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# Student Camera Use in Synchronous Classrooms: A Two-Study Exploration of CTML's Embodiment Principle

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**Keywords:** online learning, cognitive theory of multimedia learning (CTML), student-to-student communication, Zoom pedagogy, camera use

**Abstract:** Two studies were conducted to ascertain whether or not the embodiment principle of the Cognitive Theory of Multimedia Learning would apply to student's use of cameras in synchronous online instruction. Results from a cross-sectional dataset indicate that students who utilize their cameras report more positive outcomes than students who do not utilize their cameras. Results from a quasi-experimental design indicate that students do not report any significant differences between experiencing classes where their peers keep their cameras-on or when their peers keep their cameras-off.

## Introduction

In the spring of 2020, the COVID-19 pandemic demanded that colleges adopt new models of instruction (Wong, 2020). This abrupt change left many instructors struggling to translate their standard in-person teaching practices to these new online environments (Schwartzman, 2020). Instructors across higher education were faced with the process of renegotiating expectations for both themselves and their students, with many attempting to reconcile how their classrooms would operate in the new (virtual) normal (Miller et al., 2021). At the center of this renegotiation was the use of cameras in synchronous classrooms.

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Pre-pandemic research has demonstrated that students have negative attitudes toward video conferencing, such as the kind of synchronous classroom instruction that became common following the COVID-19 pandemic (Candarli & Yuksel, 2012). These negative perceptions of synchronous video instruction persisted during the pandemic, despite their necessity (Serhan, 2020). Left with few other options, many instructors opted to utilize synchronous video conferencing in an attempt to recreate a sense of normalcy in their pandemic classrooms. However, many instructors struggled with the lack of camera use among students (Castelli & Sarvary, 2021).

Scholars have devoted considerable energy toward investigating how instructors contribute to online learning environments (e.g., Kaufmann & Buckner, 2019; Vallade & Kaufmann, 2018), but far less is known about how students contribute to a synchronous virtual classroom. The embodiment principle of Mayer's (2021) Cognitive Theory of Multimedia Learning (CTML) provides a potential explanation for how students contribute to and experience these virtual environments. This study sought to explore students' communication of (non)embodiment on their own experience (Study 1), as well as the effect that peers' communication of (non)embodiment has on the experience of others (Study 2). More simply, the purpose of this work was to explore differences in student outcomes for those who choose to communicate with their classes via cameras and those who do not, and how those choices impact the student experience.

## Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning (CTML) asserts that individuals learn more deeply from words and pictures than they do from words alone (Mayer, 2005, 2021). Operating under the assumptions that individuals process information differently through auditory and visual channels (dual processing), have limited processing ability (limited processing capacity), and learn best when they actively engage in processing information (active processing). Notably, CTML shares similar underpinnings of theories that seek to explore how media transfers information (e.g., Media Richness Theory; Trevino et al., 1987). Media Richness Theory posits that media which can transfer more cues, faster, and more personally will result in more information transference and retention among an audience (Lackmann et al., 2021). CTML differs from Media Richness Theory by more directly exploring how media shapes learning, rather than information exchange through media regardless of context; however, it is worth acknowledging that Media Richness Theory originated in the organizational communication domain (Trevino et al., 1987), but that this theory has been applied across contexts included learning (Lackmann et al., 2021). To understand how media impacts learning Mayer offered a series of propositions meant to guide instructional choices.

Mayer (2001, 2005) noted that effective multimedia instruction should support learners in three key ways: reduction of extraneous processing, support of essential cognitive processing, and facilitation of generative cognitive processing. To serve these ends Mayer provides 15 principles for instructors to abide by in their pedagogical choices. In order to reduce extraneous processing instructors should be coherent and contiguous in their presentation of material, while also utilizing signaling and redundancy. For instructors to support essential cognitive processing they should segment their presentations and scaffold their information throughout a lesson and course (i.e., the pre-training principle). Finally, to support cognitive processing "aimed at making sense of the presented material" (Mayer, 2021, p. 52) instructors should, among other things, be visible and conversational in their approach, and use multiple forms of media to convey their lessons. The current study endeavored to explore how one of

Mayer's proposed principles, embodiment—meant to help students' generative processing—may apply to students as well as instructors.

The embodiment principle suggests that students' learning experiences can be meaningfully enhanced when they are able to see a pedagogical agent (e.g., an instructor) engaging in human-like body movements (e.g., pointing, eye contact, facial expressions; Mayer, 2014). Thus, embodiment could be conceptualized as simply as seeing individuals on a screen, rather than only hearing individuals over static images (Knoster, 2021). Indeed, Mayer (2014) asserted that instructors who engage in high-embodiment behaviors (i.e., nonverbal behaviors one might engage in during face-to-face interactions) stimulate students' motivation to engage more deeply with instructional content by providing positive social cues conducive to positive affective experiences. Research has consistently supported the claim that an instructor's use of high-embodiment behaviors leads to more positive outcomes for students—specifically retention and transfer of instructional content (Fiorella et al., 2019; Wang et al., 2018). While researchers have established that nonverbal immediacy, which is representative of embodiment, plays a meaningful role in student learning and engagement (Witt et al., 2004), less is known about how embodiment may operate in relation to a student's own actions and their perceptions of peers' actions.

Student's interaction with peers is a key component to a variety of outcomes including perceptions of learning, motivation (LaBelle & Johnson, 2018), engagement (LaBelle & Johnson, 2020), and persistence (Tinto, 1993). Researchers have also found that peer interactions in online education environments can reduce loneliness and feelings of isolation (Castelli & Sarvary, 2021; Kaufmann & Vallade, 2020). Unfortunately, students are typically less engaged with peers in online learning (Chen et al., 2008). This was exacerbated by changes in instructional modality as a result of the COVID-19 pandemic which prevented students from engaging in the kinds of pre- and post-class interactions that facilitate even the most casual of these relationships; even as society has moved into a pandemic management stage of life students have reported strained relationships (Dotson et al., 2022; Lee et al., 2021). Further, despite the necessity of online learning following the COVID-19 pandemic, students have generally held negative perceptions of online learning (Serhan, 2020) and are likely to stop using their cameras when able (Castelli & Sarvary, 2021). However, given the potential for peer relationships to have a positive impact on student experiences it is worth considering how even micro connections, such as seeing another person (i.e., embodiment), may impact students in positive ways. As society emerges from the COVID-19 pandemic, universities are likely to employ more opportunities for virtual and distance learning because of the opportunities afforded as a result of pandemic pedagogy (Benito et al., 2021; Neuwirth et al., 2020). Thus, it is important for scholars to investigate not only best teaching practices, but also to explore the experience of students and their peer-to-peer interactions as they relate to educational experiences. Thus, we reasoned that when students do utilize the camera function in their online classrooms they *may* be enacting Mayer's embodiment principle; insofar that camera users know they can be seen and thus identify with a visualized teacher. These students should then report more positive benefits than those who do not. Given this, the following hypotheses were proposed.

> H1: Students who kept their camera on the majority of the time will report more perceived cognitive learning than students who kept their camera off the majority of the time.

> H2: Students who kept their camera on the majority of the time will report more positive affect for both (a) instructor and (b) content than students who kept their camera off the majority of the time.

H3: Students who kept their camera on the majority of the time will report more state motivation than students who kept their camera off the majority of the time.

H4: Students who kept their camera on the majority of the time will report more peer connectedness than students who kept their camera off the majority of the time.

H5: Students who kept their camera on the majority of the time will report more engagement than students who kept their camera off the majority of the time.

# Methods

## Sample

Participants were 235 students solicited from a large Western public university; of those participants, 219 (93.2%) took classes via Zoom in the fall of 2020 and 164 were given the option to turn their camera on or off during class. Only students ($n$ = 164) who had both taken asynchronous and synchronous Zoom classes in the previous semester and who were given the option and freedom to turn their cameras on and off[1] were utilized in subsequent analyses. Notably, at the time of data collection this university had been utilizing complete virtual instruction the previous semester.

The average age of the final sample was 21.25 ($SD$ = 4.46; Range = 18–53). The majority of participants identified as female ($n$ = 110; 67.1%) with 38 participants identifying as male (23.2%); two participants identified as non-binary (1.2%); and one participant preferred not to answer (<1%).[2] The sample consisted of students from a variety of class ranks including 74 first-year students (45.1%), 13 sophomores (7.9%), 32 juniors (19.5%), 28 seniors (17.1%), and four graduate students (2.4%). Participants identified as a variety of ethnicities including Latino/Hispanic ($n$ = 89; 54.3%), White/Caucasian ($n$ = 25; 15.2), Asian ($n$ = 17; 10.4%), Mixed ($n$ = 11; 6.7%), Middle Eastern ($n$ = 4; 2.4%), Black/African American ($n$ = 2; 1.2%), other ($n$ = 2; 1.2%), and Pacific Islander ($n$ = 1; <1%). The majority of our sample identified as continuing generation ($n$ = 77; 47%), with 74 (45.1%) participants identifying as first-generation.

## Procedures

After receiving approval from the university's institutional review board participants were solicited via convenience sampling. Specifically, the first author asked other instructors to share the recruitment script and survey link with their students. Participants were solicited at the beginning of the Spring 2021 semester (i.e., first 4 weeks) and were asked to think back to their Fall 2020 semester courses and refer to the first course they took during the week (e.g., Monday morning) (cf. Plax et al., 1986). Participants were asked a variety of questions about their use of the camera function during their Zoom classes, before encountering several instruments meant to assess their own experience in the class. Participation was anonymous and voluntary; participants were required to be 18 years or older. Individuals did not receive any compensation for their participation.

1. This choice was made because previous research suggests that students given choices are known to experience classes differently than those who are not (Lewis & Hayward, 2010; Ryan & Deci, 2000). Further, students have described the flexibility of Zoom (e.g., the ability to turn their cameras on or off as they see fit) as the most positive benefit of synchronous online instruction, despite still holding negative attitudes toward online instruction in general (Serhan, 2020).
2. Approximately 13 (7.9%) participants did not complete demographic data (e.g., gender identity, ethnicity).

## Instrumentation

In order to assess camera use participants were asked two questions. First, they were asked to respond yes or no to the following item: "In this course I was given the option to turn my camera on or off." Only data from participants who were given the option to turn their cameras on or off were utilized in Study 1. Second, participants were asked to respond to the following item in order to assess the approximate amount of time they used their cameras: "In this course I kept my camera on about what percentage of the time?" On average, participants kept their cameras on for 47.93% of the time (Range = 0–100%; $SD = 34.33$). Participants were thus split into students who kept their camera on the majority of the time (i.e., ≥ 51%; $n = 64$; $M = 81.48$, $SD = 17.10$) and those that kept their camera off the majority of the time (i.e., ≤ 50%; $n = 78$; $M = 20.38$, $SD = 14.66$).

Perceived cognitive learning was assessed using the Cognitive Learning Measure (Frisby & Martin, 2010). This 10-item instrument measures students' perceptions of their own cognitive learning. A sample item from this scale reads as follows, "I have learned a great deal in this class." Higher scores reflect more perceived cognitive learning. The scale also performed reliably in this study ($\alpha = .89$, $M = 3.70$, $SD = .82$).[3]

Positive affect was measured using two dimensions of the Affective Learning Measure (McCroskey, 1994). This measure assesses students' affect for both instructor and content. Participants respond to four statements (e.g., "I feel the class content is . . .") using four bipolar adjective pairs (e.g., "Good-Bad"). This results with individuals providing 16 total responses, eight each for affect for instructor and affect for content. Participants in this study responded to these items along a 7-point scale (i.e., 1–7). Higher scores reflect more positive affect. Likewise, both affect for instructor ($\alpha = .96$, $M = 5.53$, $SD = 1.63$) and affect for content ($\alpha = .92$, $M = 5.28$, $SD = 1.39$) performed reliably in this study.

State motivation was measured using Christophel's (1990) state motivation scale. This instrument uses 12 semantic differential items (e.g., motivated-unmotivated) to assess a student's motivation in regards to a particular class. Participants in this study responded to these items along a 7-point scale (i.e., 1–7). Higher scores reflect more state motivation. The scale performed reliably in this study as well ($\alpha = .91$, $M = 4.26$, $SD = 1.28$).

Peer connectedness was measured using D. I. Johnson's (2009) 13-item version of Dwyer et al.'s (2004) Connected Classroom Climate Inventory. This scale measures students' perceptions of an open and supportive communication environment among peers along a single dimension. A sample item from this measure reads "I have common ground with my classmates." Higher scores reflect more connection among peers. The scale performed reliably in this study ($\alpha = .95$, $M = 3.36$, $SD = .98$).

Student engagement was measured using Mazer's (2012) 13-item student engagement scale, which assesses student engagement along four dimensions: silent in-class behaviors (e.g., "listened attentively to the instructor during class"), oral in-class behaviors (e.g., "participated during class discussions by sharing your thoughts/opinions"), thinking about course content (e.g., "thought about how you can utilize the course material in your everyday life"), and out-of-class behaviors (e.g., "talked about the course material with others outside of class"). Participants responded to items regarding their frequency

3. Unless otherwise noted all responses in both Study 1 and Study 2 were made on a 5-point Likert-type scale ranging from strongly disagree (1) to strongly agree (5).

of engagement with each item; a 7-point Likert-type scale with bipolar options (never/very often) was used for participant responses. Higher scores reflect more student engagement. The four dimensions each performed reliably in this study: silent in-class behaviors ($\alpha = .80$, $M = 5.58$, $SD = 1.07$), oral in-class behaviors ($\alpha = .88$, $M = 4.51$, $SD = 1.79$), thinking about course content ($\alpha = .91$, $M = 4.65$, $SD = 1.83$), and out-of-class behaviors ($\alpha = .81$, $M = 4.40$, $SD = 1.55$).

## Results

Zero order correlations for all variables are available in Table 1.

Hypothesis 1 posited that students who kept their camera on the majority of the time would report more perceived cognitive learning than students who kept their camera off the majority of the time. An independent samples $t$-test indicated that students who kept their cameras on ($n = 60$, $M = 3.94$, $SD = .75$) the majority of the time did report more perceived cognitive learning than those who kept their cameras off ($n = 76$, $M = 3.68$, $SD = .83$) ($t\ (134) = 2.08$, $p = .02$; Cohen's $d = .36$ [95% CI: .017 – .70]). Hypothesis 1 was supported.

Hypothesis 2 explores the relationship between camera use and (a) instructor and (b) content. A series of independent samples $t$-test indicated that students who kept their cameras on (positive affect for instructor: $n = 56$, $M = 6.05$, $SD = 1.47$; positive affect for content: $n = 56$, $M = 5.81$, $SD = 1.32$) the majority of the time did report more affect than those who kept their camera's off (positive affect for instructor: $n = 71$, $M = 5.43$, $SD = 1.68$; positive affect for content: $n = 72$, $M = 5.17$, $SD = 1.38$) (Affect for instructor: $t\ (125) = 2.18$, $p = .02$; Cohen's $d = .39$ [95% CI: .037–.744]; Affect for content: $t\ (126) = 2.67$; $p = .01$; Cohen's $d = .48$ [95% CI: .12–.83]). Hypothesis 2 was supported.

Regarding motivation (H3) an independent samples $t$-test indicated that students who kept their cameras on ($n = 59$, $M = 5.01$, $SD = 1.36$) the majority of the time did report more state motivation than those who kept their cameras off ($n = 75$, $M = 3.87$, $SD = 1.03$) ($t\ (105.04) = 5.36$; $p < .001$; Cohen's $d = .97$ [95% CI: .6–1.32]). Hypothesis 3 was supported.

**TABLE 1**
**Study 1 Zero Order Correlations**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Perceived Cognitive Learning | | | | | | | | |
| 2. Affect for Instructor | .69 | | | | | | | |
| 3. Affect for Content | .71 | .70 | | | | | | |
| 4. Motivation | .63 | .60 | .56 | | | | | |
| 5. Connectedness | .26 | .29 | .26 | .37 | | | | |
| 6. Silent-in-class engagement | .54 | .43 | .45 | .59 | .37 | | | |
| 7. Oral-in-class engagement | .43 | .28 | .32 | .50 | .40 | .50 | | |
| 8. Thinking about content engagement | .66 | .39 | .61 | .58 | .36 | .55 | .49 | |
| 9. Out-of-class engagement | .49 | .30 | .40 | .54 | .34 | .52 | .30 | .51 |

Note: All correlations significant at the $p < .001$ level.

Hypothesis 4 posited that students who kept their camera on the majority of the time would report more peer connectedness than students who kept their camera off the majority of the time. An independent samples *t*-test indicated that students who kept their cameras on ($n$ = 60, $M$ = 3.73, $SD$ = 1.03) the majority of the time did report more classroom connectedness than those who kept their cameras off ($n$ = 73, $M$ = 3.21, $SD$ = .91) ($t$ (131) = 3.12; $p$ = .001; Cohen's $d$ = .54 [95% CI: .195–.891]). Hypothesis 4 was supported.

Finally, hypothesis 5 inquired about how engagement might be different among camera users and non-users. A series of independent samples *t*-tests indicated that students who kept their cameras on (silent in-class: $n$ = 60, $M$ = 5.99, $SD$ = 1.06; oral in-class: $n$ = 61, $M$ = 5.48, $SD$ = 1.47; thinking: $n$ = 59, $M$ = 5.37, $SD$ = 1.68; out-of-class: $n$ = 61, $M$ = 4.79, $SD$ = 1.77) the majority of the time reported more silent in-class engagement ($t$ (131) = 3.54; $p$ < .001; Cohen's $d$ = .62 [95% CI: .267–.966]), oral in-class engagement ($t$ (132) = 5.26; $p$ < .001; Cohen's $d$ = .91 [95% CI: .553–1.27]), thinking about content engagement ($t$ (130) = 3.42; $p$ < .001; Cohen's $d$ = .60 [95% CI: .246–.948]), and out-of-class engagement ($t$ (116.23) = 2.31; $p$ = .01; Cohen's $d$ = .41 [95% CI: .064–.751]) than those who kept their cameras off (silent in-class: $n$ = 73, $M$ = 5.36, $SD$ = .97; oral in-class: $n$ = 73, $M$ = 4.02, $SD$ = 1.69; thinking: $n$ = 73, $M$ = 4.34, $SD$ = 1.77; out-of-class: $n$ = 73, $M$ = 4.13, $SD$ = 1.46). Hypothesis 5 was supported.

## Study 1 Discussion

Results from Study 1 indicate that students who utilized their cameras more than half the time in their classrooms reported more positive outcomes—specifically, greater perceived cognitive learning, positive affect, motivation, connectedness, and engagement—than students who did not. There are several plausible explanations for these findings. First, these findings support the notion that students' own demonstration of the embodiment principle (i.e., their own reported camera use) results in more positive outcomes. Students' willingness to be seen—embodiment—may encourage them to more thoroughly engage in the course and with material, than if they are not allowing themselves to be seen. To date, CTML and its corresponding propositions have only been applied to instructors. It appears that there is evidence to suggest that students' own embodiment may impact both their desire and ability to comprehend material. Future studies should continue to explore how students' own choices, such as camera use, impact their own experiences and that of their peers.

Additionally, the differences observed in this study may be due to camera users being different than non-camera users on a variety of characteristics. For example, these students may be more academically or technologically efficacious than their peers. Goldman et al. (2018) noted that academic self-efficacy might be the most critical factor in explaining differential student outcomes. When approaching virtual instruction, students high in academic self-efficacy might simply be better equipped to deal with the challenges presented to them. It might also be that students who use their cameras, and are thus more technologically efficacious, are simply more prone to succeed because of their own beliefs in their abilities.

Further, it may be that students who use their cameras are simply different types of communicators than their peers who do not. Perhaps camera users would report higher levels of sociability traits (e.g., willingness to communicate, extroversion, openness) and lower levels of traits indicative of apprehension (e.g., communication apprehension, introversion). As such, these students may be more prone to explore support options when faced with challenges than students who are more reticent. Framed another way, camera users may have been more interested in engaging with others and being seen by others during this time period (i.e., the first semester of fully virtual instruction which coincided with the most stringent lockdowns and distancing). Notably, the current study only explored these relationships cross-sectionally; future research should consider how student characteristics drive camera use and thus outcomes, rather than simply exploring the differences between camera users and non-users.

It may also be that individuals who utilized their cameras were less fatigued than those who did not use their cameras. Bailenson (2021) described that on Zoom individuals must work harder to send, receive, and self-monitor. This may have resulted in individuals often choosing to simply turn their cameras off when given the option. Indeed, Zoom fatigue includes not only visual fatigue, but also motivational fatigue (Fauville et al., 2021). Thus, individuals who may have been required to keep their cameras on for work, other classes, or family/social commitments could have been experiencing greater Zoom fatigue in all its various forms. In the future researchers should consider how external factors such as work, hours spent on Zoom, and even personal characteristics influence Zoom fatigue and therefore moderate the myriad benefits of virtual interactions.

Another potential explanation is that students who keep their cameras off are dealing with a host of other issues unrelated to their education. Indeed, Castelli and Sarvary (2021) found that students do not use their cameras for a variety of reasons, including the strength of internet connection and their physical background being seen by others. They claim these issues likely disproportionately affect underrepresented minorities (Castelli & Sarvary, 2021); this is likely exacerbated by the reality that the COVID-19 pandemic has disproportionally affected communities of color (Karaca-Mandic et al., 2020). Issues of diversity, equity, and inclusion have long been concerns across higher education (see Salmi & D'Addio, 2020), which have only been exacerbated by the increasing prevalence of virtual learning as a result of the COVID-19 pandemic (Burgstahler, 2021). Students who keep their cameras off may already be at a disadvantage compared to those who utilize their cameras more frequently. More simply put, these students may not have the support, skills, or opportunities necessary to navigate the new demands of a changing educational landscape. Notably, the ability to blur backgrounds and more easily use virtual backgrounds also reflects issues of equity as this functionality requires more advanced and powerful processing that not all student (or faculty) computers may possess; further, this functionality was first introduced to Zoom users in version 5.5.0 in February of 2021 (Zoom, 2022). These data were collected in fall of 2020 and thus participants of Study 1 did not have that option available to them. As higher education moves forward, virtual instruction should be considered in concert with an understanding that camera use may not be something easily demonstrated by all students.

Finally, it may be that these individuals simply experienced better teaching, and thus reported more positive outcomes. The impact of teachers in online environments is well established (e.g., Vallade & Kaufmann, 2018). The purpose of this study was not to explore the impact of teacher behavior or course policies (e.g., choices related to camera use), but rather to understand how students who use their cameras differ from their peers who do not use cameras with respect to typical instructional communication outcomes. It may be that students who kept their cameras on were subject to more engaging and effective instruction than those who utilized their cameras less. Thus, future research should employ designs that account for not only student choices (e.g., camera use), but also pedagogical differences that may explain students' online experiences.

## Study 1 Conclusion

Overall, these data offer support for the application of Mayer's (2021) embodiment principle in exploring the impact of a student's own camera use on their online learning experiences. That is, when students allow themselves to be seen, they self-report more positive outcomes than their peers who do not. However, while the current study explored students' perceptions of their learning, it did not assess the extent to which students actually learned. Further, the current study did not ascertain whether students were able to see their peers during class. Thus, we conceptualized Study 2 to more thoroughly explore how student camera use relates to outcomes similar to those observed in this study.

## Study 2 Rationale

Mayer's (2021) embodiment principle claims that individuals will learn more when they can see a pedagogical agent engaging in human-like behavior. Instructional communication scholars have demonstrated that students learn and are impacted by their interactions with peers (e.g., LaBelle & Johnson, 2018, 2021). Further, Study 1 indicates that within virtual classrooms when students allow themselves to be seen, that is when they utilize their cameras, they similarly report higher levels of positive outcomes. However, Study 1 does not explore the impact of seeing peers. Nor does Study 1 explore the impact that peers' embodiment might have on actual learning. As research exploring student–student interactions has often been considered both from a sending and receiving standpoint (Z. D. Johnson & LaBelle, 2016) it seems appropriate to consider not only how students' own embodiment (i.e., sending embodied messages themselves, explored in Study 1) may impact their experiences, but also how seeing others may impact their self-reported outcomes (i.e., that is reception of embodied messages from peers). Based on the principles outlined by Mayer (2021) and the findings of Study 1 it appears that students who encounter embodiment from their peers are likely to report higher levels of positive outcomes (e.g., learning recall, affective learning, motivation, and connection to peers). To that end a quasi-experimental study was conducted to assess the following hypotheses:

> H1: Students exposed to a lesson with all peer cameras on will report more cognitive learning than those exposed to a lesson with all peer cameras off.
>
> H2: Students exposed to a lesson with all peer cameras on will report more positive affect for (a) instructor and (b) content than those exposed to a lesson with all peer cameras off.
>
> H3: Students exposed to a lesson with all peer cameras on will report more state motivation than those exposed to a lesson with all peer cameras off.
>
> H4: Students exposed to a lesson with all peer cameras on will report more perceived classroom connectedness than those exposed to a lesson with all peer cameras off.

## Methods

### Participants

Participants were 119 students solicited from a large Western public university. Participants ranged from 18 to 47 years old. The average age of the sample was 23.82 ($SD = 5.44$). The majority of participants identified as female ($n = 71$; 60.2%) with 47 participants identifying as male (39.8%); no participants selected the inclusive options of "non-binary" or "prefer not to answer." The sample consisted of students from a variety of class ranks including 24 first-year students (20.3%), five sophomores (4.2%), 32 juniors (27.1%), 56 seniors (47.5%), and one graduate student (<1%). Participants identified as a variety of ethnicities including Latino/Hispanic ($n$ = 49; 41.5%), White/Caucasian ($n$ = 22; 18.6%), Asian ($n$ = 19; 16.1%), Mixed ($n$ = 15; 12.7%), Middle Eastern ($n$ = 5; 4.2%), Black/African American ($n$ = 2; 1.7%), other ($n$ = 3; 2.5%), and Pacific Islander ($n$ = 2; 1.7%). The majority of our sample identified as continuing generation ($n$ = 68; 57.6%) with 50 (42.4%) participants identifying as first-generation.

## Procedures

After receiving approval from the Institutional Review Board, one of the researchers visited Zoom classrooms to invite students to participate. Individuals were directed to an online data collection system. After providing consent participants were randomly assigned to one of two conditions presented via a video: (1) a cameras-on condition (10:08 in length) in which a lesson was presented in the gallery view of Zoom with all 22 (21 "students" and one instructor) participant cameras-on and (2) a cameras-off condition (9:22 in length) in which the same lesson was presented in gallery view with only the instructor camera on (this condition appeared as a Zoom room with one visible individual and 21 blocks with no name or face attached). The lesson was scripted and covered the basic tenets of Self-Determination Theory (Ryan & Deci, 2000). Videos were created using volunteer students from an upper division communication theory course. Each individual was instructed to change their Zoom display name to a pseudonym and appear engaged and interested in the camera on condition. For the video off condition each participant turned their camera off and remained muted, this allowed for students to still appear to be in the Zoom room. The lecture script and videos are available from the first author. Participants were given the following instructions along with video "Please watch the entire video. Do not skip ahead. You will be asked to answer a series of questions regarding the content of this lecture and your experience after it concludes." Within the data collection system participants were unable to advance in the questionnaire until 10 minutes had passed for both conditions. A review of the video watch statistics indicates viewership that is reflective of the degrees of freedom obtained within the $t$-tests described below.

## Instrumentation

### *Test Variables*

Learning was assessed using a 10-item multiple-choice test that was developed in accordance with the lecture. The quiz assessed lower levels of learning (e.g., recall, understanding, application). Participants were asked about the various psychological needs purported by the theory (e.g., "If you feel like you're a master of given tasks SDT would suggest that you have satisfied which of the following basic needs?"), and differences in motivation relative to the broader tenets of SDT (e.g., "Which of the following terms is best described as motivation that occurs as the result of a separate outcome or reward?"). Each question had four possible answers (i.e., one correct and three incorrect). The measure was created by the first author who then asked the second author if it appeared to measure the basic tenets of SDT and the appropriate levels of learning.[4] Participant responses were dichotomized into correct (scored as 1) or incorrect answers (scored as 0). Scores on this 10-item quiz were then totaled for use in subsequent analysis ($KR-20$ = .68, $M$ = 7.44, $SD$ = 2.15; Range = 1–10). This measure is available from the first author.

4. While each author is well-versed in the construction and development of both perceptive and objective instruments, neither author is a formal psychometrician and thus, in this case, face validity only represents an appearance of assessing the basic tenets of SDT theory, and not whether or not there were potential testing effects or wording issues with each question.

As with Study 1, positive affect was measured using McCroskey's (1994) Affective Learning Measure. Participants were asked to respond regarding their experience in the lesson they just watched. Participants responded on a 7-point semantic differential scale. Both dimensions of this scale performed reliably in this study (affect for instructor: α = .96, *M* = 5.44, *SD* = 1.42; affect for content: α = .90, *M* = 5.23, *SD* = 1.16).

Motivation was measured using four representative items from Christophel's (1990) State Motivation Scale (i.e., motivated-unmotivated, interested-uninterested, not stimulated-stimulated, don't want to study-want to study). Participants responded on a 7-point semantic differential scale. The scale performed reliably in this study (α = .83, *M* = 4.16, *SD* = 1.49).

Connectedness was measured using four representative items from Dwyer et al.'s (2004) Connected Classroom Climate Inventory. Items were also adapted for use in the experimental context by adding "I feel like if I were a member of this class," to the stems from the original scale. For example, the original item "The students in my class are concerned about one another," was changed to "I feel like if I was a member of this class the other students would be concerned about me." This scale performed reliably in this study (α = .77, *M* = 3.36, *SD* = .75).

## Confound Check Variables

To ensure that instruction was standard across both conditions, that the conditions (though artificial) were perceived as one in which participants could realistically encounter, and that participants had no great prior knowledge of the content of the lesson several potential confounds were assessed. These confounds were selected based off the work of exemplary instructional communication research which has employed similar quasi-experimental designs (e.g., Bolkan et al., 2016; Kromka & Goodboy, 2021).

Instructional clarity was measured using the five items developed by Bolkan et al. (2016) based off of the work of Chesebro and McCroskey (1998). These five items measure the clarity with which the instructor presented material from the less. Higher scores reflect greater perceptions of instructor clarity. Sample items include "This lesson was clear" and "This lesson was easy to follow." This scale has performed reliably in the past (α = .95; Bolkan et al., 2016). This scale performed reliably in this study (α = .94, *M* = 4.08, *SD* = .86).

Plausibility was measured using an adapted version of Cho et al.'s (2014) plausibility subscale, from the Perceived Realism Scale. In this study, the measure ascertained whether participants find this lesson to be representative of an actual classroom experience. Items were adapted for the instructional setting by changing the stems of the original scale from advertising related concepts to "This lesson…" Higher scores reflect more perceived plausibility. This scale performed reliably in this study (α = .80, *M* = 3.94, *SD* = .74).

Perceived familiarity was measured using Bolkan et al.'s (2016) three-item *perceived familiarity scale* (e.g., "How familiar were you with this topic before today?"). These items reflect an individual's prior knowledge of a subject. This scale has performed reliably in the past (ω = .86; Kromka & Goodboy, 2021). This scale performed reliably in this study as well (α = .93, *M* = 2.18, *SD* = 1.1).

Perceived difficulty was measured using one item (e.g., "How difficult would this material be to learn if taught in an ideal manner?"). This item measures an individual's perception of how challenging they find the material. This has been used by previous scholars as well (Bolkan et al., 2016; Kromka & Goodboy, 2021). Participants responded on a 5-point Likert-type scale ranging from *very difficult (1)* to *very easy (5)* ($M$ = 3.47, $SD$ = .9).

# Results

## Preliminary Analysis

In order to assess potential differences between the quality of instruction between the two conditions, participants were asked to report on the clarity of instruction, plausibility of instruction, familiarity with the topic, and perceived difficulty of the topic. No significant differences were observed between the two conditions on clarity of instruction, plausibility of instruction, or familiarity with the topic. A small difference did appear between the groups regarding the perceived difficulty of the topic with the cameras-on condition reporting slightly higher perceived difficulty than the cameras-off condition; this may be due to the one item measure to assess perceived difficulty. Taken together, these results indicate that across the two conditions the groups were largely homogenous in their previous understanding of the topic and perception of the topic. These results are available in Table 2. Zero order correlations from Study 2 are available in Table 3.

**TABLE 2**
**Study 2 Manipulation Check**

| | | | Cameras-On Lesson | Cameras-Off Lesson |
|---|---|---|---|---|
| Clarity | $t(116) = -.89$, $p = .19$, Cohen's $d = .16$ [95% CI: –.53–.20] | | | |
| | | M | 4.15 | 4.01 |
| | | SD | .83 | .89 |
| | | *N* | 57 | 61 |
| Plausibility | $t(116) = .15$, $p = .44$, Cohen's $d = .03$ [95% CI: –.33–.40] | | | |
| | | M | 3.93 | 3.93 |
| | | SD | .82 | .68 |
| | | *n* | 57 | 61 |
| Familiarity | $t(116) = -1.04$, $p = .15$, Cohen's $d = .19$ [95% CI: –.55–.17] | | | |
| | | M | 2.29 | 2.08 |
| | | SD | 1.22 | .97 |
| | | *N* | 57 | 61 |
| Difficulty | $t(116) = 1.84$, $p = .03$, Cohen's $d = .34$ [95% CI: –.03–.70] | | | |
| | | M | 3.63 | 3.33 |
| | | SD | .94 | .85 |
| | | *n* | 57 | 61 |

**TABLE 3**
**Study 2—Zero Order Correlations**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Learning | | | | | | | | |
| 2. Affect for Instructor | .20* | | | | | | | |
| 3. Affect for Content | .31** | .73*** | | | | | | |
| 4. Motivation | .05 | .54*** | .54*** | | | | | |
| 5. Connectedness | –.17 | .36*** | .28** | .44*** | | | | |
| 6. Clarity | .24** | .69*** | .60*** | .56*** | .34*** | | | |
| 7. Plausibility | .24* | .30** | .12 | .01 | .04 | .24** | | |
| 8. Familiarity | .00 | –.06 | .00 | –.07 | –.11 | .14 | .00 | |
| 9. Difficulty | –.19* | .11 | .01 | .07 | .08 | –.12 | –.15 | –.36*** |

Note: *** $p < .001$, ** $p < .01$, * $p < .05$

Hypothesis 1 posited that students exposed to a cameras-on lesson will report more cognitive learning than those exposed to a cameras-off lesson. An independent samples *t*-test did not reveal a significant difference between students exposed to a cameras-on lesson ($n = 56$, $M = 7.54$, $SD = 2.12$) and students exposed to a cameras-off lesson ($n = 61$, $M = 7.31$, $SD = 2.17$) ($t$ (116) = –.56, $p = .57$, Cohen's $d$ = –.10 [95% CI: –.47–.26]). Hypothesis 1 was not supported.

Hypothesis 2 suggested that students exposed to a cameras-on lesson will report more positive affect for (a) instructor and (b) content than those exposed to a cameras-off lesson. A series of independent samples *t*-test (instructor: $t$ (115) = .84, $p = .20$, Cohen's $d = .16$ [95% CI: –.21–.52]; content; $t$ (115) = .27, $p = .39$, Cohen's $d = .05$ [95% CI: –.31–.41]) did not reveal a significant difference between students exposed to a cameras-on lesson (affect for instructor: $n = 56$, $M = 5.33$ $SD = 1.5$; affect for content: $n = 56$, $M = 5.22$, $SD = 1.22$) and students exposed to a cameras-off lesson (affect for instructor: $n = 61$, $M = 5.55$, $SD = 1.36$; affect for content: $n = 61$, $M = 5.28$, $SD = 1.11$). Hypotheses 2 (a) and 2 (b) were not supported.

Hypothesis 3 argued that students exposed to a cameras-on lesson will report more state motivation than those exposed to a cameras-off lesson. An independent samples *t*-test did not reveal a significant difference between the cameras-on lesson ($n = 57$, $M = 4.07$, $SD = 1.49$) and the cameras-off lesson ($n = 61$, $M = 4.24$, $SD = 1.51$) ($t$ (116) = .61, $p = .27$, Cohen's $d = .11$ [95% CI: –.25–.47]). Hypothesis 3 was not supported.

Hypothesis 4 posited that students exposed to a cameras-on lesson will report more perceived classroom connectedness than those exposed to a cameras-off lesson. An independent samples *t*-test did not reveal a significant difference between those exposed to a cameras-on lesson ($n = 57$, $M = 3.42$, $SD = .72$) and those exposed to a cameras-off lesson ($n = 61$, $M = 3.3$, $SD = .79$) ($t$ (116) = –.94, $p = .18$, Cohen's $d$ = –.17 [95% CI = –.53–.19]). Hypothesis 4 was not supported.

## Study 2 Discussion

In contrast to the findings of Study 1, the findings of Study 2 suggest that peers' camera use may not play a meaningful role in influencing instructional outcomes. Students who encounter embodied messages from their peers do not appear to be impacted by these messages in hypothesized way. As such, it may be that the embodiment principle has a more nuanced relationship to student-student interactions. Indeed, embodied interactions between peers may exist differently within peer-only interactions (e.g., breakout rooms). Recall that the embodiment principle asserts that students being able to see their instructors behaving in human-like ways will cultivate an increased sense of social presence and thus engagement, as well as other positive outcomes (Mayer, 2021). Simply put, when instructors utilize the embodiment principle by showing themselves engaging in high-embodiment behaviors, students engage almost as a courtesy to another human being. It is plausible that students' camera use would increase an instructor's sense of social presence (see Ratan et al., 2022), thus making them feel as though they are interacting with other real individuals who are there alongside them and thereby motivating them to invest more energy when teaching the lesson. Researchers have demonstrated—and we can anecdotally concur—that teaching to students not utilizing their cameras is challenging for a variety of reasons (Castelli & Sarvary, 2021; Englander & Russell, 2022).

Mottet's work on student responsiveness can provide further insight into these findings. The ways students respond to teachers have a wide-ranging impact on everything from a teacher's willingness to comply with student requests (Mottet et al., 2004b) and grading practices (Mottet et al., 2005) to teacher self-efficacy and job satisfaction (Mottet et al., 2004a). In the experimental, and thus somewhat artificial, nature of Study 2, students received instruction that was approximately the same. That is to say, the two lessons were kept consistent in delivery. Mottet's findings point to a reality that student responsiveness leads to more satisfied and likely more engaging teachers. Given this, it stands to reason that across the course of a semester when students opt to keep their cameras off, thus limiting their responsiveness (i.e., embodiment), teachers who are teaching synchronously and utilizing lectures may experience class in ways that lead to very different teaching than when students are responsive (i.e., cameras on). Future research could also consider how asynchronous and flipped modalities are impacted by the use of student cameras in assignment submissions, or during discussion. Ultimately, it is feasible that students seeing other students might not be what ultimately drives positive outcomes in online environments. Rather, it may be a much more nuanced relationship between *students seeing their instructor* and an *instructor seeing their students*.

## General Discussion

Overall, it appears that Mayer's (2021) embodiment principle may not apply to students in the same way that it applies to instructors. Given that instructional communication researchers have demonstrated that students and teachers engage in similar processes with unique messages and strategies (Z. D. Johnson & LaBelle, 2016), this is unsurprising. It appears that students' embodiment, and perception of peers' embodiment, has differential effects. Perhaps, instead of increased connectedness, there is simply a decreased sense of isolation or stress (Kaufmann & Vallade, 2020), or it may be that more visual cues impact a student's own sense of reticence regarding class participation—especially when considering differences in frequency of camera use among students and potential issues associated with camera use (e.g., background sharing). It may also be that students who use their cameras possess a variety of characteristics which amount to a profile of students in virtual instruction. Likewise, for some students it may be that the extra nonverbal information communicated to peers via camera use makes it more challenging to focus solely on the lecture at hand. While the principles of CTML, specifically the embodiment principle, may not translate to students, researchers should continue to consider how students may impact the virtual learning experience of their peers, especially as the necessity of building virtual communication skills continues to grow in importance for success beyond the academy. The findings from this study demonstrate that the embodiment principle of CTML is not an appropriate explanatory mechanism for how the virtual student experience is impacted by other students. As such, we encourage researchers to continue exploring how theories of learning and instruction can more readily explain the online learning experience, rather than overlooking the impact that students can have on one another or by approaching the context from a product-process paradigm or a variable analytic framework.

When considering the results from both Study 1 and Study 2, it is evident that more research is necessary to fully grasp the role that students' camera use plays in their online learning experiences. Researchers have argued that the pedagogical practices of instructors are shaped by their interactions with students (Bolkan & Holmgren, 2012; Z. D. Johnson et al., 2018; Mottet et al., 2004a, 2004b, 2005). Further, student-teacher interaction can also impact instructors' approach to their job (Frisby et al., 2015). It may be the case that less embodiment from students leads to dissatisfaction among teachers, and thus less care and attention in their lesson planning, design, classroom management, and content delivery. Future research in both online and face-to-face environments should consider the reciprocal nature between student behavior and teacher behavior.

## Practical Implications

While these results do not support CTML's application to student camera use as a way to understand student outcomes, these studies still have some practical applications to offer instructors and administrators. Based on the results of Study 1, it seems that students who utilize their camera at least *perceive* more positive instructional outcomes than students who do not. While Study 2 revealed no differences between cameras-on and cameras-off conditions related to learning, motivation, and connectedness, we did not assess engagement. It may be that students who utilize their cameras are simply more engaged, and thus more likely to report higher levels of positive outcomes. Further, it may be that having their cameras on leads to more engagement, rather than an intrinsic sense of engagement driving the camera use. Certainly, this would be a fruitful area of scholarship, especially as higher education continues to adapt to a post-pandemic virtual sense of normalcy. However, without knowing if cameras drive engagement or if engaged students simply use their cameras more, instructors are faced with the issue of requiring camera use and the myriad of issues raised by such a policy (e.g., equity issues). As noted above, students who are given choices in their experience report more positive outcomes than those who are forced into given circumstances (Lewis & Hayward, 2010; Ryan & Deci, 2000). Thus, we do not recommend *mandating* camera use—instead, it may be that continual encouragement from the instructor to use cameras would be beneficial for students and teachers alike. Indeed, instructors could plan for specific "cameras on" days or have short low-stakes "cameras on" portions of class in order to build efficacy among those who are hesitant to use their cameras. Likewise, it may be beneficial for the class to rotate cameras on moments among groups of students (i.e., students could count off and know that every fifth class they will be expected to turn their cameras on). Such moments may help other students to feel as though they are not alone in their experience. Further, by planning these moments ahead of time, students with equity-based issues could contact the instructor for alternative opportunities, or plan ahead to be sure that turning their camera on will be feasible. While such moments may have only small direct effects for students, they may have largely beneficial effects for the instructor—which in turn serves the students' experience.

Finally, instructors may also simply take note of camera users and non-users, and make efforts to check in on non-camera users. Given the perceived differences between these students noted in Study 1 such efforts may make notable differences in the experience of non-camera users. This may hold especially true for students who keep their cameras off due to equity issues, as such efforts to connect—from a member of the institution—may help them to feel more connected and thus less likely to depart before degree completion (Tinto, 1993).

## Theoretical Implications

While the embodiment principle of CTML (Mayer, 2005) does not easily apply to students' camera use, there may still be theoretical mechanisms that could help to guide future research in this area. First, future researchers should consider the ways that students' camera use satisfies a basic psychological need for belonging (Ryan & Deci, 2000). It may be that students who utilize their cameras feel as though they are more connected to their peers, instructor, and university community than those who do not, thus they report higher positive outcomes. Similarly, receiving the opportunity to turn their cameras on, rather than being forced to do so, may result in more positive experiences given an instructor's respect for students' autonomy (Ryan & Deci, 2000). Overall, it may be that Self-Determination Theory works to explain much of the reasoning for student camera use and the differential outcomes reported in Study 1.

Another potential theoretical explanation may be the Actor Partner Independence Model (Cook & Kenny, 2005). APIM explains that dyads (e.g., students and teachers) are interdependent in their actions (Cook & Kenny, 2005). Results from Study 2 indicate that, when teaching is held constant, students report no differences in outcomes from cameras-on and cameras-off conditions. However, as previously noted, instructors' pedagogical choices are certainly impacted by student behavior (Mottet et al., 2004a, 2004b, 2005). Thus, the differences observed in Study 1 may be the result of student camera use impacting teachers' approaches to instruction, and thus the experiences of students. Moving forward, researchers should consider the ways in which students and teachers are interdependent, especially in virtual environments.

## Limitations and Future Directions

These studies were met with several limitations. First, students in Study 1 were not asked whether or not their peers kept their cameras on. It may be that for those students who were utilizing their cameras, their peers were also. While Study 2 partially addresses this limitation in design, it is still an artificial experiment. Real classrooms likely operate somewhat differently. Future research should explore not only student self-report camera use, but also the reported camera use of peers.

Second, as is commonly reported in communication-based experiments (Knoster & Goodboy, 2021), Study 2 utilized a multiple-choice test immediately following a lecture. While short-term recall is a component of learning, it is indeed a lower level of learning compared to synthesis or evaluation. It is possible that student recall over time would be different for students with cameras-on and cameras-off lessons. Goodboy et al. (2018) stated such designs overlook "students' meaningful efforts to learn that include notetaking, studying, and reading," (p. 321). Knoster and Goodboy note that future research could use different time intervals to assess learning. Researchers should continue to explore ways to assess meaningful levels of learning, rather than just recall.

An additional limitation of Study 2 was that while efforts were made to ensure that students played the entire video (e.g., timings in the online questionnaire) there is no way to know for certain that they sat and watched the video. They may have been occupied while the video played and they listened, but did not watch, attentively. The freedom afforded students in online environments is often cited as a primary benefit of virtual instruction (Serhan, 2020). Future research should consider designs that offer more control than were available to researchers at the height of the pandemic when data were collected.

Finally, the majority of Study 2 participants were further along in their degree program than participants of Study 1. The most common class rank in Study 1 was first-year (40.9%), while the most common class rank in Study 2 was senior (47.5%). As such, it's possible that participants of Study 2 were more comfortable listening to a lecture, taking a quiz, and in general engaging with material than participants in Study 1. While there were no differences among the experimental conditions on familiarity with material or difficulty, students closer to degree completion (i.e., those in Study 2) are likely more familiar with some of the ideas apparent in the presented lesson (e.g., intrinsic, extrinsic, theoretical assumptions). Future research should consider issues of class rank when conducting experiments, as students across the spectrum likely have different wants and needs.

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