

Selection of communication media by design and construction personnel for problem-solving

Luciana de Cresce El Debs, PhD and Mark Shaurette, PhD
Purdue University
West Lafayette, Indiana

Zofia K. Rybkowski, PhD
Texas A&M University
College Station, Texas

Effective communication and teamwork are essential skills for the management of construction projects. Part of effective communication and collaboration involves selecting the optimal communication media appropriate to the task. Research on media selection for construction communication has already been done. However, new communication technologies are continually emerging, old forms are being improved, and existing ones are becoming more widespread. Because of this, there is a need to reassess communication media preferences in the construction industry as they change over time. The authors of this study investigated differences between communications used for general conveyance of information and communications used to solve design problems. They also studied media preferences when solving design problems within the US construction industry. The researchers used an online questionnaire and quantitative methods of analysis. Six levels of communication media were assessed: face-to-face, telephone, email, text message, videoconferencing, and online instant messaging. Results revealed differences between general professional communication and design-specific problem-solving communication, only for email communications. For communication of design issues between site supervision and design personnel, results confirmed that more traditional media (face-to-face, telephone, and email) are still considered by both groups to be the most helpful.

Key Words: communication; problem-solving; design; teamwork; communication media

Introduction

Effective communication skills are seen as essential for managing the information that flows through each stakeholder during the construction process (Dave & Koskela, 2009; Emmitt & Gorse, 2003; Mohamed, Tilley, & Tucker, 1999). The same value can be placed on teamwork skills because of the fragmented nature of the architectural, engineering, and construction (AEC) industry (Dave & Koskela, 2009; Emmitt & Gorse, 2003; Nesan, 2012). In the AEC industry, a number of disciplines with different areas of specialized expertise must interact, from the conception of a building until its initial use. Information between parties is exchanged and continuously refined as the process moves forward. This is necessary for solving problems in a collaborative manner. Researchers have recently indicated that communication is closely related to trust building among project stakeholders and, consequently, to project success (Cheung, Yiu, & Lam, 2013).

Problem-solving within the AEC industry must take into account some particularities of that sector. Li et al. (2008) listed three main differences between the traditional manufacturing industry and the construction industry: (1) lack of well-established tools to reuse knowledge from one project to another; (2) lack of a fixed production line; and (3) impracticality of constructing a full-sized prototype before construction. All of these characteristics are connected to the one-off nature of building construction and, together with time and budget limitations, increase the complexity of a project.

Within this complex context, accomodating changes is a difficult process that requires teamwork and effective communication, especially since “errors, changes, and consequent conflicts are common and lead to significant schedule and cost overrun” (Lee & Peña-Mora, 2007, p. 35). In order to solve these issues, input from other stakeholders may be necessary. In these cases, requests for information (RFIs) are created in order to obtain further clarification about a subject (Mohamed, Tilley, & Tucker, 1999). However, research has found that collaboration and dicussion may take place in parallel with or even prior to documented communication (Gorse, Emmitt, & Lowis, 1999). Studying change management in construction, Lee and Peña-Mora (2007) concluded

that there is a need for a more efficient coordination process in order to manage errors and changes that may arise during the design and building process.

The first decision a professional must make when collaborating pertains to how information will be delivered to peers and collaborators. Moreover, researchers have identified that the selection of communication method in one of the key factors influencing communication between parties in a project (Cheung, Yiu, & Lam, 2013). Researchers of the construction industry suggest that face-to-face increases trust between collaborators (Nesan, 2012) and is best for complex communications (Cheung, Yiu, & Lam, 2013). This finding is similar to students' preference of face-to-face communication over written and electronic verbal communication during their internships (Shaw & Sullivan, 2015). However, face-to-face is not always feasible in construction since most activities in construction take place on-site; when face-to-face is not possible, a number of media options are available. Despite this, few recent studies have surveyed the industry about preference of media channels for communication of design problems in construction. The purpose of the present study is to address this gap.

Gorse, Emmitt and Lowis (1999) studied AEC professionals in England and their communication channel preferences. Using a questionnaire that listed eight different types of media, the researchers found face-to-face to be the most effective form of communication, followed by written letters and faxes with drawings, and then verbal communication over telephone and written faxes. The research by Gorse, Emmitt and Lowis (1999) showed no differences in preferences of architects and construction managers for all but two communication media. The exceptions were for verbal and email communication, and these were due to availability issues, especially in the case of email communication (Gorse, Emmitt, & Lowis, 1999).

To help understand media preferences, the authors of this study use Media Richness Theory (MRT). This theory states that our choice of media depends on: (1) message content to be conveyed – its uncertainty and equivocality; and (2) situational factors during communication. It also indicates that "communication media differ in their ability to facilitate understanding" (Daft, Lengel, & Trevino, 1987) through their differing abilities to provide feedback, multiple cues, language variety, and personal focus. Taking into consideration each media's ability to accommodate these characteristics, Media Richness Theory researchers have created a ranking of channels. In this ranking, face-to-face communications are first, followed by telephone, then written and addressed communications, and at the end written and unaddressed communications (Daft, Lengel, & Trevino, 1987). Richer channels, such as face-to-face communication, allow for message receivers to process not only the message but also tone of voice and non-verbal cues such as posture and gestures, as opposed to unaddressed written documents – the poorest of the media – which do not include any personal content or other social and physical cues (Webster & Trevino, 1995).

Given the importance of effective communication in construction and the rise of new communication media, the authors chose to re-evaluate the preferences of communication media within the AEC industry today. The present paper addresses the following questions:

(1) Is there a significant difference in preference of communication media between general professional and design-problem-solving communications for designers and site supervision personnel?
(2) Which communication media are found to be most helpful for design and construction interactions during a design problem-solving task?

Method

The research used a quantitative approach in order to answer both of the research questions mentioned previously. An online questionnaire was developed by the researchers. In this questionnaire, participants were asked to self-select their area as either design personnel who interact with site personnel, design personnel with no site interaction, site supervision personnel who interact with design personnel, site personnel who do not interact with design personnel, or neither design personnel nor site supervisor. Only respondents who reported interaction were invited to complete the rest of the questionnaire.

The population of this research was architects and site supervision personnel who work in construction companies in the United States. Company contact information was obtained through online research in professional associations, including the American Institute of Architects, the Associated General Contractors, and the Associated Builders & Contractors. Only publicly available contact information was used. A pre-test study with twelve respondents was conducted to verify if the wording and data collection methods needed adjustment prior to sending the final questionnaire. The responses from these participants were not included in

the final pool of responses. After adjustments were made, a questionnaire invitation was sent to 641 architectural companies and 826 construction companies between the months of June and July of 2015.

The final questionnaire included two cases for each category of respondents – architects or site supervisors. These two cases were developed by the researchers, tested in a pre-test, and also reviewed for face validity by two researchers from one of the authors' home institutions. The excerpts below show case 1 used for each group:

- *Field personnel case*: You are in the field and your workers call you because they are having problems fitting all pipes within the space specified in the construction drawings due to unforeseen conditions. You need to understand why this happened and find a quick solution to keep up with the work schedule. After going over all construction documents available, you decide to communicate directly with design personnel for causes and possible solutions.
- *Design personnel case*: Your client went to the field and complained that the ceilings were not placed according to previously approved architectural drawings and specifications. He did not mention which ceilings, but just that they were close to the main building entrance. You need to confirm with site personnel which ceilings were built, and make sure the heights and design conform to specifications.

Both cases were designed to address: (1) the need for interaction between parties; (2) a visual or design element; and (3) time constraints. Each category of participants was presented with the two cases and then asked to rate the helpfulness of each of six communication media: face-to-face (control), telephone and text message (telephone or cellular network based), email, videoconferencing, and online instant messaging (digital media). Because it was decided to impose time constraints, postal communication was excluded from media options.

Two different scales–rating and ranking–were used for each case. A rating question used a Likert-type scale including the following levels: un-utilized, of little help, moderately helpful, helpful, and very helpful. Participants were asked to rank the six media from (1) most helpful, to (6) least helpful. The use of both scales in both cases increased the reliability of the findings. Media selection was based on literature (Gorse, Emmitt, & Lowis, 1999), and was updated to include new media such as videoconferencing, text messaging, and online instant messaging, as well as to exclude fax communication. At the end of the questionnaire, one question asked respondents to rank their preferences for any professional communication using the same level as the cases. This question was included to verify differences in media preference between design-problem communication involving site supervisors and design personnel and general professional communications. At the end of each case, participants were provided with a space for qualitative, open input if they wished to provide it. The participants were also asked to provide general demographic information about themselves and their companies.

Results were analyzed using analysis of variance (ANOVA) as well as the Friedman and Wilcoxon tests because of the different scales used (rating and ranking). The ANOVA is a common test for verifying differences across more than three groups (Gall, Gall, & Borg, 2007), and in the case of this group, to verify differences between all six variables in a rating scale. If significance was found in the six variable test, the ANOVA was followed by a pairwise comparison with a Bonferroni adjustment. The Friedman test is usually used in ranking scales with more than two comparisons (in this case there were six channels). When significant differences were found in the Friedman test, a Wilcoxon post-hoc test was performed in pairs of channels. All tests were analyzed using a significance level of α=5%.

Results

From the 1467 invitations sent, 73 respondents provided answers to the survey, resulting in a 5% response rate. The authors believe that this low rate could be due to email spam filters and the amount of work during the summer building season when data was collected.

From the 73 respondents who answered the questionnaire, 13 were excluded because they reported either not being from the design or site supervision areas, or because they were from those areas but did not interact with the opposite group. In other words, design personnel who did not interact with site supervisors, and vice-versa, were excluded. Additionally, 8 respondents did not answer any questions in their response and were excluded from the analysis. One participant had inconsistent results and after careful consideration was also excluded from the analysis. This resulted in 51 valid responses representing 28 site supervision personnel and 23 designers.

All but the East South Central region were represented in the results, as can be seen in figure 1. Three respondents chose not to fill out the demographic section of the questionnaire. The size of companies also varied; however, the majority (26 respondents) were from companies with fewer than 50 employees. Company focus also spread through multiple types of construction; however, 27 respondents indicated that their companies built general commercial buildings. For this question, respondents had the option to choose more than one answer.

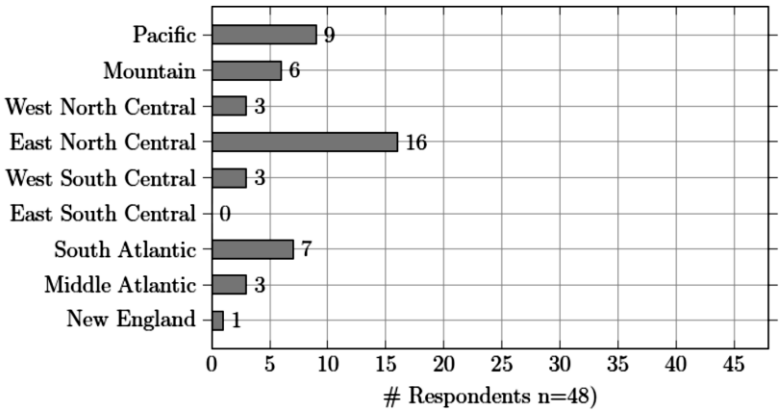

Figure 1: Geographic work location of respondents

Years of experience of participants ranged from zero to 48, with a median of 28 years of fulltime construction-related professional experience. The median age group for respondents to the survey was between 50 and 59 years, and 36 respondents were male, while only 12 were female. Four respondents indicated that they had only high-school degrees as their highest educational degree, while 30 had bachelors, one had a master's in Business Administration (MBA), and 14 had a master's degree in a construction related field. For the participants who had higher education, 21 had architectural degrees, one had an interior design degree, four had civil engineering degrees, two had architectural engineering degrees, 13 had construction management degrees, and two had other degrees.

An internal consistency analysis using Cronbach's alpha was performed between the Likert type answers in cases one and two for both roles and found α=0.598. This is much lower than the α=0.865 obtained for the pilot test, and could have been influenced by the multitude of factors taken into account by respondents or the small number of items in the questionnaire (Tavakol & Dennick, 2011). When analyzing the internal consistency for each channel, the researcher found email to be the only channel with an internal consistency below 0.70. This suggests that more research should be done to explore differences regarding the use of email for design problems.

For answering research question #1 (Is there a difference in preference of communication media between generic professional communications and design-problem-solving communications for designers and site supervision personnel?) the researcher used case 1 for both site supervision and design personnel, and compared with answers obtained for channel. Only case 1 was chosen because it had a higher response rate than case 2. In the case of design professionals, 26 complete responses were received for case 1 and 23 for case 2. For site supervision personnel, 28 responses were received for case 1 and only 20 for case 2.

Results obtained through the Wilcoxon pairwise comparison test indicated no significant differences between media selection for general professional communication and design problems communication for designers and site supervision. Results showed an α=0.05 level for five of the six media: for face-to-face (designers: ρ =0.081, site supervision: ρ =0.260), telephone (designers: ρ =0.171, site supervision: ρ =0.083), text messaging (designers: ρ =0.180, site supervision: ρ =0.206), videoconferencing (designers: ρ =0.204, site supervision: ρ =0.238), or online instant messaging communications (designers: ρ =0.705, site supervision: ρ =0.564). However, significant differences were found regarding email for both designers (ρ =0.015) and site supervision personnel (ρ =0.034). Analysis of the qualitative answers provided by respondents indicate a preference for using email to keep a record of communications. One respondent indicates that they "…try to use email as much as possible […] to keep a paper trail of quick decisions so that they are easily tracked, but […] that is not always an option since people do not hover on their email all day." Further research should provide more information about this difference.

In order to answer research question #2 (Which communication media are found to be most helpful for design and construction interaction during a problem-solving task?), the researchers analyzed the data for both cases and both groups. Tables 1 and 2 show descriptive statistics for the rating and ranking questions of cases 1 and 2 for design professionals. Tables 3 and 4 show descriptive statistics for the rating and ranking questions for cases 1 and 2 for site supervision personnel.

Table 1
Descriptive statistics for rating of channel variables - design personnel case 1 and 2

Variable	Case 1 Respondents	Case 1 Mean*	Case 1 Standard Deviation	Case 2 Respondents	Case 2 Mean	Case 2 Standard Deviation
Face-to-face meeting	27	4.59	0.971	26	4.58	0.857
Telephone	28	4.21	0.738	26	4.73	0.533
Email	28	3.93	1.152	26	3.96	1.148
Text Message	27	2.70	1.265	26	2.88	1.423
Videoconferencing	26	2.65	1.441	26	2.35	1.325
Online Instant Messaging	28	2.04	1.138	26	1.85	1.120

*for a 5-point Likert-type scale from 1=unutilized... to 5=very helpful

Table 2
Descriptive statistics for ranking of channel variables - design personnel case 1 and 2

Variable	Case 1 Respondents	Case 1 Mean*	Case 1 Standard Deviation	Case 2 Respondents	Case 2 Mean	Case 2 Standard Deviation
Face-to-face meeting	28	1.57	1.034	26	2.08	1.262
Telephone	28	2.25	0.928	26	1.81	0.895
Email	28	2.96	0.922	26	3.04	0.824
Videoconferencing	28	4.04	1.374	26	4.38	1.388
Text Message	28	4.39	0.994	26	4.08	1.164
Online Instant Messaging	28	5.79	0.418	26	5.62	0.852

*the ranking system considered 1=most helpful... to 6=least helpful

Table 3
Descriptive statistics for rating of channel variables – site supervision personnel case 1 and 2

Variable	Case 1 Respondents	Case 1 Mean*	Case 1 Standard Deviation	Case 2 Respondents	Case 2 Mean	Case 2 Standard Deviation
Face-to-face meeting	23	4.28	1.123	21	4.48	1.030
Telephone	23	4.13	0.757	22	4.18	0.958
Email	23	3.61	0.891	22	3.55	1.057
Text Message	23	2.70	1.185	22	2.82	1.097
Videoconferencing	23	2.57	1.343	22	2.41	1.532
Online Instant Messaging	23	1.96	1.022	22	1.86	1.167

*for a 5-point Likert-type scale from 1=unutilized... to 5=very helpful

Table 4
Descriptive statistics for ranking of channel variables - design personnel case 1 and 2

Variable	Case 1 Respondents	Case 1 Mean*	Case 1 Standard Deviation	Case 2 Respondents	Case 2 Mean	Case 2 Standard Deviation
Face-to-face meeting	20	1.45	0.999	18	1.78	1.114
Telephone	20	2.60	1.392	18	1.94	0.938
Email	20	3.00	0.649	18	3.17	0.857
Videoconferencing	20	3.95	1.432	18	4.28	1.487
Text Message	20	4.35	1.137	18	4.00	0.907
Online Instant Messaging	20	5.65	0.587	18	5.83	0.383

*the ranking system considered 1=most helpful... to 6=least helpful

Then, in order to continue the analysis for question #1, a repeated analysis of variance (ANOVA) was performed using the Likert-type questions for both cases and both roles to assess if there was a significant difference between channels at the 0.05 level (α=5%). All four tests resulted in a $\rho < 0.000$, rejecting the null hypothesis that there is no difference between channels. A Friedman test was performed to find differences of channel preference regarding helpfulness at the 0.05 level using the ranking question of both cases. Again, the researchers found significant differences between channels in all four tests, with a $\rho < 0.000$. Pairwise comparisons then were conducted for cases 1 and 2 in both roles using a Bonferroni adjustment for the Likert-type questions and using a Wilcoxon test for the raking questions. To illustrate and summarize differences at the 0.05 level, the authors have created lines plot for each role, which are presented in table 5 (designers) and table 6 (site supervision). Channels with the same letter do not present significant differences at the α=0.05 level.

Table 5
Lines plot for channel variables - design personnel case 1 and 2 – pairwise comparisons

Variable	Case 1 – Rating n = 26	Case 1 – Ranking n=28	Case 2 – Rating n=26	Case 2 – ranking n=28
Face-to-face meeting	A	A	A	A
Telephone	A	A	A	A
Email	A	B	A B	B
Text Message	B	C	B C	C
Videoconferencing	B	C	C D	C
Online Instant Messaging	B	D	D	D

Table 6
Lines plot for channel variables – site supervision personnel case 1 and 2 – pairwise comparisons

Variable	Case 1 – Rating n = 23	Case 1 – Ranking n=20	Case 2 – Rating n=21	Case 2 – ranking n=18
Face-to-face meeting	A	A	A B	A
Telephone	A	A B	A	A
Email	A	B	B C	B
Text Message	B	C	C	C
Videoconferencing	B	C	C D	C
Online Instant Messaging	B	D	D	D

Results shown on tables 5 and 6 may not indicate clear differences between all channels, but they do indicate the existence of two groups: one upper-tier group with the three most helpful channels (face-to-face, telephone, and email) for design problems communication between site supervision and design personnel; and one lower-tier group with the three least helpful channels (text message, videoconferencing, and online instant messaging) for the same type of communication. Furthermore, as an answer to research question #2, the authors propose in table 7 the following ranking for both designers and site supervision personnel communicating design issues.

Table 7
Proposed ranking of most helpful channels for design issue communications between site and designers

Variable	Proposed Ranking
Face-to-face meeting	1
Telephone	1
Email	3
Text Message	4
Videoconferencing	4
Online Instant Messaging	6

Discussion

Results indicate that patterns of communication within the construction industry for general communication and design issues communication between designers and site supervision personnel are not significantly different for five of the six communication channels. Email is the only channel that showed significant differences at α=0.05 level for both designers and site supervision personnel. Qualitative responses indicate that users believe email, even though it has advantages for record keeping purposes, is not as effective for urgent situations. Studies have found that the need for constant record-keeping stems from a general lack of trust between stakeholders within the AEC industry (Cheung, Yiu, & Lam, 2013; Nesan, 2012). Additionally, the issues with time constraints and email communication revealed in this study are similar to findings in studies of design revisions in the AEC industry (Tauriainen, Marttinen, Dave, & Koskela, 2016).

As for the main media used for design and site supervision communication of design issues, results are consistent with previous research in construction communication (Cheung, Yiu, & Lam, 2013; Emmit & Gorse, 2003, Nesan, 2012); the consensus is that face-to-face communications are the most helpful method. Results for telephone and email communication are different from those reported by Emmit and Gorse (2003). In the case of Emmit and Gorse's (2003) research, faxes were still the second preferred method of communication. This change could have been caused by advances in information and communication technology, as well as the broader availability of email technology on site. The lack of email communication availability on construction sites in the late 1990s was suggested by Gorse, Emmitt, and Lowis (1999) as a cause of the low usage of email.

The findings in this research are consistant with Media Richness Theory (MRT) for the top three communication channels: face-to-face communication, telephone, and email. Email would be similar to written and addressed communications (Daft, Lengel, & Trevino, 1987). Qualitative input from respondents also indicate situational factors such as availability as a factor influencing media choice, which is also reported by Trevino, Lengel, and Daft (1987) in their research on media selection within organization communications.

Conclusions

Results from this research revealed that media selection for general professional communications in the AEC industry and specific site supervision and design personnel communication for design-related issues are similar for five out of six communication media researched for this paper. Communication via email for both designers and site supervision personnel showed a difference between general communication and design-specific communication in both roles. Finally, results indicated that the most helpful media for the communication of design issues between designers and site supervision personnel are: first, face-to-face and telephone; second, email; third, videoconferencing and text messaging; and, last, online instant messaging.

Limitations apply to the interpretation of the results in the present paper. For instance, the researchers received a very low response rate (5%), which could have influenced results. Another limitation is that cases presented to design and site supervision personnel were slightly different in order to represent cases closer to each role's professional responsibilities. Finally, the internal consistency of the questionnaire was lower than an ideal 0.70 Chronbach's α.

The findings presented in this paper suggest that more research needs to be done to further explore areas within design and site supervision communication, especially regarding the rational and other factors influencing media selection. Some of the suggested research areas are: investigation of the role of email for record-keeping within

construction companies, access and use of new communication media, such as video conferencing, within the construction industry, and the exploration of qualitative reasons for media selection for design-related problems within the AEC industry.

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