FEATURE ARTICLE

# Developmental Mathematics: Students' Predicted Outcome Value of Electronic Communication

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## ABSTRACT

This study investigated the predicted outcome value of electronic communication from the viewpoint of developmental mathematics students. Students at a large Texas community college completed a combination of instruments that were administered in three prior studies. Three reasons for using electronic communication that were included in this study were procedural/clarification, personal/social, and efficiency. Results indicated that (a) student-initiated electronic communications conversations were correlated with students' predicted outcome value of electronic communications; (b) instructor immediacy behaviors via electronic measures was correlated with students' reasons for electronic communication; (c) instructor immediacy of electronic communication and the reasons for communicating explained 34.3% of the variance in students' predicted outcome value of electronic communication; (d) procedural/clarification reasons was the largest predictor of predicted outcome value; and (e) the β weight and structure coefficient suggested that personal/social reasons was a possible suppressor.

**Keywords:** developmental mathematics, electronic communication, predicted outcome value, regression, suppressor variable

Communication is an essential element of a productive society. The mobile phone is one technological tool that has transformed communication on a global scale. Asurion (2018) reported that, while on vacation, "Americans checks their phone an average of 80 times a day" (para. 2). Recording the number of times people check their phones does not gauge the effectiveness of communication; however, it does provide a measure of the ease to which technology-based communication tools can be accessed and verifies Americans' obsession with their phones. Technology-based communication, which includes text messaging, email, and social media easily accessed from a smart phone, can be useful in forming relationships. Schreiner et al. (2011) posited that students (specifically high-risk) "do not stay or leave institutions as much as they stay in or leave [faculty] relationships" (p. 333). Chickering and Gamson (1987) claimed that students tend to persist through difficult times when they have a connection with their instructors. Perceptions of the usefulness of technology to form relationships might vary by generation. Brandon (2017) reported that 52% of millennials in his study thought that technology had improved their peer relationships but 57% of the boomers thought that technology had ruined peer relationships.

### Developmental Mathematics Classrooms

In this study, we examined the use of electronic communication in developmental mathematics classrooms. These classrooms provide an interesting setting for a study because the population is comprised of many students who exhibit high levels of mathematics anxiety (Zientek et al., 2010, 2019) and for which mathematics has been an obstacle (Bahr, 2008). Students enrolled in developmental mathematics often have been classified as non-traditional or at high-risk, which means they tend to be over the age 21, hold full-time jobs and/or have family responsibilities, and must complete one or more remedial mathematics course (Schreiner et al., 2011). Furthermore, according to Ganga et al. (2018), only about 25% of students who enroll in at least one developmental course will graduate in 6 years. Many also will decide to delay their enrollment in a college-level mathematics course (Zientek et al., 2020). Interactions between developmental mathematics students and their

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instructors are important to consider and can occur through extra-class technology. Therefore, we investigated the predictive nature that students' reasons for communicating electronically with their instructor and instructor immediacy had on students' value of electronic exchanges.

**Encouraging Student-Faculty Contact**

Student-teacher relationships have been identified as fundamental to students' academic success and satisfaction with their college experience (Bippus et al., 2003; Dobransky & Frymier, 2004; Hershkovzt & Forkosh-Baruch, 2017; Li & Pitts, 2008; Schreiner et al., 2011; Young et al., 2011). Chickering and Gamson (1987) declared that one of the most basic elements in student motivation is recurrent student-faculty contact. They also claimed that when students know faculty members are concerned, then students believe they can persist through the "rough times" (p. 4). The benefits of student-faculty contact are abundant in the literature. Astin (1984) theorized that frequent interaction with faculty members was a strong factor associated with student satisfaction. Tinto (2012) posited that students were more likely to succeed if they were academically and socially engaged with faculty. Astin (1984) and Tinto (2012) both emphasized the importance of student-faculty contact in their respective theories on student engagement and student retention. Providing time with the teacher outside of class hours, even if it is only 5 minutes before class, can influence students more than teachers might realize (Dinman, 1996). Sorcinelli (1991) maintained that student-faculty contact is an evidenced-based characteristic of good teaching.

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Sunnafrank (1988) proposed that initial communication behaviors impact attempts at future relational outcomes. In other words, people try to predict consequences of their interaction with others to decide whether to continue further or discontinue the relationship. Predicted outcome value (POV) has strong associations with oral communication, familiarity level of the interaction, nonverbal expression, and liking (Sunnafrank, 1988) and is relevant to instructional communication. Furthermore, the principles of POV theory pertain to both face-to-face extra-class communication and email communication (Young et al., 2011).

**Extra-Class Communication**

The focus of this study is extra-class electronic communication. Dobransky and Frymier (2004) defined extra-class communication as student-teacher interactions outside of formal class time that is initiated by either the student or instructor. Extra-class communication provides students with opportunities to discuss a variety of topics or ask questions without fear and allows the value of the communication to be retained regardless of the physical availability of the instructor. In regards to extra-class communication, POV relates to students' prediction of the importance of extra-class communication with their instructors (Bippus et al., 2003; Young et al., 2011). Students have a choice to seek out extra-class communication and will choose experiences they perceive as beneficial (Young et al., 2011). Bippus et al. (2003) posited that faculty members need to exhibit behaviors that encourage students to seek out extra-class communication, but his conjecture was not focused on technology-based communication.

***Email***

Early research on extra-class communication focused on face-to-face interactions between students and their instructor (Young et al., 2011). As technology evolved, email became a communication tool that was readily-available across universities and colleges. Therefore, it should not be a surprise that, as the popularity of email grew, researchers studied whether email communication was beneficial (DeBard & Guidera, 2000; Waldeck et al., 2001). Research has indicated that email can supplement face-to-face communication and can help reduce students' anxiety about asking questions (Waldeck et al., 2001). Email communication has the added benefit of being able to transcend the confines of space and time. According to Young et al. (2011), "unlike face-to-face context, email allows students and teachers to communicate at any time without the need to be physically present among one another" (p. 382).

Among developmental mathematics instructors, email has been a leading choice to communicate with students about their course and to provide students with grade or performance updates (Skidmore et al., 2014). Regarding email, researchers have found that developmental education faculty members primarily use email as a reminder tool (Cafarella, 2014; Jacobson, 2005). Faculty members interviewed in Cafarella's (2014) study indicated that email was an effective way to increase student attendance, which they theorized would benefit student success. In fact, attendance has been identified as a predictor of student success (Albert et al., 2018; Zientek et al., 2013). Jacobson (2005) investigated the intervention of sending an email reminder to students who missed class. While Jacobson (2005) found that attendance did increase, sending attendance reminders alone did not translate to more learning for some students.

***Frequency***

High-risk college students have identified genuineness and authenticity as the basis for connecting with their instructor (Schreiner et al., 2011). When looking at how email communication influences student-teacher relationships, Young et al. (2011) found frequency of emails and teacher immediacy were two instructor qualities that increased the likelihood of developing relationships. More frequent emails indicated a greater likelihood of developing a relationship (Young et al., 2011). While studies of student-faculty contact that pre-date technology-based communication have indicated that frequency of contact was important to student success (Sorcinelli, 1991), Schreiner et al. (2011) found that for students at high-risk, the quality of extra-class communication (not electronically mediated) was more important to developing a relationship than frequency of communication.

***Immediacy***

Immediacy also influenced the development of student-teacher relationships (Young et al., 2011). Immediacy has been defined as perceived physical or psychological closeness between people or more specifically, for teachers, verbal and nonverbal behaviors that enhance interaction (Babad, 2007; Dobransky & Frymier, 2004). Teacher immediacy behaviors in technology-based communication include using students' first names, appropriate capitalization, and various emoticons (Waldeck et al., 2001). Research suggests that when teachers used immediacy behaviors, students were more likely to communicate via email (Waldeck et al., 2001). Babad (2007) claimed that teacher immediacy measures the same characteristics as teacher enthusiasm, but noted the two concepts are mutually exclusive in literature. Immediacy behaviors enhances student learning and motivation (Dobransky & Frymier, 2004).

***Reasons For Extra-Class Communication***

Students communicate with their instructors outside of class for various reasons, including (a) relational (to develop a relationship), (b) functional (to ask for clarification), (c) excuse making (to explain late work or absences), (d) sycophantic (to make a favorable impression), and (e) participatory (to demonstrate curiosity; see Denker et al., 2018; Young et al., 2011). When email is the choice of extra-class communication, Waldeck et al. (2001) presented a similar set of reasons for why students were likely to email their instructors which included, in order of preference, (a) procedural or clarification, (b) efficiency (to not waste time), and (c) social or personal (private matters).

**Problem Statement**

Contact between faculty members and students was one of the *Seven Principles of Good Practice in Undergraduate Education* (Chickering & Gamson, 1987). In fact, Chickering and Gamson (1987) claimed "frequent student-faculty contact in and out of classes is the most important factor in student motivation and involvement" (p. 4). Skidmore et al. (2014) noted that because developmental mathematics faculty reported using email to communicate with students, future studies should "investigate in detail the purpose for their emails" (p. 39). Young et al. (2011), noted that:

> There is an array of other computer-mediated modes of communication that both teachers and students can employ to maintain contact outside of the classroom, including texting and instant messaging or using Facebook, Twitter, Linked In, or Skype… Future scholars may wish to cast a wider net in examining how various computer mediated channels for ECC may influence students' likelihood to develop a professional relationship with their instructor. (pp. 385–386)

We answered those calls for future research by investigating extra-class communication in developmental mathematics courses.

**Purpose**

Because a central role in fostering student motivation and success is student-faculty interactions and developmental mathematics students have a higher-risk for academic failure, determining their students' perceptions of technology-based communication tools for classroom interaction can be informative. The purpose of this study was to extend prior research on how student-teacher relationships develop through extra-class communication by examining faculty members' use of electronic communication from the student viewpoint within the special area of developmental mathematics. The educational significance of this study is two-fold. First, the results can yield information on why students engage in extra-class communication and on the relationship of extra-class communication within the framework of positive outcome value. Second, the results can inform faculty members on how electronic communication tools can improve extra-class communication and help develop relationships that might improve student success.

**Research Questions**

Given the benefits of student-faculty contact, the convenience of electronic communication, and the low pass rates in developmental mathematics, it is important to examine the use of technology-based communication tools in developmental mathematics classrooms.

The present study is guided by two research questions:

1. To what extent does students' POV of extra-class electronic communication relate to the frequency of (a) student-initiated and (b) instructor-initiated communication with the electronic tool used most often between students and instructors?
2. To what extent does students' perceptions of their instructor's electronic communication immediacy and their own reasons for contacting their instructor predict their POV of extra-class electronic communication?

## Method

### Participants

Participants in this study were students from a large community college system in Texas who were enrolled in two different developmental math courses: college algebra with co-requisite and intermediate algebra. Community college students were the target population because most developmental mathematics courses have been taught at community colleges (Bahr, 2008). The five mathematics instructors who distributed the survey to their students reported their original enrollment numbers for their courses. Response rates for four instructors varied from 12.5% to 82.2% ($n$ = 68 students; 16 males, 51 females, 1 unidentified). Calculations of response rates was not possible for one instructor who taught a mixed College Algebra class comprised of both college-ready and College Algebra with co-requisite students. This instructor indicated that nine students were in the co-requisite class but 14 students reported enrollment in the co-requisite class.

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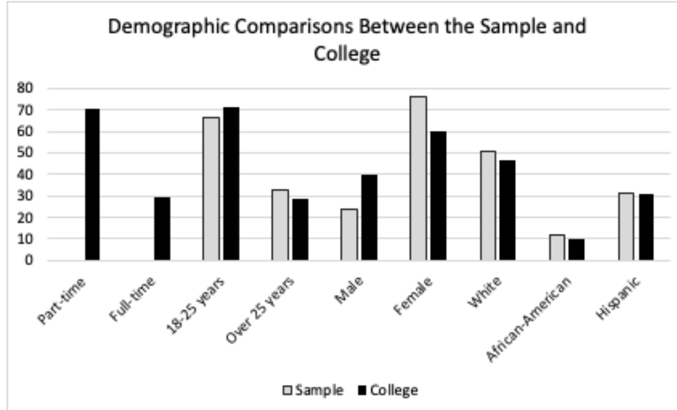
As recommended by Wilkinson and Task Force on Statistical Inference (1999), the sample characteristics were compared to the college population characteristics. In the Fall 2018 semester, the participating two-year college enrolled approximately 15,300 students with 989 registered in developmental education. This number did not include students enrolled in co-requisite courses. The majority of the student population was 18 to 25 years old (71.7%), attended part-time (70.6%), and were female (61%). Two ethnic groups had the most representation: White (45.7%) and Hispanic (32%). As seen in Figure 1, the sample was somewhat comparative to the population on the percentage of students who were 18 to 25 and ethnicity but there was a larger percentage of females in the sample compared to males. Full-time enrollment status was not available for the sample.

**Figure 1**

*Demographic Comparisons Between Sample and College*




*Note.* Values are in percents. The college data was obtained from the college's website.

### Instrumentation

Surveys in the present study were based on instruments administered in previous studies by Waldeck et al. (2001), Bippus et al. (2003), and Young et al. (2011). Prior studies focused on email. In this study, the instrument included additional types of technology-based communication. Students were asked to choose the type of technology-based communication (i.e., email, text messaging, or social media) they used most frequently to communicate with their developmental mathematics instructor. Students were asked to answer subsequent questions from four sections based on that technology tool. Students answered items, which were (a) students' frequency of use, (b) students' reasons for use, (c) students' perceived benefit of use, and (d) instructor immediacy-based communication. Students' frequency of use was measured using a 5-point categorical time scale. Students' reasons for use as well as instructor immediacy were measured using a 7-point Likert scale. Perceived benefit of use was measured using a 7-point semantic differential scale for responding to questions. A semantic differential scale measures a person's attitude towards something using a scale with polar opposite adjectives (Glen, 2016). For example, student participants were asked "interacting with my instructor using technology-based communication is likely to be" and given the scale of (1) positive to (7) negative.

***Reasons for Electronic Communication***

The measure for students' reasons for using electronic communication was based on an instrument by Waldeck et al. (2001). They conducted a factor analysis that indicated a three-factor model, "which accounted for 65% of the variance" and defined the three factors as "personal and social reasons, procedural and clarification reasons, and efficiency reasons" (p. 63). Young et al. (2011) used the same instrument and also reported ~~a~~ the same three-factor model, which accounted "for 57.89% of the variance" (p. 379). Both studies computed composite scores for each factor. For this study, we hypothesized some items would not load on the original factor structure by Waldeck et al. (2001) when administered with a sample of developmental mathematics students. Correlations are reported in Table 1. Reliability coefficients were consulted and reliability improved if one communication item was removed. The item "To avoid speaking to the teacher by phone or in person" (R15) was deleted because responses were rated in almost the opposite direction than and were minimally correlated with the two other communication problems. Avoidance to communicate by phone or in person in R15 might occur for reasons other than wasting time such as an intimidation to speak to the teacher asked in R16 and R17. Cronbach's alpha (α) were acceptable (i.e. above .70) for personal and social reasons (α = .86), procedural and clarification reasons (α = .91), and efficiency reasons (α = .73). Because of the low sample size and possible survey fatigue, composite scores for (a) personal and social reasons and (b) procedural and clarification reasons were calculated by taking the average responses for each construct as long as participants answered all or all but one of the items for each construct.

***Instructor Immediacy via Electronic Communication***

Instructor immediacy via electronic communication was measured based on a 19-item instrument by Waldeck et al. (2001) that related to verbal and non-verbal "message strategies that simulate immediacy behaviors" (p. 66) such as using first names or including emojis. Waldeck et al. (2001) referred to this instrument as the "Teacher E-Mail Interaction Proficiency Scale" (p. 65). Both factor analyses by Waldeck et al. (2001) and Young et al. (2011) showed a unidimensional measure with a Cronbach alpha reliability of .89 and .95. Instructor immediacy in this study was also considered unidimensional and a composite score was calculated (α = .934). Composite scores for instructor immediacy were calculated by taking the average responses for each construct as long as participants answered at least 17 out of the 19 items.

***Perceived Outcome Value (POV)***

To measure students' POV of extra-class electronic communication, students in this study completed an instrument by Bippus et al. (2003). In this study, POV relates to their decision to engage in extra-class communication with electronic tools. Young et al. (2011) administered the Bippus et al. (2003) instrument and performed a factor analysis that produced a one-factor model explaining 63.82% of the variance. Young et al. (2011) modified the items to be specific to email and developing a student-teacher relationship; we modified the items to be specific to electronic communication in general. We changed the instructions from ''interacting with this

**Table 1**
*Correlations and Descriptive Statistics for Reasons for Electronic Communication*

| | *M* | *SD* | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 3.22 | 1.91 | - | | | | | | | | | | | | | | | |
| R2 | 4.38 | 1.94 | .593 | - | | | | | | | | | | | | | | |
| R3 | 2.74 | 1.95 | .580 | .440 | - | | | | | | | | | | | | | |
| R4 | 2.09 | 1.53 | .445 | .262 | .550 | - | | | | | | | | | | | | |
| R5 | 3.40 | 1.87 | .279 | .393 | .331 | .295 | - | | | | | | | | | | | |
| R6 | 3.24 | 1.99 | .517 | .377 | .551 | .480 | .422 | - | | | | | | | | | | |
| R7 | 2.34 | 1.92 | .559 | .376 | .526 | .572 | .494 | .550 | - | | | | | | | | | |
| R8 | 2.17 | 1.66 | .470 | .302 | .454 | .508 | .481 | .457 | .811 | - | | | | | | | | |
| R9 | 3.97 | 2.13 | .395 | .668 | .433 | .261 | .224 | .413 | .429 | .306 | - | | | | | | | |
| R10 | 5.03 | 2.04 | .290 | .578 | .385 | .157 | .308 | .456 | .091 | .102 | .460 | - | | | | | | |
| R11 | 4.90 | 2.03 | .309 | .518 | .232 | .139 | .324 | .406 | .154 | .078 | .364 | .774 | - | | | | | |
| R12 | 4.66 | 2.11 | .246 | .445 | .230 | .239 | .386 | .511 | .291 | .234 | .436 | .606 | .639 | - | | | | |
| R13 | 4.95 | 2.06 | .346 | .470 | .197 | .068 | .323 | .363 | .200 | .213 | .395 | .762 | .781 | .621 | - | | | |
| R14 | 3.62 | 2.28 | .242 | .570 | .266 | .030 | .307 | .261 | .288 | .204 | .566 | .501 | .518 | .572 | .638 | - | | |
| R15 | 2.38 | 1.75 | .216 | .362 | .127 | .324 | .350 | .115 | .254 | .293 | .230 | .124 | .194 | .322 | .176 | .293 | - | |
| R16 | 3.97 | 2.25 | .047 | .378 | -.078 | .129 | .308 | .222 | .141 | .124 | .249 | .367 | .495 | .427 | .348 | .364 | .285 | - |
| R17 | 3.76 | 2.14 | .185 | .425 | .077 | .329 | .283 | .320 | .398 | .354 | .345 | .287 | .353 | .394 | .248 | .327 | .298 | .728 |

*Note.* $n$ = 58; *M* = Mean; *SD* = Standard deviation. The numbers correspond to the questions in the Waldeck et al. (2001) article and the three factors: personal/social reasons (R1–R9), procedural/clarification reasons (R10–R14), and efficiency reasons (R15–R17).

instructor outside of class is likely to be'' (Bippus et al., 2003, p. 268) to ''interacting with the instructor using electronic communication is likely to be..." Both Bippus et al. (2003) and Young et al. (2011) reported high alpha reliability scores (i.e., .94 and .93). Because of a data collection error, only seven of the nine items were included on the survey. The two items that were omitted were "worth the effort" and "informative." However, despite this oversight, worth the time and worth the effort were very similar beliefs and informative and valuable were also similar. Future studies should include all nine items. A composite score was calculated for the unidimensional POV (α = .88). A composite score for POV was calculated by taking the average responses of POV items as long as participants answered at least 6 of the 7 items.

**Procedures**

Students were invited to participate through email communication with developmental mathematics instructors from the community college system. Thus, the sample for this study was a voluntary and convenience sample because it included participants who were easily recruited and willing to participate (Johnson & Christensen, 2014). After submitting an application to the Institutional Review Board, the study was approved and granted an exemption from a full-board review. Emails were sent to developmental mathematics faculty from the college. Faculty members were asked to distribute the electronic surveys to their developmental mathematics students. All 78 faculty members at the participating college were sent an email requesting participation. Six of the faculty members (7.7%) agreed to distribute the survey to their students, but only five distributed the survey. Participants had to give their consent before they were granted access to the survey instrument. Data collection took place during the sixth and seventh weeks of the semester. This time period provided time for students to have experienced the behaviors being studied, but not too close to finals that would have added more stress. As an incentive, participants were offered an opportunity to enter their email for a chance to win a gift card.

**Data Analysis**

Survey results were sorted according to students' preferred method of communication: email, text messaging, social media, or other. If students chose "other", they were asked to list the method they preferred. Initial data formatting and analyses were conducted in SPSS. Matrix summaries were provided, which allow for secondary analyses and encourage meta-analytic thinking. Correlation coefficients (Pearson *r*) were calculated to measure the relationships between perceived outcome, students' reasons, and instructor immediacy. Spearman's rho (ρ) measures the magnitude and direction of relationships between at least one interval-scaled variable and at least one ordinal-scaled variable. Spearman's ρ was calculated to measure the relationship between perceived outcome and frequency of use.

Multiple regression was used because we wanted to predict the value of the dependent variable based on two or more independent variables (Thompson, 2006). We conducted a multiple regression analysis and commonality analysis in R (Nimon, 2015) to determine the extent to which students' reasons for communicating with their instructors (i.e, three constructs) and perceived immediacy behaviors of instructors (i.e., one construct) explained variance in POV of electronic communication (i.e., dependent variable). Multicollinearity was investigated with variance inflation factors. A commonality analysis was conducted to determine the unique contributions variables made to the model and possible suppressor effects (see Kraha et al., 2012).

Survey results were sorted according to students' preferred method of communication: email, text messaging, social media, or other.

## Results

Students first reported the electronic communication that they used most frequently to communicate with their developmental mathematics teacher and how often they used that particular technology and for what purposes. Of the 58 students who reported most common type of communication, email was chosen most often (63.8%; $n$ = 37). Text messaging, including *Remind*, was second at 24.1% ($n$ = 14) followed by *other* at 6.9% ($n$ =4) and social media at 5.2% ($n$ =3). No specific social media platform was specified. All 4 students who chose "other" listed *Remind*, which is an application that allows participants to send and receive text messages without sharing personal contact information. The use of *Remind* might have been prevalent because one instructor introduced the use of this messaging service to their students.

All subsequent survey responses were answered based on the students' most frequently used technology ($n$ = 64) that they reportedly used to communicate with their instructor. Students rated their frequency of the technology they used most often to communicate with their instructor for the purposes of (a) school, work, and/or personal communication,

**Table 2**
*Students' Frequency of Electronic Communication Most Often Used by Students to Communicate With Their Developmental Mathematics Instructors in Percentages*

| Frequency | General student use of electronic communication | Student initiated contact with their instructors | Instructor-initiated mass communication | Instructor-initiated individual communication |
|---|---|---|---|---|
| Never | 4.7 | 6.3 | 1.6 | 14.1 |
| Rarely | 25.0 | 45.3 | 17.2 | 37.5 |
| Monthly | 0.0 | 0.0 | 0.0 | 0.0 |
| Twice/ Month | 7.8 | 23.4 | 25.0 | 20.3 |
| Weekly | 29.7 | 20.3 | 46.9 | 23.4 |
| Daily | 32.8 | 4.7 | 9.4 | 4.7 |

*Note. n* = 64.

(b) initiating communication with their instructors, (c) instructor-initiated communication to the whole class, and (d) instructor-initiated communication to individual students. Frequencies are provided in Table 2. About a third of the students (32.8%) reported that they communicated daily with their instructors using the self-reported most frequently used technology, with weekly (29.7%) and rarely (25%) having the next most responses. In regards to personal communication, we want to emphasize that we believe students used electronic communication daily, but just not necessarily to communicate with their instructor. When students were asked about their frequency of electronic communication to initiate contact with their instructors, 45.3% reported that they rarely initiated communication with their instructors. In reference to the technology of students' preference, students reported that their instructors initiated electronic communication to communicate with their class (i.e., mass communication) weekly ($n$ = 30, 46.9%) but that the instructors were less likely to initiate weekly individual communication ($n$ = 24, 37.5%).

**Research Question 1**

Spearman's rho (ρ) correlations were computed to examine to what extent frequency of electronic communication relates to students' POV of extra-class communication. Spearman's rho (ρ) correlations indicated that POV had a moderately positive relationship with student-initiated communication (ρ(59) = .354, $p$ = .006, $\rho^2$ = 12.53%). No statistically significant relationship existed between POV and the frequency of teacher-initiated mass (ρ(59) = .128, $p$ = .335, $\rho^2$ = 1.63%) or individual electronic communication (ρ(59) = .215, $p$ = .102, $\rho^2$ = 4.62%).

**Research Question 2**

A multiple regression was conducted to determine the extent to which students' reasons (i.e., personal/social, procedural/clarification, and efficiency) and instructors' immediacy behaviors predicted students' POV of electronic communication with their instructors. Correlations and descriptive statistics are provided in Table 3. Collectively, the three reasons selected by students (i.e., procedural/clarification, personal/social, and efficiency) and instructors' immediacy behaviors explained 34.4% of the variance in students' POV ($F$ [4, 55] = 7.20, $p$ <.001, $R^2$ = .343, $R^2_{\text{Adjusted}}$ = .296). As seen in Table 4, beta (β) weights were largest in magnitude for procedural/clarification and personal/social reasons followed by immediacy behaviors. Squared structure coefficients ($r_s^2$) supported the importance of students' procedural/clarification efficiency reasons and instructors' immediacy behaviors, which suggests that interpretation of β weights alone would have denied efficiency reasons some explanatory credit (Thompson, 2006). The variance inflation factors was less than 2.6, which suggested that multicollinearity was not a concern. As seen in Table 3, the POV of extra-class electronic communication had a somewhat weak positive relationship with instructors' immediacy behaviors ($r$ (60) = .291, $p$ = .024, $r^2$ = 8.47%), a moderate positive relationship with students' procedural/clarification reasons (r (60) = .404, p = .001, r2 = 16.32 %), a somewhat weak positive relationship with students' efficiency reasons ($r$ (60) = .331, $p$ = .010, $r^2$ = 10.96%), and no statistically significant relationship with students' personal/social reasons ($r$ (60) = –.030, $p$ = .820, $r^2$ = 0.09%).

**Table 3**
*Pearson's* R *Correlation Coefficients and Descriptive Statistics for Regression Variables*

| | POV | Proc/Clar | Pers/Soc | Eff | Imm |
|---|---|---|---|---|---|
| Proc/Clar | .404 | | | | |
| Pers/Soc | –.030 | 0.561 | | | |
| Eff | .331 | 0.451 | 0.383 | | |
| Imm | .291 | 0.544 | 0.594 | 0.475 | |
| *M* | 5.463 | 4.630 | 3.078 | 3.808 | 3.356 |
| *SD* | 1.247 | 1.843 | 1.381 | 2.109 | 1.500 |

*Note.* $n$ = 60; POV = students' perceived outcome value of extra-class technology-based communication; Proc/Clar = Procedural/clarification reasons; Pers = Personal/social reasons; Eff = Efficiency reasons; Imm = Instructor's immediacy behaviors

**Table 4**
*Multiple Regression Results*

| IV | B | $r_s^2$ (%) | Unique (%) | Common (%) |
|---|---|---|---|---|
| Procedual/clarification | 0.469 | 47.5 | 12.9 | 3.5 |
| Personal/social | –0.517 | 0.30 | 15.1 | –15.0 |
| Efficiency | 0.200 | 31.90 | 2.9 | 8.1 |
| Immediacy | 0.248 | 24.70 | 3.3 | 5.1 |

*Note. n* = 60; Dependent variable = Perceived outcome value (POV) of electronic communication.

Personal/social reasons was not statistically significantly correlated with the dependent variable (POV), but was correlated at a noteworthy level with the other three independent variables (see Table 3). The large β weight and relatively low $r_s^2$ supports that Personal/social reasons was a possible suppressor. According to Nathans et al. (2012), "an independent variable [with] a near-zero or negligible zero-order correlation with the dependent variable and a large and statistically significant β weight" suggest "that the variable is a suppressor" (p. 4). Pandey and Elliott (2010) added that a suppressor "improves the overall predictive power of the model" (p. 28). Lo (2012) stated that classical suppression occurs when a suppressor variable "(1) is uncorrelated or slightly correlated to the dependent variable, (2) is correlated to the other predictors (which it suppresses), and (3) increases the $R^2$" (p. 15). Per these definitions, students' personal/social reasons appears to be a classical suppressor with this sample of students. The classic suppressor variable is able to increase the model's predictability by removing irrelevant predictive variance from other predictive variables and increasing the predictors' weight (Pandey & Elliott, 2010).

Commonality analysis results provided in Table 5 further support the regression results, in particular the suppressor effect (Nimon, 2015; Thompson, 2006). Commonality analysis first "takes all possible subsets further and divides all of the explained variance in the criterion into unique and common (or shared) parts" (Kraha et al., 2012, p. 6). All of the predictor variables uniquely contributed variance. Students' procedural/clarification reasons uniquely accounted for 12.9% of the variance or rather 37.61% of the explained variance of the students' POV (i.e. $U_{Clar}/R^2$ = 12.9%/34.3% = 37.61%, and students' personal/social reasons uniquely accounted for 15.1% of the variance or rather 44.02% of the explained variance of the students' POV (i.e. $U_{Pers/Soc}/R^2$ = 15.1%/34.3 % = 44.02%). The largest shared contribution to variance was made by the combination of three predictor variables: students' procedural/clarification reasons, efficiency reasons, and instructors' immediacy behaviors. This combination shared 4.9% of the variance or rather 14.29% of the explained variance (i.e. $C_{Clar,Eff,Imm}/R^2$ = 4.9%/34.3% = 14.29%). The combination of 2 predictors—students' procedural/clarification reasons and instructors' immediacy behaviors—shared 4.3% of the variance or rather 12.54% of the explained variance (i.e. $C_{Clar,Imm}/R^2$ = 4.3%/34.3% = 12.54%). The combination of the students' procedural/clarification reasons and efficiency reasons shared 3.8% of the variance or rather 11.08% of the explained variance (i.e. $C_{Clar,Eff}/R^2$ = 3.8%/34.3% = 11.08%). Even though personal/social reasons provided the largest unique contribution, negative commonality coefficients in Table 5 support that personal/social reasons was a possible suppressor. All commonality analysis coefficients that included personal/social reasons were negative except for the shared commonality components with immediacy behaviors, which was close to zero.

**Table 5**

*Unique and Common Components of Variance of Dependent Variable POV Extra-Class Technology-Based Communication*

| Components | Clar(%) | PS (%) | Eff (%) | Imm (%) | Total (%) |
|---|---|---|---|---|---|
| U(Clar) | 12.9 | | | | 12.9 |
| U(PS) | | 15.1 | | | 15.1 |
| U(Eff) | | | 2.9 | | 2.9 |
| U(Imm) | | | | 3.3 | 3.3 |
| C(Clar, PS) | –6.9 | –6.9 | | | –6.9 |
| C(Clar, Eff) | 3.8 | | 3.8 | | 3.8 |
| C(Clar, Imm) | 4.3 | | | 4.3 | 4.3 |
| C(PS, Eff) | | –0.7 | –0.7 | | –0.7 |
| C(PS, Imm) | | –3.2 | | –3.2 | –3.2 |
| C(Eff, Imm) | | | 2.2 | 2.2 | 2.2 |
| C(Clar, PS, Eff) | –1.2 | –1.2 | –1.2 | | -1.2 |
| C(Clar, PS, Imm) | –2.1 | –2.1 | | –2.1 | –2.1 |
| C(Clar, Eff, Imm) | 4.9 | | 4.9 | 4.9 | 4.9 |
| C(PS, Eff, Imm) | | –1.6 | –1.6 | –1.6 | –1.6 |
| C(Clar, PS, Eff, Imm) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Total | 16.3 | <.001 | 10.9 | 8.4 | 34.3 |

*Note*. *n* = 60. U = unique; C = common; Clar = Procedural and clarification reasons; PS = Personal and social reasons; Eff = Efficiency reasons; Imm = Immediacy behaviors; Dependent variable = POV of electronic communication. Total columns for dependent variables sum to the $r^2_{xy}$.

## Discussion

While educators understand the importance of student-teacher interactions, an evolving influence on these interactions is the use of technology to communicate outside of the classroom. Electronic communication, such as email and text messaging, have been growing in popularity. Therefore, we can expect that students also model this behavior and choose to communicate using technology. Furthermore, using studies by Waldeck et al. (2001), Bippus et al. (2003), Young et al. (2011), and Predicted Outcome Value (POV theory; Sunnafrank, 1988) as a guide, this study explored developmental mathematics students' POV of electronic communication through email and other forms of electronic communication (i.e., email, text messaging, and social media). This population has been identified as underprepared for college mathematics and possibly have negative experiences with mathematics. The POV theory was developed around face-to-face communication and "is positively related to amount of verbal communication, intimacy level of communication content, nonverbal affiliative expressiveness, and liking" (Sunnafrank, 1988, p. 169). Young et al. (2011) examined the theory through email communication with non-communication majors at a university.

**POV of Extra-Class Electronic Communication**

This study found that (a) student-initiated electronic conversations were correlated with students' POV of extra-class electronic communication; (b) instructor immediacy behaviors via electronic communication were correlated with students' reasons for communicating; and (c) students' reasons for communication and instructor immediacy predicted students' POV of extra-class electronic-based communication. Furthermore, procedural and clarification reasons contributed a large amount of variance with personal and social reasons serving as a possible suppressor. Although one intent of this study was to compare different modes of electronic communication, due to the small sample size in this study and the fact that most students chose email as the most frequent communication used, it was not possible to separate responses by technology tools. Thus, most of the discussion is in reference to electronic communication by email. Future research could examine the impacts different types of communication have on the frequency of use.

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***Frequency of Electronic Communication***

Young et al. (2011) focused on the relationship between POV of email correspondence and fostering student relationships versus our focus on POV of electronic communication. We hypothesized, based on the findings by Young et al. (2011), that higher POV of electronic communication would correlate with a student's desire to formulate a teacher-student relationship. Young et al. (2011) found that frequency of instructors' use of *both* mass and individual emails had a positive correlation with POV "of student-teacher relationship" (p. 380). In contrast, we did not find a relationship between instructors' frequency of mass or individual instructor-initiated electronic messages and developmental mathematics students' POV of electronic communication. The differences might be attributed to different measures used in the studies. Developmental mathematics students who exhibited higher levels of POV of extra-class electronic communication initiated electronic conversations more frequently than students with lower POV levels. Also, there was a positively statistically significant correlations with the frequency of electronic-based communication initiated by the student and instructor-initiated mass (Spearman's ρ = .338) and instructor-initiated individual communications (Spearman's ρ = .389). To summarize, we found that both the frequency of instructor's individual and mass emails appeared to be related to students' frequency of communicating electronically and that students with higher POV initiated emails more frequently.

***Instructor Immediacy, Reasons For Using, and Predictive Outcome Value Of Electronic Communication***

The three reasons students used electronic communication included in this study and instructor immediacy behaviors explained 34.3% of the variance in students' POV of electronic communication. Using electronic communication for procedural/clarification reasons explained the most variance and might serve as a predictor because many developmental mathematics students struggle in mathematics. Even though personal/social reasons contributed the largest amount of unique variance, the β weight was large and there was a near zero structure coefficient. Furthermore, personal/social reasons was not correlated to POV of electronic communication and the majority of the commonality coefficients associated with personal and social reasons were negative. Collectively, those results indicated that personal/social reasons was important to the model because it suppressed irrelevant information and thus increased the $R^2$. Future research should examine the possible suppressor effect across subject matters and academic levels.

Efficiency reasons (i.e. to avoid wasting time) was a predictor. The importance of this reason for explaining variance in POV of electronic communication might be because the sample was drawn from a community college with a majority of the student population attending part-time while working full-time jobs. Therefore, being able to send and receive messages asynchronously might be advantageous for part-time students to develop relationships with their instructors.

Instructor immediacy behaviors have been linked to students' POV of extra-class communication (Waldeck et al., 2001). Our findings, based on the corresponding β weight and structure coefficient for immediacy, support that assertion. In order for students to value electronic communication, immediacy behaviors need to be used in extra-class messages to negate the missing non-verbal cues typically employed in a face-to-face course such as tone of voice, facial expressions, and body language. Students might see that the manner in which an instructor responds to electronic messages as an indicator of how much the instructor cares.

***Reasons for Electronic Communication at the Item Level***

We think it is also important to look at some of the reasons students indicated they were or were not communicating. Recall that these responses were in response to the technology they used most often to communicate with their instructor. As seen in Table 1, descriptive statistics suggest that students were not avoiding communicating with their instructor by phone or in person (R15), nor were they communicating to try escape or divert their attention from working on other tasks (R4) or to tell instructors about themselves (R7). Students reported that they mostly were communicating electronically to ask questions about the content (R10) or exam (R12), clarify information from the lecture (R11), or acquire guidance regarding assignments (R13).

**Limitations**

All studies have limitations, which are important to consider. First, data in this study was self-reported by students about their current instructors. However, their opinions on POV might have been influenced by previous instructors or prior learning experiences, which might have skewed their choices. Another limitation to consider is that the data were collected at one community college within a specific level of courses. These students and instructors might not be representative of all community college students. Additionally, only a few instructors agreed to invite their students, and student participation was voluntary, resulting in a small sample size and possible bias. In particular, bias would be introduced if instructors who chose to participate had a more positive perception of their extra-class participation than those who did not choose to participate. Therefore, the results lack generalizability. Future researchers should consider collecting data from a wide range of schools to obtain a larger sample size and variety in student demographics. This study attempted to examine various types of technology-based communication, but email was the primary mode of communication. Future research, with larger a sample, should examine the prevalence of other modes of technology-based communication and their impact on the development of student-teacher relationships or specific aspects of email that encourages communication.

**Implications**

Extra-class electronic communication between instructors and students is important, particularly with students enrolled in developmental mathematics at a community college who often have to balance work, life, and school and often attend college on a part-time basis. Thus, asynchronous technology-based communication provides additional means to promote student-teacher interactions outside of class time. This might be especially beneficial for community college students who attend school part-time and thus have limited opportunities for face-to-face communication when they do not have access to the campus during the day. Using technology means that physical presence is not needed for students to perceive value in communication with their instructors outside of class (Bippus et al., 2003). Another benefit of communication with technology might be that the physical distance presents a number of students with a way to reduce anxiety about communicating in person with their instructor (Waldek et al., 2001).

An implication of this study is that instructors should encourage students to initiate electronic communication for clarification and procedural reasons, help students understand that the electronic communication is not wasting anyone's time, and respond with verbal and non-verbal cues through the use of immediacy behaviors (i.e., emojis and use of names) that show the instructor cares. As noted by Young et al. (2011), extra-class email communication can build student-teacher relationships, and technology-based communication continues to assist in connecting students and instructors both inside and outside of the classroom. Furthermore, positive views of electronic communication can solidify a commitment to student-faculty contact—the latter claimed by Sorcinelli (1991) to be a characteristic of good teaching—and facilitates students' ability to reach their academic goals. We found that the outcome value of electronic communication outside of class was high and was predicted best by students' procedural/ clarification reasons; however, students' personal/social and efficiency reasons and instructors' immediacy behaviors also predicted the value students saw in electronic communication.

Finally, as college classrooms evolve to include more remote-learning options and activity-based learning, electronic communication between students and instructors will become more crucial in the student-teacher relationship. Furthermore, the ability for almost everyone to have access to a mobile phone has increased the ability for electronic communication to flourish. Instant access to email, text messages, social media and other forms of technology-based communication allow students the opportunity to engage with their instructors throughout the day without regard to proximity and the challenge of matching their schedules with instructor office hours. However, communication is not limited to talking; the same immediacy behaviors needed in a traditional face-to-face classroom need to be simulated in the electronic environment.

## Conclusion

Electronic communication provides students with the opportunity to build relationships with their instructors outside of the classroom environment. The electronic communication used most often with this sample was email, but faculty members should consider various technology communication tools to facilitate communication between instructors and students. Faculty members should also understand that electronic sources are a viable tool to clarify course materials and assignments.

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