenges when they exhibited greater CE.



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If success seen in implementing teaching and learning is attributed to controllable causes, teacher efficacy beliefs are strengthened. Failures tend to undermine CE (Hoy et al., 2002). PD, when implemented to encourage group-level teacher agency, can engage practitioners with positive mastery experiences by allowing them to discuss challenges and successes, and to reflect upon them (Durksen et al., 2017).

Studies specifically understanding the CE of special education teachers have shown promising results. These findings point to the fact that creating cooperative cultures thriving on cultural tolerance and resource sharing can augment pedagogical confidence of special educators. Chu and Garcia (2021) recruited 344 in-service special educators from three urban school districts, finding that while there was limited confidence in accessing resources to serve children with learning differences, there were strong relationships between collective teacher efficacy, self-efficacy for teaching that catered to students' distinct needs, and outcome expectancies for teaching practices. Viel-Ruma et al.'s (2010) study of in-service special educators revealed direct relationships between collective efficacy and self-efficacy, but no direct effects on job satisfaction; indicating that the school culture and individual confidence created by group cohesion need deeper investigation. Cultural factors guiding teacher attitudes towards inclusion have also been revealed to have a positive relationship with teacher CE, as revealed by Fohlin et al.'s (2024) study of 930 special education teachers. Chong and Ong's (2016) study investigated the effects of collective efficacy on workplace culture for both traditional and special educators, finding collective efficacy mediated the relationship between teacher self-efficacy and workplace culture factors such as student support, affiliation, mission consensus, empowerment, resource adequacy, external control, and supportive leadership. These studies reveal that fostering cooperative inquiry and practice can produce adaptive effects in the confidence that special educators have in working as a team to serve students.

While these studies reveal the adaptive potential of special education teacher CE, they do not focus on the role that collaborative professional development can play in fostering CE for special educators. Studies that do investigate the role that professional development has on collective teacher efficacy have focused on mainstream schools. Findings suggest positive relationships between collaborative teacher learning and collective efficacy (Durksen et al., 2017); and that network cohesion arising through collaborative PD is related to teacher CE, and student achievement (Moolenaar et al., 2012). This study expands current research by exploring the role that collaborative professional development plays in fostering the CE of special educators.

With most schools integrating innovative technology into instruction, especially post-COVID-19, the knowledge of technology teachers bring can affect how the perceptions of group cohesion develop; having more confidence in this regard can help teachers join forces to create engaging technology-assisted instruction, and communicate seamlessly using digital modes. For special education teachers, this process may also encourage a sharing of assistive technology software and implementation techniques. A shared language, or cohesive teacher knowledge can emerge from such practices. Cohesive teacher knowledge is a construct that informs mechanisms of CE – it subsumes perceptions related to teaching techniques, digital and physical, expectations related to student behavior, and effective assessment (Donohoo et al., 2020).



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## 3 The current study

The current mixed methods study involved measuring effects of a collaborative technology-assisted PD initiative designed for and by special education teachers in consultation with a robust research team (Jankowski et al., 2024). It examines whether 21 practitioners at a 1–12 school serving students with learning differences became unified in goals they set for improved classroom behavior management and their students' academic and social development. Three research questions are answered:

**RQ1:** *To what extent does a technology-mediated collaborative method of PD lead to increases in teacher collective efficacy?*
**RQ2:** *Do teacher mastery experiences with technology increase the benefits teachers reap from technology-mediated collaborative PD?*
**RQ3 (Exploratory):** *How do collaborative technology-mediated PD activities help construct joint perceptions of measures to be taken to ensure student learning and effective behavior management?*

## 4 Method

### 4.1 Participants

We recruited 21 teachers from a 1–12 independent school in Southeastern Virginia serving students with learning differences (e.g., autism spectrum disorder, attention deficit hyperactivity disorder [ADHD], specific learning disability, and their comorbidities). The sample was 73.9% Female, 73.9% White, 17.5% Black, 8.6% Asian American. One participant (4.7%) had less than a year of teaching experience, while 38.1% had one to five years of teaching experience. Five teachers (23.8%) had six to 10 years of teaching experience, and 33.34% had 10+years of experience. The study was approved by the Institutional Review Board (IRB) at a small liberal arts university, and by an internal education and research committee comprised of parents and board members at the school. The participants attended a two-part PD session comprised of vision boarding and behavior management discussions using collaborative interface/surface technologies. Teachers were put into four groups. The lower school group comprised six teachers teaching first through fifth grades (four homeroom teachers, a teaching assistant, and a reading specialist). The middle school teacher group taught grades six through eight and comprised seven teachers; the four core subject teachers, a reading specialist, a behavioral assistant, and the director. The upper school teachers taught grades nine through 12 and were three in number, a social studies, math, and science teacher, owing to two absences. The specials teacher group, five in number, taught cross-divisionally, comprising an art teacher, a music teacher, a physical education (PE) teacher, a Makerspace teacher, and the school counselor. The head of school and research staff led the activities. An assistant, neutral to the study, took fieldnotes to document ideas that groups shared during whole group discussions. Twenty teachers completed the survey items.



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### 4.2 Procedures

The 21 teachers took part in a two-part PD exercise that involved vision boarding and behavior management discussions. Cutting-edge hardware and software interfaces were used. Teacher groups sat at four workstations.

#### 4.2.1 Materials/Technologies

*Vibe and Newline interactive interface.* Dubbed as the "Swiss army knife of meeting rooms," the Vibe interface is a responsive whiteboard that responds to a tactile stylus, and connected laptop interfaces (Vibe, 2023). Users can either draw on the board using the stylus, or type inputs on an attached screen. The Newline interface is a significantly bigger surface with similar capacities. It features a built-in central processing unit (CPU) computer with a Windows operating system and can be used to initiate multiple browser instances with ease. Four Vibe interfaces were used in both PD activities. The Newline board was used to view the output on the four Vibe boards using the web browser, by the head of school, research personnel, and support staff in real-time. The two tools are hardware solutions with diverse capabilities to facilitate digital communication and collaboration both remotely, and in-person.

*SurveyMonkey.* A SurveyMonkey online questionnaire was used to facilitate the behavior management activity. The tool could be opened on each Vibe interface. Teachers answered one multiple choice question regarding the most common type of behavioral issues they saw in their classrooms individually. They then each completed an open-ended response providing an example of the type of behavioral disruption they thought was most common. The survey results were made available so teachers could reflect on their own responses in their working groups.

#### 4.2.2 PD activities

**Vision boarding** The vision boarding activity was conducted in the first hour of the two-hour PD. The interfaces featured Venn Diagrams with three intersecting circles representing academic, social, and technological facets for each discipline. Teachers filled in the circles using a stylus or their laptops.

**Behavior management** The second hour was utilized to refresh teachers' knowledge about functional behavior analysis using the concepts of antecedent, behavior, and consequence (Virginia Department of Education, 2015). A brief resource was designed on the Vibe interface to explain how locating the root causes of problem behaviors and designing consequences to assertively manage these behaviors could improve the school's learning culture.

We let teachers navigate their own survey feedback activity; each teacher reported a common type of behavioral disruption observed in their classes within their groups individually inputting one multiple choice response and one open-ended example



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from their classes, and then as a group, strategized solutions for these examples. The survey was designed using a previously administered poll about the most seen behavioral disruptions at school, conducted over the summer as part of the design process for this study (Jankowski et al., 2024). Work avoidance, failure to abide by classroom etiquette, overt behavioral disruption, and distractibility in class emerged as the four key forms of behavior disruption when teachers were asked about their classes during the design phase of this study. The goal was to identify whether teachers' perceptions about the most common behavioral issues in their divisions/working groups resonated. The survey format is provided in the supplementary sections attached to this paper (Appendix A, Table 2).

### 4.3 Data collection

Four data sources were collected. The extensive nature of data collection made up for the small sample of 21 teachers, and helped follow a social cognitive framework, wherein perceptions and behaviors were presented side-by-side to understand the effects of technology-mediated PD. The first were two self-report surveys examining teachers' collective efficacy and their comfort in using technology. These measures were collected using SurveyMonkey QR codes as pre- and post- data, before and after exposure to PD activities; technological knowledge was collected at the pre- timepoint. Averaged scores were used in answering research questions. These scales served to measure self-reported perceptions. Specifically, per social cognitive theory, the pre-surveys measured the mechanisms of the cognitive filter of teachers using proxy self-report responses prior to PD, while the post-CE survey captured mechanisms of the modified cognitive filters of participants immediately post the short-term PD session, after experiencing the outcomes of PD. The second data source were fieldnotes taken during PD implementation. The assistant to the head of school, who was neutral to the study, collected these notes during the two activities using a template in Microsoft word. These fieldnotes serve to recount conversational experiences and behaviors of teachers, through a narrative of ideas shared during post-activity discussions, initially collected by a neutral observer, and later interpreted further by a member of the research team.

In addition to the fieldnotes, the artifacts produced from PD were also analyzed as observable indicators of CE. During the first hour of PD, teachers worked in their groups on four interactive interfaces and created vision boards/maps of their academic, social, and technological goals for students, connecting goals across disciplines. These maps were the third data source. They were downloaded as images from the Vibe interfaces, and connections between nodes and ideas on these images were input into Microsoft Excel, and then RStudio for analysis. During the second hour of PD, a survey measure was administered around a self-reflective exercise regarding behavior management. Open-ended survey responses were collected from SurveyMonkey, forming the fourth data source. Together, the fieldnotes, and analyses of PD artefacts enables a deeper understanding of the emergent behavior of teachers. Post surveys and PD output, when taken together, show how teachers respond to feedback from their environment, to modify their thinking. We showcase how the data sources relate to Bandura's theory below (Fig. 1).



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### 4.4 Instruments

Apart from PD output, two survey measures, and fieldnotes were used:

**Teacher collective efficacy** Donohoo et al.'s (2020) enabling conditions of teacher collective efficacy scale, a validated instrument, was administered before and after PD implementation. The cohesive teacher knowledge subscale ($\alpha = 0.86$), informed whether vision boarding and discussing behavior related issues emergent at school helped teachers become more unified in their goals and purposes for teaching and learning; all strong indicators of CE. This subscale specifically investigates how teachers perceive their unity in managing student academic goals, implementing pedagogy, and crafting effective assessment methods. It uses a 6-point Likert scale ranging from Strongly Disagree to Strongly Agree. Items are provided in supplementary sections attached to this paper (Appendix A, Table 3).

**Teacher technology comfort** To understand whether growth in teacher cohesiveness was also associated with greater comfort with technology (what we have chosen as a proxy for mastery experiences), we administered items related to technological knowledge or comfort ($\alpha = 0.82$) from Schmidt et al.'s (2009) validated technological, pedagogical, and content knowledge (TPACK) survey. The survey measures comfort with technology, and curiosity to explore modern technologies. It uses a

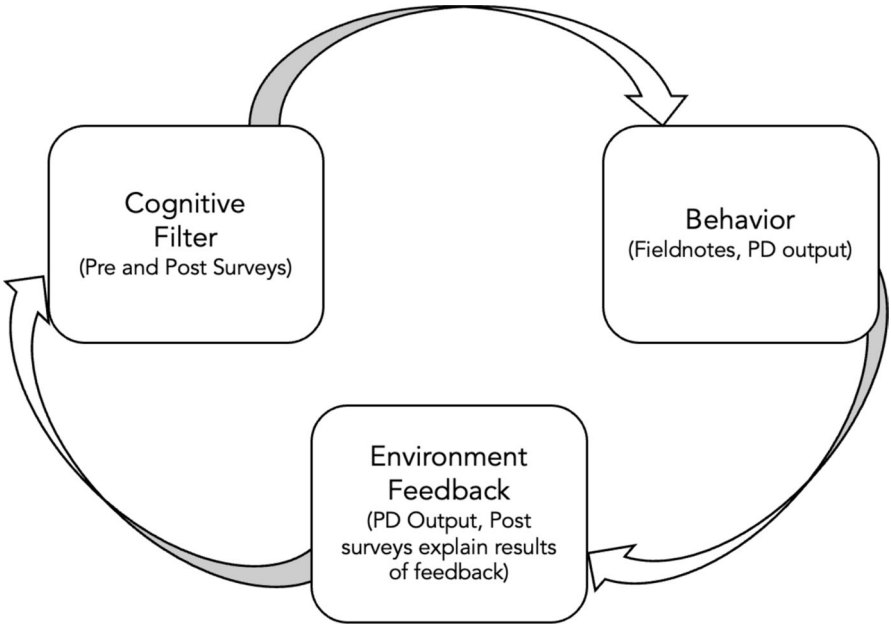


**Fig. 1** Data collection from a social cognitive theory lens



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5-point Likert scale, ranging from Strongly Disagree to Strongly Agree. Items are provided in supplementary sections attached to this paper (Appendix A, Table 4).

**PD fieldnotes** During PD implementation, a neutral observer who served as support staff, and executive assistant to the head of the school wrote fieldnotes to document teacher activity during vision boarding and behavior management exercises. This observer utilized a template with placeholders to outline the feedback of the three divisions and specials teachers for each activity. The template is provided in supplementary sections attached to this paper (Appendix A, Table 5). These fieldnotes were analyzed by a member of the research team, and narrated in-text to supplement network graphs provided for teacher vision boards, and behavior management discussions. The narrative inquiry methodology used is described in the Data Analysis section of the paper.

### 4.5 Data analysis

To understand growth in CE in the overall sample, or changes in the cognitive filter in response to their environment, and answer RQ1, we conducted a paired samples t-test to assess mean difference in pre-post test scores. We used a multiple regression model that gauged whether pretest collective efficacy was associated with post-test collective efficacy and technology comfort to answer RQ2. Aware of our small sample, we tested the power of our regression model to detect a moderate to large effect size. T-tests and regression analyses of surveys revealed changes in inner perceptions of teachers.

Vision boards produced during the first half of PD were visualized as network graphs using RStudio's igraph package. We also analyzed behavior management survey output using descriptives, and by narrating classroom behavioral challenges stated in open-ended responses that teachers used for self-reflection as part of the activity. Fieldnotes taken by the neutral observer during the PD activities are paraphrased to support analysis of teacher artifacts. A narrative inquiry methodology was used, wherein the fieldnotes, populated in the template by the neutral observer, were summarized by a second individual from the research team; a characteristic step wherein multiple agents co-construct meaning from qualitative recounting of events in a free-form manner (Knight & Sweeney, 2007). The notes considered the personal and social dimensions of the sample by delineating possible responses group-wise, assumed the notion of place by being focused on the initiative at the school, and temporal aspects related to their progressive completion of PD activities. PD output analyses, along with fieldnotes, serve to answer RQ3, and understand observable behavioral processes emerging from PD.

## 5 Results

First, we computed skewness and kurtosis for survey variables, to understand whether data allowed parametric tests (linear regressions and t-tests). We searched for skewness values outside the range of $+2$, and kurtosis values outside the range



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of ± 10 (Mardia, 1974). For two time-points of collective efficacy responses, and one time point of technology comfort responses, skewness and kurtosis values lied within this range. We also computed histograms in RStudio. These histograms showed a uniform distribution across Likert Scale metric values for each time-point (Fig. 2), permitting our t-tests and regressions.

### 5.1 RQ1

Our first research question sought to answer whether teachers in our sample, on average, grew in self-reported collective efficacy post-PD. We first computed a paired samples t-test to understand if there was significant difference in mean values for pre and post-test collective efficacy; by grouping them into a before and after condition using a binary variable. Average post-test collective efficacy (M = 4.9, SD = 0.61) was significantly higher than pre-test (M = 4.4, SD = 0.74) scores [t (19) = 3.67, p = 0.001]. We also generated a boxplot with a 95% confidence interval using the R ggplot package to visually display differences in pre- and post-test collective efficacy metrics (Fig. 3). The effect size was large ($d = 0.771$), indicating that the results were significant for our small sample.

Paired t-test results suggest the implementation of collaborative PD activities using cutting-edge learning technologies improved perceptions of teacher cohesive knowledge in our modest sample; answering **RQ1**.

### 5.2 RQ2

To answer RQ2 and understand if teacher mastery experiences with technology were predictive of greater growth in collective efficacy, we ran a multiple regression in RStudio (Table 1). We first used GPower and found that implementing a regression model with two predictors (comfort with technology and pre-teacher CE) and one outcome variable (post-CE) to detect a moderate to large effect size ($f^2 = 0.40$; University of Cambridge, 2021) would have sufficient power (0.80) in explaining these relationships with 25 participants. Thus, we decided that our sample size of 21 was almost adequate for this analysis. The regression model successfully explained 47.08% variance in post-CE, and this model was significantly more indicative of these relationships than the baseline. For every unit increase in pre-test CE, there was a statistically significant increase of 0.3485 units in post-test CE, suggesting that teachers with stronger perceptions of group cohesion at the school augmented their perceptions of such cohesion at the end of the intervention.

Secondly, teachers' perceived comfort with technology before the PD activities was strongly associated with increases in post-test CE; an increase in perceived technology comfort by one unit was associated with increases in post-test CE by 0.2405 units. This relationship was statistically significant, which suggests that those that were most technologically savvy (i.e., those with the most positive technology related mastery experiences) grew most in teacher cohesive knowledge, answering RQ2.



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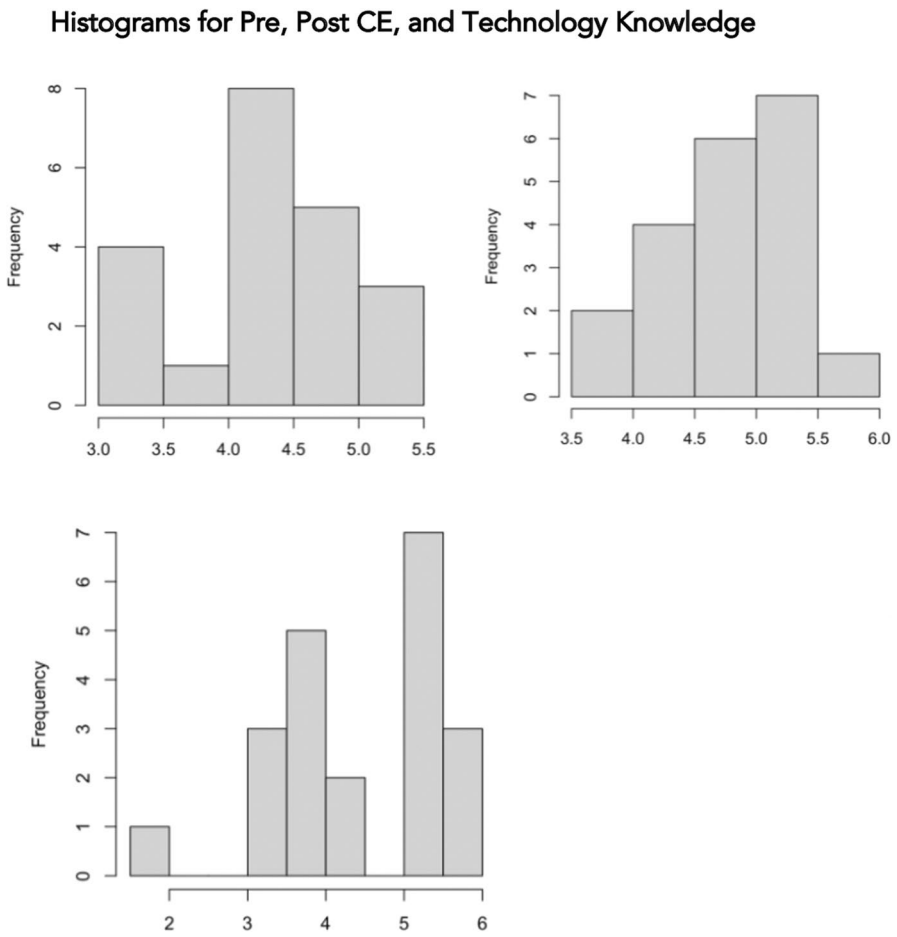


**Fig. 2** Histograms

### 5.3 RQ3

Our third research question focuses on understanding the processes followed by teachers in their working groups to heighten their cohesive knowledge of goals for the school year (in terms of academic classes, and behavior management) during the PD session. We first analyze the output from the vision boards created on the Vibe interfaces and the output from the behavior management surveys.

#### 5.3.1 Vision boarding

In analyzing vision board output, we share insights developed by each group based on network visualizations of the four vision boards, and ideas shared in the whole group based on fieldnotes taken by the assistant to the head of the school. In these



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**Fig. 3** Box plots

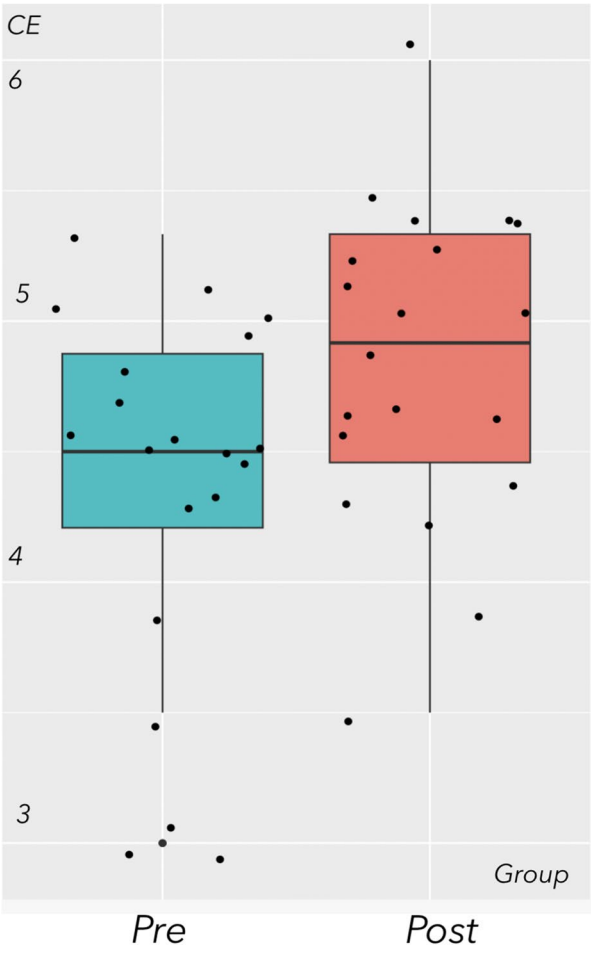


**Table 1** Regression model

| Variable | B | t | p |
|---|---|---|---|
| Intercept | 2.2431 | 3.522 | 0.002 |
| Pre- Teacher CE | 0.3485 | 2.185 | 0.04* |
| Pre- Teacher Tech Comfort | 0.2405 | 2.295 | 0.034* |

Dependent variable: Post- Teacher CE

*: significant at $p = 0.05$ level

undirected network diagrams, pink nodes are goals that teachers listed under their subjects and blue nodes are subject areas themselves. The grey lines (edges) connect goals to subject areas, and goals to one another as well. Larger node size indicates a larger number of edges that each node is part of, or degree (Kolaczyk & Csardi, 2014). While text size may differ in these images, they are not indicative of any differences in network quality and were inserted into our visualizations as such in the interest of laying them out in a readable manner.



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**Lower school** All teachers contributed to understanding goals to set out for students across core subjects, since each of them taught multiple subjects in their homerooms. This fact explains why the vision board created by these teachers was concise but well connected (Fig. 4).

Technology and its use were brought as a skill required in mathematics (e.g., using calculators) and social studies (e.g., in using online sources to answer questions), highlighting the cross curricular importance of basic tech-savviness. The Language Arts classes relied on Canvas for online discussions and reading, and this projected goal of learning to use the tool was also connected to the notion of using online resources. Collaboration was another theme that ran through each subject area and was marked out with purple asterisks on the side of the vision board, for all four subjects. Teachers also linked goals related to peer tutoring (language arts), learning new concepts in class (such as negative numbers in math), gaining confidence in collaboration, and collaborative research projects (social studies) in their vision boards. Broadly, social skills and technology use were areas thar were marked by the most linkages in the lower school vision board network.

**Middle school** Core teachers (Fig. 5) agreed that problem-solving through a logical process was a central skill for students. The linkages between the ability to defend and discuss concepts (social studies), write information in journals (math), and work in small groups are illustrative of this view. Social interaction was also emphasized as central to learning. Confidence in collaboration on classwork spanned across goals outlined the four core subjects. These links are showcased by edges connecting nodes like confidence in working with others (language arts) and confidence in public speaking (social studies); collaborating with peers to discuss mathematical processes (math), and the ability to engage in small group and class discussions (social studies). Content knowledge was also stressed as important, with mathematical and scientific vocabulary knowledge related nodes being connected.

The scientific method was also brought up as an important skill students need, illustrated by links between nodes related to identifying *bad science* in science class, research skills in language arts, and conducting research online and through reading textbooks in social studies. The appropriate use of technology such as BrainPOP in science and gamification sites in mathematics were also discussed as connected skills. Problem-solving, technology use, and content learning were themes, broadly, that emerged as resonant in terms of student goals and skills among the middle school teachers.

**Upper school** The vision boards created by the upper school teachers did not show any explicit linkages, perhaps owing to the often self-contained nature of credited classes at the school. Thirty-one nodes were contained across each subject in the network visualization. However, links between them were discussed in real-time when the teachers shared insights. Several themes emerged. The social studies and math teacher discussed the overlap between mapping practices (geography), and working with graph paper. Having students engage with the history of mathematics came



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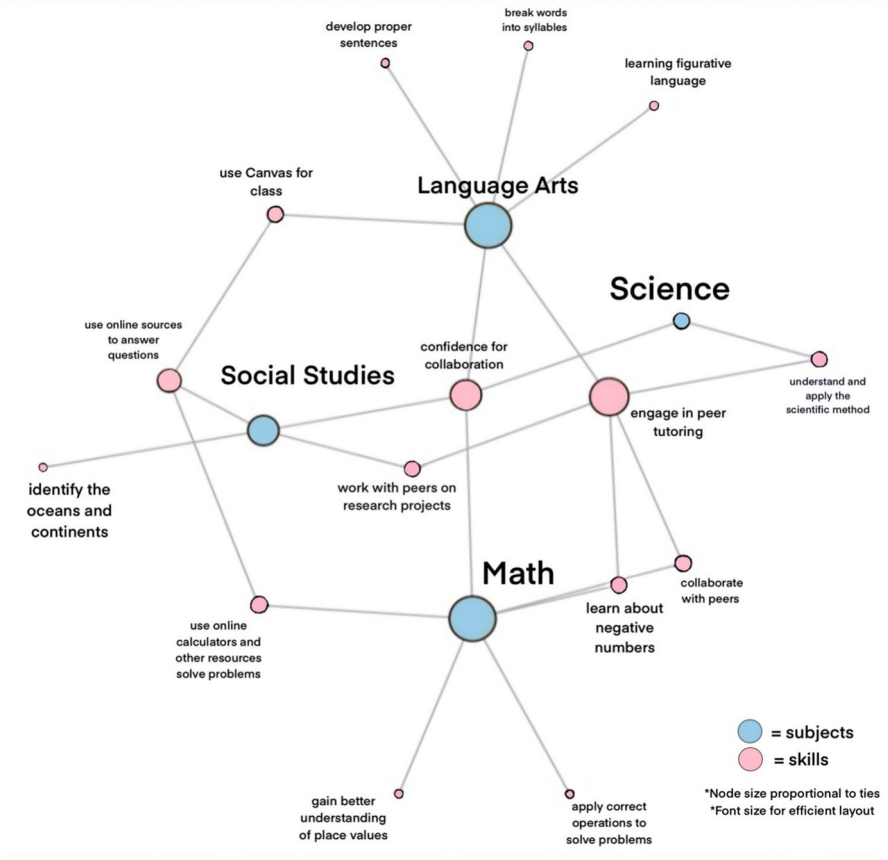


**Fig. 4** Lower school vision board network

up as a possible way to engage interdisciplinary learning. The teachers also shared that technology was a common theme in their vision boards. The idea of respecting living organisms in science, and communicating with respect, suggested by the social studies teacher emerged as related academic themes that concern morality and mindfulness.

The teachers also discussed how online research in social studies, using assessment tools such as Geogebra and ALEKS in mathematics, and simulated content on Labster all involved technical knowledge and process-oriented learning. Assistive technology like multimodal content in social studies, audiovisual resources in science, and online textbooks and notebooks in mathematics was also a theme that ran through the three self-contained graphs, that emerged when teachers shared their insights. In sum, the goals and skills that emerged in verbatim share outs as resonant between varied subjects were broadly related to technology use, and the basic philosophies and aims guiding the core subjects.



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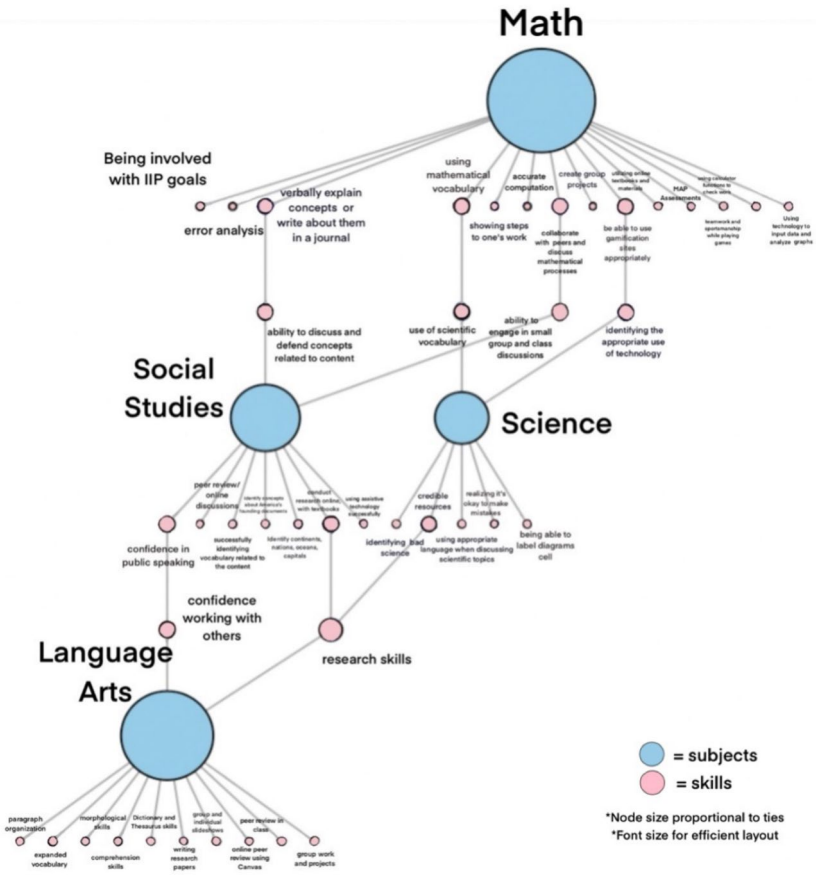


**Fig. 5** Middle school vision board network

**Specials teachers** The specials vision board showed extensive linkages across subject area Venn diagrams (Fig. 6).

Creativity was emphasized as a common thread running through Makerspace, art, and music classes, exemplified by edges connecting nodes related to using composition software utilized in music, creating projects in Makerspace, and understanding how to apply the elements and principles guiding artistic technique in art.

Content learning was also stressed as important, with links established by the PE and Makerspace instructor including the idea of learning varied game rules (e.g., volleyball), and learning block programming and Java coding to deploy projects in Makerspace. Apart from collaborative and individual learning, character development was also stressed as key to student learning; with nodes such as perseverance to learn skills and win for example in PE, and perseverance in character development (counselor) being linked. Such character development was also brought up in the shared discussion when teachers from the group provided insights about group work being strongly



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related to a healthy classroom climate. A healthy climate of critique (art), feeling supported while taking musical risks (music), and being open-minded to learn from one's peers (counselor) were all perceived as connected nodes by the specials teachers.

The more informal, practical nature of specials classes at the school created many opportunities for student collaboration. Embracing joint work in Makerspace, teamwork in playing games in PE, an atmosphere of community and caring in the art class and learning how to be a civil productive member of the school community suggested by the counselor, were all regarded as pillars of activity by teachers in these classes. Collectively, this group shared that treating everyday problems and those encountered in class as processes of continuous, collaborative improvement helped students to understand how classroom concepts could be applied to the real world. Broadly, the areas of resonance among these teachers were related to student collaboration/community formation, and process or skill-oriented learning.

The network analysis of vision boards shows that teachers not only worked to set goals for their students for their own subjects; but also understood the common threads across disciplines.

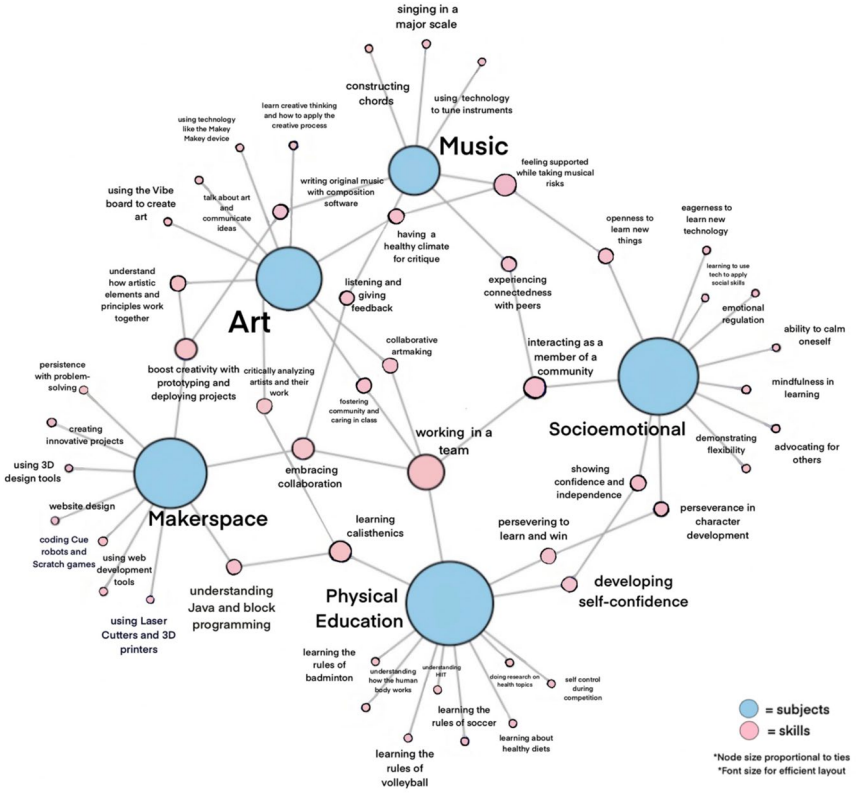


**Fig. 6** Specials vision board network



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### 5.3.2 Behavior management activity

In analyzing the behavior management activity output, we provide descriptive graphs (Fig. 7) to showcase what percent of teachers perceived each of the four categories as a common occurrence in their classes. Teachers picked the most observed behavior of challenge they observed as part of their work and then described the challenge in greater detail with an open-ended response.

We describe these statistics by group, and present the open-ended responses generated by teachers stating examples of each type of behavioral disruption(s) members of each team perceived as most common.

**Lower School** One hundred percent of the lower school teacher responses attributed active behavioral disruption and physical outbursts as the most common behavioral challenge faced in their classrooms. Examples include:

> "*A child wanting to control the teaching by acting out to get class focus off lesson or asking off task questions*."

Techniques for redirection like brain-breaks with the counselor, short walks, providing fidgets, and alternative seating were discussed. The importance of token economies and reward systems promoting positive behavior were also discussed when a teacher shared the example of a student who was:

> *"Standing up frequently and walking around during instruction time. We were able to work on redirecting him and by the use of him handing out items, and using a timer, as well as creating a first/then reward. "*

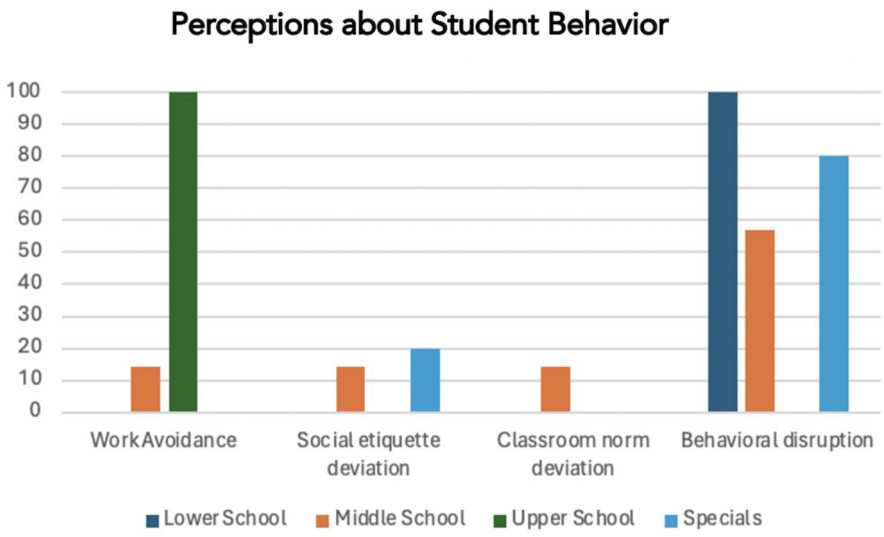


**Fig. 7** Teacher perceptions related to commonly seen behavioral challenges



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Carefully designed reinforcement allowed the child to engage in the classroom in ways they felt comfortable with.

**Middle school** The middle school teachers had varied responses about behavioral challenges commonly faced in their own teaching. Four newly hired teachers were asked to recall their previous experiences as teachers or student teachers. Over half of the middle school teachers, 57% suggested that overt classroom disruption was the most experienced behavioral challenge. A smaller number, 14.33%, stated that such active disruptions were also accompanied by off-task behavior during classwork. One teacher, in their open-ended response shared,

> "*A student would not focus on his essay. He would constantly distract his classmates, work on other assignments, and would respond rudely to redirection attempts*."

Redirection by the teacher assistant and provision of appropriate reinforcement to the child was suggested as a solution; and the group agreed.

Work avoidance and off-task behavior was another common challenge suggested by 14.34% of the teachers. The following example illustrates this concern:

> *"When students do not feel like a task is "worth it" they do not see value in completing that task. Navigating those internalized feelings is one of the hardest things to overcome."*

Having students interact with content in informal ways, for example, using gamification or innovative technology and focusing on basic principles/application of content to real life were suggested as ways to make students feel motivated about their work.

Another 14.33% of the teachers suggested that students sometimes deviated from social etiquette when addressing the teacher and their peers. The following example illustrates this challenge:

> *"A student continued to joke about what the teacher was saying during a lesson. Other students laughed with him."*

Adequate reinforcement using token economies, and explicit ways to set classroom norms using bulletin boards, Jamboards, and Vibe interfaces for everyone to remember as a class were discussed as ways to maintain social decorum. Revisiting classroom norms and expectations to make them explicit to students was also discussed to ensure consistent reinforcement. Including responses from the four new middle school faculty members may have contributed to the disparate nature of responses.

**Upper School** Work avoidance was identified as the most common behavioral challenge in their classroom by 100% of the upper school teachers. One response stated:

> *"Many students struggle with avoidance of work they find challenging."*



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Teachers stressed that students often displayed lower motivation to do tasks they found difficult, preferring to give up rather than learn from challenging tasks. The teachers suggested rewarding small steps towards significant gains and progress could help maintain student motivation. One of the teachers responded saying they observed:

> *"Students misusing class time, not completing work when help is available. They then run into difficulties when trying to do the work at home."*

Others suggested that asking students to explicitly state when they are having doubts during class, and reinforcing their efforts to overcome their doubts would help reduce work avoidance. Teachers in this group also suggested that asking students explicitly about whether the difficulties they are having emerge from a lack of prior knowledge or motivation, or both, would help address the issue of late work and non-submission of assignments.

**Specials teachers** According to 80% of the specials teachers, distractibility was a frequent problem in the specials classes. An example of a behavioral disruption of this nature would be:

> *"Students get easily distracted when another student says something unrelated to our classroom activities and it interrupts classroom activities especially when collaborating."*

Constant redirection of activity to allow a healthy balance between recreational talk and sustained work necessary for composing sheet music, making and tinkering, art practice, and playing soccer was suggested. Teachers shared examples of when students forgot to take medication, and exhibited disruptive behavior:

> *"A student who happened to not have taken their ADHD medication continued to blurt loud words, sounds, laughs, and jokes, even after being reminded several times to stop. It was almost as if the words/requests of others were not getting through or being processed by the student (a runaway motor that can't be "turned off")."*

The teachers and counselor collaboratively discussed solutions to such issues, saying that diverting student activity to avoid disturbing others, consulting the school nurse, allowing brain breaks, bringing fidgets to class, and effective, consistent reinforcement could help curb such disruptions.

Our descriptive and narrative analysis of behavior management surveys showed that the lower school, upper school, and specials teachers had cohesive views related to common classroom behavioral disruptions and ways to tackle them.

The PD initiative and its two parts highlight how teachers used conversational practices that emerge through the facilitation of technology mediated activities to create a cohesive view of their goals for the school year in their classrooms, answering RQ3.



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## 6 Discussion

Our study results rely on diverse methods: t-tests and regressions conducted on self-report surveys, fieldnotes, network analysis, and descriptive analyses of collaborative survey reflections, to make up for our small sample. They reveal that teachers not only grow in group cohesion or CE from technology mediated PD but engage in rich conversational practices to give effect to this growth.

RQ1 in our study asks: *Does a technology-mediated collaborative method of PD lead to increases in teacher collective efficacy?* Our t-test results show that using innovative technologies, central to the culture of the school, during a collaborative PD session led to growth in teacher CE, or changes in the cognitive filter in a positive direction. These results are significant owing to detection of a large effect size even in our small sample. The nature of PD practices implemented also speaks to these adaptive changes. Vision boards involved creating opportunities to establish an interdisciplinary learning culture through the development of collective goals; and the behavior management activity involved joint self-reflection about common disruptions, and ways to tackle them. We aimed not only to enable teachers to become more confident about their individual contributions, but also more confident about the competence of the groups themselves; what Bandura suggests constitutes the dual-layered nature of collective efficacy (Glassman et al., 2021). The Vibe interface tools allowed teachers to put their heads together using tactile tools and networked interfaces to curate common goals and easily access behavior survey backend data. These activities set the stage for positive changes in the cognitive filter, by facilitating productive, reflexive collaboration.

Positive mastery experience with specific practices (e.g., inclusion, embodied learning) can heighten teacher CE (Cantrell & Callaway, 2008; Lyons et al., 2016). Corresponding antecedents can be amplified at a school specializing in technology-assisted special education through PD that utilizes cutting-edge tools to facilitate collaboration. Those with previous positive experiences with classroom technologies grew most from the PD session, revealed by our regression analysis. Our results, that were computed post a power analysis, tie directly into Bandura's social cognitive theory, and answer RQ2, which asks: *Do teacher mastery experiences with technology and collective behaviors increase the benefits teachers reap from technology-mediated collaborative PD?*

Processes that guide the development of teacher CE can be analyzed using dynamic methods like network analysis, to reveal how teachers band together in their views about student learning and behavior. Extant research has attributed greater network cohesion and connectivity as a factor strongly related to CE (Moolenaar et al., 2012). Accordingly, our third exploratory research question asks: *How do collaborative technology-mediated PD activities help construct joint perceptions of measures to be taken to ensure student learning (academic, social, technological) and effective behavior management?* Our analysis of vision boards shows that teachers could use styluses and computer systems to not only better structure out their own goals for the academic year in their classes, but also to work with others to find divergences and commonalities. While lower, middle, and specials faculty made considerable linkages in their boards, upper school teachers chose to spontaneously voice out connections in



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real-time by just looking at their self-contained diagrams, while sharing out insights from their conversations to the group. The lack of linkages could be explained by the absence of the language arts teacher, and the fact that two of the three remaining teachers were very seasoned and able to shepherd a real-time interdisciplinary conversation, having taught at the school for close to 20 years. The unified responses to the behavior management surveys in the case of the lower and upper school teachers, and specials teachers explain the increases in teacher cohesive knowledge, which subsumes perceptions of pedagogical techniques, behavior management, and effective assessment (Donohoo et al., 2020). While the middle school teacher group had several diverse insights related to student behavior management and commonly seen disruptions, the presence of four new staff, who shared their previous experiences in the survey responses variegated the results. However, these teachers interfaced with other seasoned faculty to heighten their understanding of the school's culture. Together, the descriptive and analytical presentation of the PD output recounts the emergent behaviors of teachers, and a possible explanation for how these behaviors facilitated a change in their thinking.

This study's results firstly, expand extant findings in special education settings that investigate the adaptive potential of teacher collective efficacy, that reveal strong relationships between CE, workplace culture (Chong & Ong, 2016), teacher self-efficacy (Viel-Ruma et al., 2010) perspectives related to inclusion (Fohlin et al., 2024), and confidence in individualized teaching/learning practices (Chu & Garcia, 2021). A comprehensive investigation of self-perceptions and conversational practices emergent from collaborative, technology-mediated PD expands these lines of research. Results from the current study reveal that CE can be bolstered by reflecting the community flavor of workplace culture in teacher continuing education. Results also resonate with extant studies in general education settings (Durksen et al., 2017; Moolenaar et al., 2012) that display the importance of distributed teacher education on CE.

## 7 Limitations

This study has some limitations. The first is our small sample of 20 teachers in terms of survey data, and 21 teachers in terms of participation in all activities. While our t-test and regression analyses could still be conducted on this sample, results may not be generalizable. However, the richness of data analyzed makes up for the lack of a large sample. Our network analysis and narrative elaboration of behavior survey responses enabled a deeper understanding of the processes followed by teachers, better explaining the results from the self-report responses of our sample. We also acknowledge the population for which this study was conducted (special educators at a technology-enhanced independent school) limits its scope for generalizability; however, since we focus on the idea of mastery experiences in Bandura's theory, the existing technology-related skills possessed by teachers turned out to be an important asset in our results, since teachers with the most technology related mastery experiences grew most from the PD. The paucity of literature related to collaborative PD and its effects on teacher CE in special education contexts also presents a strength for the present



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study. Future directions involve adapting and replicating this approach with special educators in public schools and general educators.

## 8 Conclusion

The results of this study display how using collaborative, technology-assisted methods for professional development focused on behavior management and student learning can heighten the CE of special educators. The fact that mastery experiences played a vital role in guiding increases in collective efficacy explicitly points back to Bandura's work, showing scope to apply social cognitive theory to further efforts that investigate the effectiveness of teacher learning. We used self-report variables to understand how teachers think about their own behaviors as a team or collective. But, our analysis of PD artifacts, that adds a mixed methods dimension to the current study highlights observable conversational processes and practices, mediated by technology, that teachers can engage in to create a unified understanding of learning, behavior, and global culture within their school environment.

## Appendix A

**Table 2** Behavior Management Survey questions

| Question Type | Question Content |
|---|---|
| Multiple Choice | Which area would you say you find most challenging when it comes to tackling problem behaviors in the classroom?<br>• Maintaining on-task behavior in class<br>• Non-compliance with the rules for social etiquette in class<br>• Active disruption of classroom activities by students<br>• Non-completion of assigned work |
| Open-Ended Response (Textbox) | State an example or case from your classroom focusing on the broad theme from your choice in the previous question; describing a time you encountered a behavior management issue. Describe it in 2–3 sentences. This response will be collected by your group's facilitator and discussed in your group level pod. The only rule we request to follow is not directly naming any student |



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**Table 3** Cohesive staff subscale in Donohoo et al.'s (2020) teacher collective efficacy scale

| Items | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| I know about the feedback my colleagues provide to students | 1 | 2 | 3 | 4 | 5 | 6 |
| I am aware of the teaching practices used by others on staff | 1 | 2 | 3 | 4 | 5 | 6 |
| The staff holds shared beliefs about effective instructional approaches | 1 | 2 | 3 | 4 | 5 | 6 |
| The staff holds shared beliefs about what constitutes effective classroom instruction | 1 | 2 | 3 | 4 | 5 | 6 |
| The staff agrees about assessment strategies that are the most effective | 1 | 2 | 3 | 4 | 5 | 6 |



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**Table 4** Technical knowledge subscale from Schmidt et al.'s (2009) TPACK scale

| Items | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| I know how to solve my own technical problems | 1 | 2 | 3 | 4 | 5 |
| I can learn technology easily | 1 | 2 | 3 | 4 | 5 |
| I keep up with important new technologies | 1 | 2 | 3 | 4 | 5 |
| I frequently play with the technology | 1 | 2 | 3 | 4 | 5 |
| I know about a lot of different technologies | 1 | 2 | 3 | 4 | 5 |
| I have the technical skills I need to use technology | 1 | 2 | 3 | 4 | 5 |
| I have had sufficient opportunities to work with different technologies | 1 | 2 | 3 | 4 | 5 |

**Table 5** Fieldnote template (own elaboration)

| Activity/Division | Lower | Middle | Upper | Specials |
|---|---|---|---|---|
| Vision Boarding | | | | |
| Behavior Management | | | | |

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**Data availability** This paper uses data from 21 special education teachers at an independent school. Data is stored confidentially and aggregated or deidentified responses may be requested by external stakeholders within reason.

## Declarations

**IRB approval** This study was approved by the Institutional Review Board at Virginia Wesleyan University as an exempt study investigating regular educational activities.

**Consent to participate** This paper uses data from 21 special education teachers at an independent school. Teachers consented to study participation.

**Clinical trial number** This paper is not a clinical trial.

**Competing interests** The authors declare and confirm that they do not have any competing interests.

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