



CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

User Maturity and Benefits
Achieved Through the Use of
SMART Board Collaboration
Technology in Collaboration
Sessions

By

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User maturity and benefits achieved through the use of SMART Board collaboration technology in collaboration sessions

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Abstract

We surveyed four different groups currently using interactive group display technology during group design and planning collaboration sessions for construction industry and academic teaching purposes. The results of a survey of users show broad and consistently high levels of perceived benefit of technology to support interactive group collaboration for facility design and construction. The study found that all groups reported a consistently high level of a range of benefits from technology use, although surveys showed differences between the levels of benefits perceived by different user groups as well as within the user groups themselves. The study also found that an increase in user maturity, namely user understanding and use of the collaboration technology, has significant positive impact in the level of benefits perceived from the adoption of collaboration technology. We surveyed interaction technology use of a major European facility design and facility planning firm, two American construction general contractors, and a group of students taking a Building Information Modeling (BIM) course at Stanford University. The results of an economic analysis of these benefits and associated costs suggest a very strong business case for this collaboration technology for a broad spectrum of design and construction organizations.

1. Introduction

We defined a user maturity level index to represent how users of collaboration technology understand and use the technology during collaboration meetings. It summarizes the levels of skill, training and knowledge level of technology users as well as the commitment and willingness of end users to implement the collaboration technology. This study examines the user maturity level of a group and its relation with the benefits perceived from the use of SMART collaboration technology in group meetings across a sample of construction industry practitioners and students. For the study, we surveyed four different user groups currently using SMART Board technology during collaboration meetings. We identified the level of training received by users prior to the implementation of the technology, their receptivity to adopt the use of new technology, the different uses given to the technology during collaboration meetings and the benefits that users perceive from the adoption of the technology. Additionally, we described the economic impact of implementing the collaboration technology using conservative cost and benefit assumptions based on perceived economic benefits of two of the surveyed user groups.

2. Methods

54 participants in industry and academia completed online surveys. All the surveyed groups, both companies and the student group, used SMART interactive collaboration technology. Two of the companies we surveyed are general contractors (GCs) performing most of their work in the United States. The third industry respondent is a major European company offering international design consulting services. Additionally we estimated the Total Economic Impact^(TM)1 (TEI) of the use of collaboration technology using a pro-forma financial statement with data based on our assumptions and on the estimated economics benefits identified by the collaborating GC and the design firm.

Direct observation of student groups at Stanford University

The study included a group of eleven students taking a BIM course that was focused on the creation, management, and application of building information models at Stanford University. We gave a one hour introductory session on the use of SMART Board collaboration technology at the beginning of the course to all enrolled students. The introductory session included a basic explanation on how the collaboration technology works. During the course, students completed weekly assignments that included a critical thinking process in teams of three or four members. We observed and documented the collaborative sessions of two of the student groups. Additionally, these two groups were further oriented on the use of SMART Board technology and received help and training on the use of collaboration technology. During the five weeks we observed students working with the collaboration technology, we determined the most important aspects to be analyzed in the online survey sent to industry practitioners to evaluate their uses and benefits of the collaboration technology.

Online Surveys sent to Industry Practitioners.

In addition to students at Stanford, we sent online surveys to two major GCs and one design firm actively using collaboration technology during their collaboration sessions. We collected the survey results separately for each of the user groups and used the results to determine the relation between maturity and level of benefits perceived by each company.

Survey Questions.

¹ Total Economic Impact (TEI) is a trademark of Forester Research

The online survey included the following questions:

1. Please identify your level of interest in using SMART Board collaboration technology.
2. How much training did you receive in use of SMART Board technology?
3. Please identify the types of software tools you use on SMART Boards (select as many as apply)
4. Describe your proficiency level with the software you mentioned in the previous question
5. Please identify the types of tasks you do using the collaboration technology (select as many as apply)
6. Please identify important uses of SMART Board during recent collaborative sessions (select as many as apply)
7. What level of benefits did you perceive from the use of the collaboration technology?
8. How has your level of interest in the using SMART Board technology changed since the first time you used it?
9. (Optional) please share any comments about your use of SMART collaboration technology

[Economic Impact of the use of collaboration technology.](#)

We estimated the TEI of SMART collaboration technology considering two main elements:

- Benefits
- Total Cost of Ownership (TCO)

The benefits represent the value created for the company by the implementation of SMART Board collaboration technology in the form of cost reductions as well as the creation of business value. The TCO represents the investments necessary to enable the use of the collaboration technology. The TCO considers expenses such as training, capital costs, labor etc. The TEI estimates the benefits derived from the implementation of the collaboration technology versus the costs incurred in implementing it. We compared the benefits perceived and the TCO through the use of a pro-forma financial model that contains the baseline data for each case study. The baseline data is the starting point of the analysis and considers the performance of the surveyed company before the implementation of the technology. The assumed and estimated benefits as well as the TCO from the implementation of the technology are included in the pro-forma financial model to estimate the total impact of the implementation of the technology.

[3. Metrics used for the study.](#)

[User Maturity](#)

We surveyed three factors that together we defined as user maturity study: 1) The training received prior to the use of the collaboration technology 2) The receptivity to use a new collaboration technology during collaboration sessions 3) the different number of technology uses, or use breath, reported by the different user groups. The weighting of the different factors was done based on previous research on Virtual Design and Construction use. However, the model has not been calibrated and must be taken with reserve. The weight distribution among the three different factors is shown in Table 1.

Area	Weight
User Training	15%
User receptivity	15%
Technology Use	70%

Table 1: We defined a maturity index as the weighted sum of three factors that we assumed affect volume and value of collaboration technology use. This table summarizes the factors and the weights we assigned to each.

Level of Benefits.

We summarized the perceived level of benefits based on the 54 answers gathered from a question of the online survey, shown in Figure 1. In this question, respondents identified the benefits perceived in six different categories. On each of the categories, the respondents reported a level of benefits that ranged from 1 (No benefit) to 5 (significant benefit). Table 2 shows the question and collected answers for one organization in matrix form.

. What level of benefits did you percieve from the use of the collaboration technology ?

	1 No Benefit	2	3 Some Benefit	4	5 Significant Benefit
Fewer project Requests for Information (RFIs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reduced latency of communication among stakeholders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Shorter project meetings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Better engagement from team members	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Better understanding of client requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Conformance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 1: Question in an online collaboration technology user survey of perceived level of benefit of technology use. Table 2 and Figure 5 show survey results.

	1 No Benefit	2	3 Some Benefit	4	5 Significant Benefit
Fewer project Requests for Information (RFIs)	1	1	4	4	0
Reduced latency of communication among stakeholders	0	0	0	10	1
Shorter project meetings	1	3	3	2	2
Better engagement from team members	0	1	2	4	5
Better understanding of client requirements	0	2	2	4	4
Quality Conformance	0	2	3	3	2
Safety	1	5	4	0	0

Table 2- Participants reported the level of benefits perceived from the use of collaboration technology. The numerical value for each entry is the total number of participants that reported a specific level of benefits (matrix's column) on each of the different suggested benefits (matrix's rows). The table shows the results obtained from the surveyed design company.

Online survey results

The total value of the benefits identified by the respondents is obtained through the mathematical expression shown in Figure 2 and in Figure 3.

$$\begin{array}{c}
 \xrightarrow{m} \\
 \left[\begin{array}{ccccc}
 X_{11} & X_{21} & X_{31} & X_{41} & X_{i1} \\
 X_{12} & X_{22} & X_{32} & X_{42} & X_{i2} \\
 X_{13} & X_{23} & X_{33} & X_{43} & X_{i3} \\
 X_{14} & X_{24} & X_{34} & X_{44} & X_{i4} \\
 X_{1j} & X_{2j} & X_{3j} & X_{4j} & X_{ij}
 \end{array} \right] \left[\begin{array}{c}
 Z_1 \\
 Z_2 \\
 Z_3 \\
 Z_4 \\
 Z_i
 \end{array} \right] \\
 \left. \begin{array}{c} \downarrow \\ n \end{array} \right\} \text{Level of Benefits} \\
 \underbrace{\hspace{10em}}_{\text{Number of Answers}}
 \end{array}
 \quad
 \sum_{i=1, j=1}^{i=m, j=n} X_{i,j} \times \sum_{j=1}^{j=n} Z_j$$

Figure 2: The mathematical expression to obtain the numerical value of the answers given by X number of respondents. In Figure 2, m is equal to the different level of benefits that were evaluated and n is equal to the number of benefit categories that were evaluated. The Z_i represent the weights of each of the benefits, as assumed in Table 1. The sum of the values for each row, or $\sum_{i=1}^{i=m} X_{i,j}$, is equal to the total number of respondents in the survey.

	0	1	2	3	4
Answer	1 No Benefit	2	3 Some Benefit	4	5 Signif. Benefit
Fewer project Requests for Information (RFIs)	5	6	1	3	4

X_{11}	X_{21}	X_{31}	X_{41}	X_{i1}	0
X_{12}	X_{22}	X_{32}	X_{42}	X_{i2}	1
X_{13}	X_{23}	X_{33}	X_{43}	X_{i3}	2
X_{14}	X_{24}	X_{34}	X_{44}	X_{i4}	3
X_{1j}	X_{2j}	X_{3j}	X_{4j}	X_{ij}	4

Figure 3: Obtaining a numerical value for a specific benefit category (e.g., number of project's RFIs) using a matrix operation. The value of m is equal to five because five different levels of benefits were evaluated in our survey, ranging in value from 0 to 4. The values for X_{ij} in the first row correspond to the number of respondents reporting a certain level of benefits. Thus, $X_{11}=5$, $X_{21}=6$, $X_{31}=1$, $X_{41}=2$ and $X_{51}=4$. The total numeric value of the benefits is equals to the product of the two matrixes.

4. The user maturity and level of benefit indices.

We developed a user maturity index and a level of benefit index to evaluate the maturity of the different user groups as well as the benefits they perceived from the use of SMART Board collaboration technology. The development of these indexes is necessary to evaluate the maturity and benefits perceived by different user groups under a common metric. In addition, we used the indices to analyze the relation between the user's maturity and the level of benefits perceived.

Each index reflects the use or benefit levels reported by a specific user group (i.e., general contractor, design firm etc.) compared against a perfect matrix. We defined a perfect matrix as a set of theoretical maturity and benefit levels from the use of the collaboration technology. It represents the hypothetical situation in which every survey respondent identifies the highest possible level of benefits or level of use for each of the evaluated categories. Our index is valid for surveys with an arbitrary number of respondents.

We define the maturity and benefits indices using the generic mathematical expression shown in Figure 4.

$$\frac{\begin{bmatrix} X_{11} & X_{21} & X_{31} & X_{41} & X_{i1} \\ X_{12} & X_{22} & X_{32} & X_{42} & X_{i2} \\ X_{13} & X_{23} & X_{33} & X_{43} & X_{i3} \\ X_{14} & X_{24} & X_{34} & X_{44} & X_{i4} \\ X_{1j} & X_{2j} & X_{3j} & X_{4j} & X_{ij} \end{bmatrix} \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ Z_4 \\ Z_i \end{bmatrix}}{\begin{bmatrix} 0 & 0 & 0 & 0 & T \\ 0 & 0 & 0 & 0 & T \\ 0 & 0 & 0 & 0 & T \\ 0 & 0 & 0 & 0 & T \\ 0 & 0 & 0 & 0 & T \end{bmatrix} \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ Z_4 \\ Z_i \end{bmatrix}} = Index$$

Figure 4: The benefits and maturity indices define standardized summary results of the surveyed groups with different types and number of respondents. The numerator represents the weighted maturity or benefit reported by respondents. The denominator represents a theoretical ideal in which each respondent reports the highest possible maturity or benefit. Thus, the index represents the reported fraction of the ideal benefit or maturity.

5. Results

Principal uses identified by the surveyed user groups.

We identified the most commonly reported uses of the collaboration technology based on the results obtained from the online surveys. The main uses of the technology have considerable importance in determining the user maturity level of the surveyed groups. The most commonly reported uses were:

- Navigate among files
- View models (e.g., BIMs)
- Annotate Models (Use SMART Board to make hand annotations on BIMs)
- Elaborate design/project reports
- View project files (PDF, Power point, Word, Excel, etc.)

Benefits identified by the surveyed user groups.

We identified the main benefits perceived by the surveyed user groups are presented in Figure 5 through Figure 8.

Design Company

Benefits Perceived

The answers collected from the respondents in the design company are shown in Figure 5. Better engagement of team members and a reduced latency of communication among stakeholders were common benefits perceived by all of the other surveyed groups as well by respondents in the design company. In addition, the design company reported a better understanding of client's requirements as one of the top benefits perceived from the use of collaboration technology.

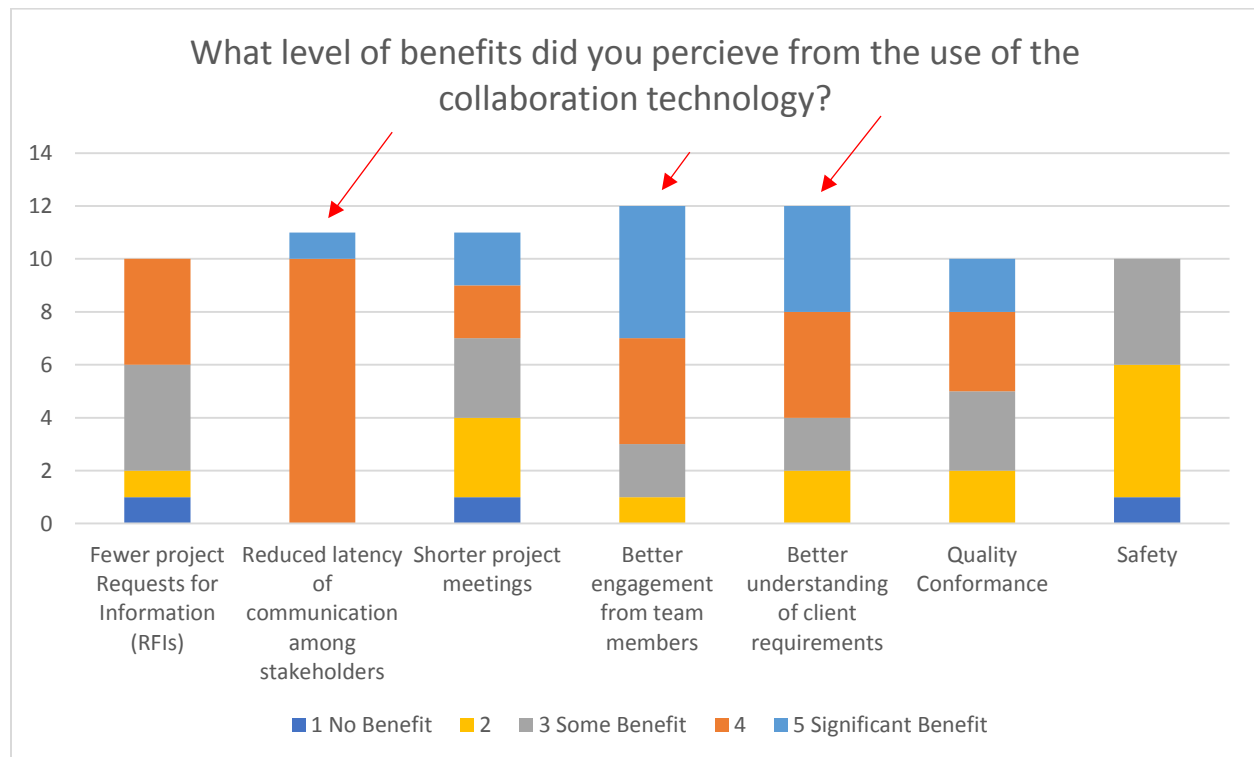


Figure 5: Benefits perceived by users in the surveyed design company. The figure shows that the users in the design company found significant benefit in each area we surveyed. Arrows indicate those areas that had the greatest overall benefit (better engagement and better understanding of client requirements) and that reduced latency was the area with the benefit level ≥ 4 .

General Contractor 1

Benefits Perceived

As with the design firm (Figure 5), General contractor 1 (GC1) respondents identified significant benefit in each area we surveyed. As shown in Figure 6, results show a reduced latency of communication among stakeholders, a better engagement of team members and a better understanding of client requirements as the main benefits perceived from the use of collaboration technology.

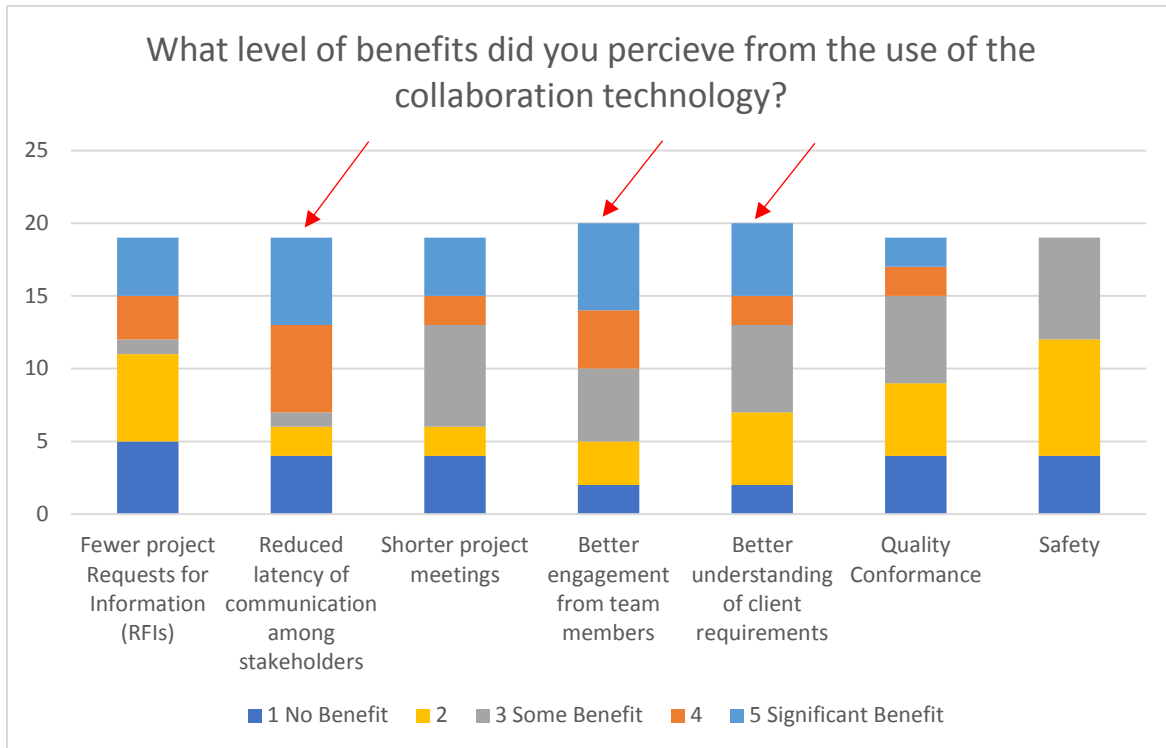


Figure 6: Benefits perceived by users in the first surveyed General Contractor (GC1). As with the design firm, the results show that the users in the GC found significant benefit in each area we surveyed. Arrows indicate those areas that had the greatest overall benefit (better engagement and better understanding of client requirements) and that reduced latency was the area with the benefit level ≥ 4 . While the benefits reported are the same as in other user groups, the magnitude of benefits is smaller.

General Contractor 2

Benefits Perceived

Figure 7 shows the benefits identified by the general contractor 2 (GC2). As with other user groups, a reduced latency of communication among stakeholders and a better engagement from team members were reported as two of the main benefits of the use of collaboration technology. GC2 reported quality conformance as one of the main benefits perceived.

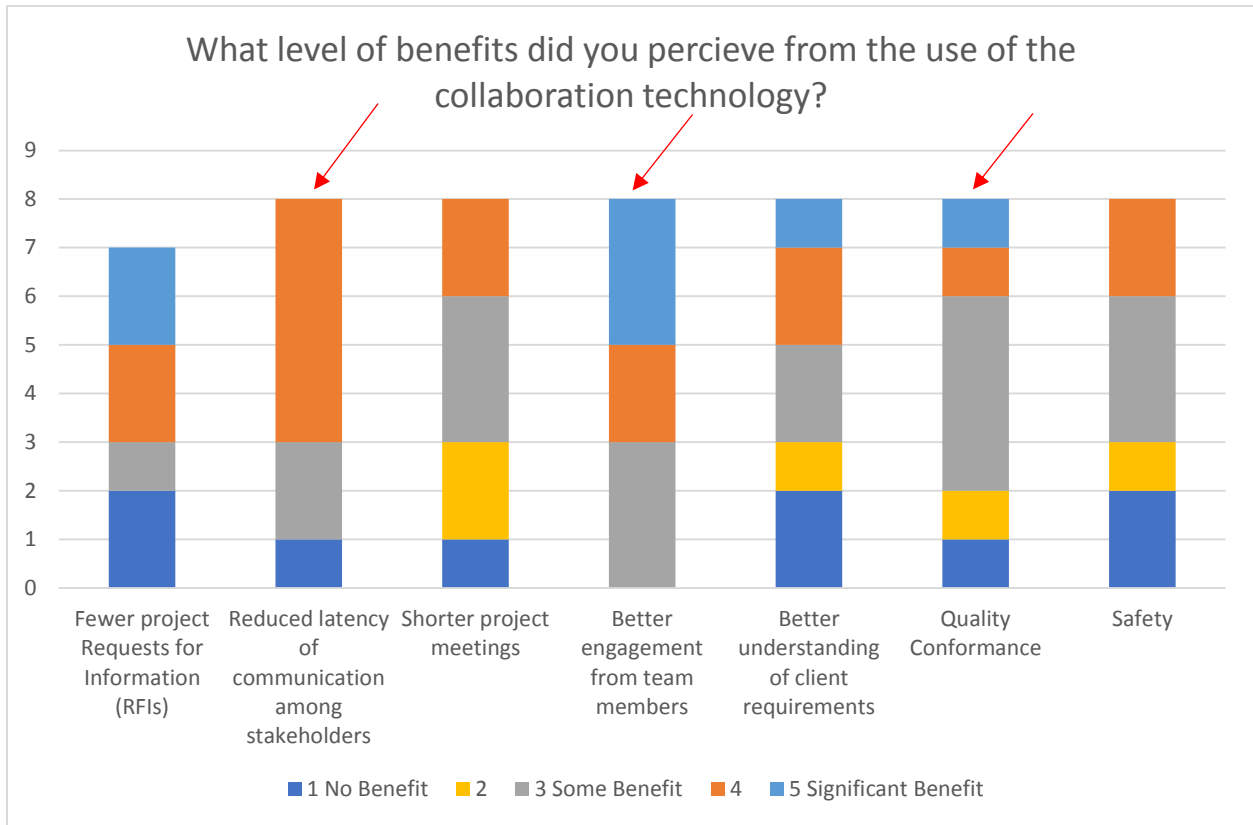


Figure 7: Benefits perceived by GC2. A Reduced latency of communication among stakeholders and a better engagement from team members were reported as the main benefits of the use of collaboration technology. GC2 was the only surveyed group that reported quality conformance as one of the main benefits perceived.

Students

Benefits Perceived

The students we surveyed identified a reduced latency of communication among stakeholders and better engagement from team members as two of the most important benefits derived from the use of SMART Board collaboration technology. Additionally, students were the only group that identified shorter project meetings as one of the main benefits resulting from the use the technology.

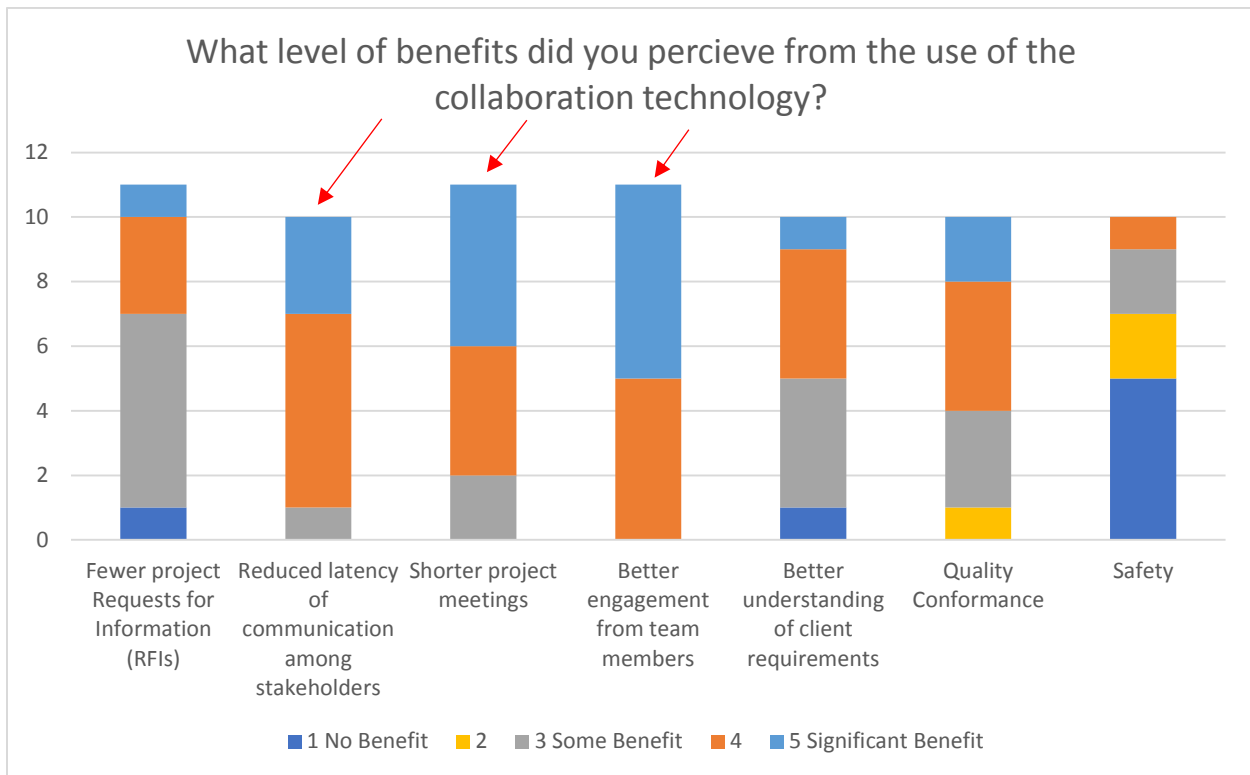


Figure 8: The students group also identified a reduced latency of communication among stakeholders as well as better engagement from team members as main benefits. They identified shorter project meetings as one of the main benefits.

Determining the individual user maturity and benefit level index.

We used the results presented in the previous sections to identify the most important uses and level of benefits within each of the user groups. However, so far we have not made a relative comparison between the benefits perceived by each of the different surveyed groups. Additionally, we have not identified a relationship between the maturity level and the level of benefits perceived. To make these comparisons, we calculated and plotted the user maturity and benefits indexes for each of the online survey 54 respondents.

The user maturity index, i.e., the amount of training, user receptivity to the new technology and the breath uses of the technology, is plotted in the X axis in Figure 9. The benefits index, i.e., the level of benefits reported by the survey respondents is plotted in Y axis. We plotted individuals within the same user groups in a single data series to obtain an adjusted trend line for each user group. The A trend line represents the least mature user group (GC1) and the B line the most mature group (students). While the data are not statistically significant, the greater value of the slope for the A trend line suggests that benefits increase in direct relationship to user maturity. This increase is a classic “dose response,” in which there is a greater response to greater change. In this study, the data suggest a greater predictable return on investment from investing in professional development to increase maturity in combination with an investment in technology.

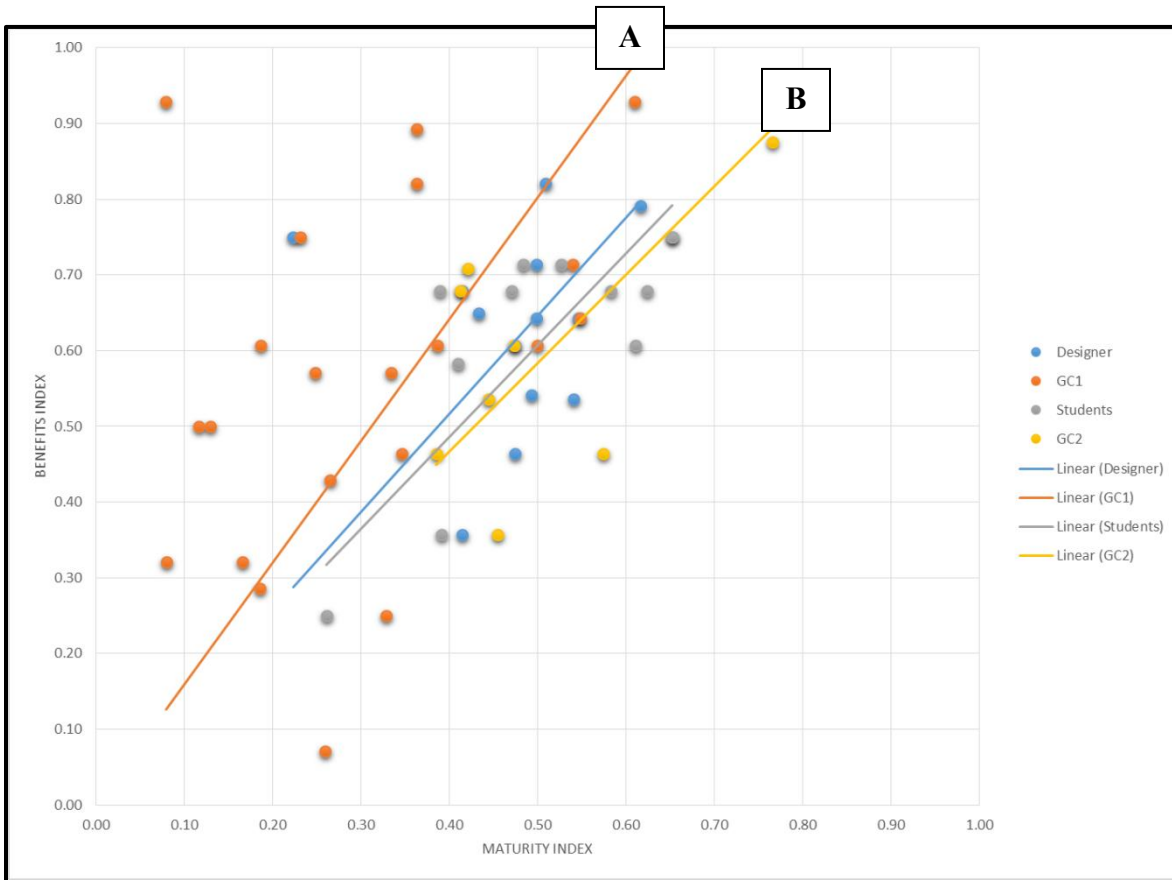


Figure 9: This graph shows the relationship between benefits and user maturity. The [A] trend line shows the benefit-maturity relationship for the least mature organization, and the [B] trend line shows the benefit-maturity relationship for the most mature organization. Data from the more mature organization have less variance from the trend line. Data from the less mature organization show a stronger dose-response to increased maturity. These data suggest together that organization-wide performance is more reliable and consistent with greater maturity, and that investment to increase maturity has a particularly high benefit for less mature organizations.

Determining user group maturity and level of benefit indexes.

We used the individual answers obtained to determine an overall maturity and benefit index for each of the surveyed user groups. We defined the group user and maturity indices as the mathematical average of the individual user maturity and benefits index for each of the respondents within that same group, where Figure 4 defines the maturity and benefits. The ratio between the benefits index and user maturity index, which is an indicator of the relationship between the maturity level of a user group and the level of benefits perceived, is obtained as shown in Figure 10.

$$\text{Benefit – Maturity Ratio} = \frac{\text{Benefits Index}}{\text{User Maturity Index}}$$

Figure 10: The benefit-maturity ratio between the benefits and the user maturity index is obtained by the quotient of the benefits index and the user maturity index, showing the relationship between the two metrics. In more mature companies the ratio suggests a dose-response behavior. In Figure 9 above and Table 3 below, the [A] and [B] groups have the lowest and highest benefit-maturity index respectively.

User Group	User Maturity Index	Benefits Index	Ratio
Designer	0.55	0.62	1.11
GC1	0.36	0.49	1.34
GC2	0.54	0.53	0.99
Students	0.58	0.66	1.14

Table 3: We computed overall maturity index and a level of benefits index value for each surveyed group. The data suggest a dose-response behavior (i.e., benefit increases with maturity) as the maturity level increases. The graph of Figure 9 shows the details of these summarized data. GC1 has the lowest maturity index and the students the highest maturity index. The high maturity index of the students probably is related to the one hour of training and repeated coaching sessions they had in addition to their assumed comfort with technology as younger people.

6. Economic Impact of implementing SMART Collaboration Technology.

Based on the experience of two of the surveyed companies as well as on our assumptions on the impact of the collaboration technology, we determined the TEI of implementing SMART Board collaboration technology.

Costs of Implementation.

The cost of implementation of SMART Board collaboration technology considers the installation of a collaborative room with three SMART Boards, four high performance desktop computers, one qualified full time engineer for training, maintenance and user support and operation costs such as electricity. The costs assumed for the implementation of SMART collaboration technology are shown in Table 4.

Hardware costs

Concept	Costs	Units	Total Cost
PC - Workstation Desktop	\$2,500.00	4	\$10,000.00
SMART Board 885ix interactive whiteboard system	\$8,000.00	3	\$24,000.00
Installation Cost	\$3,000.00	1	\$3,000.00
Total Hardware Costs			\$37,000.00

Table 4: Estimated Hardware implementation costs for the necessary equipment required for a collaborative equipped with SMART Board collaboration technology.

Training, Maintenance, User Support and Electricity

The cost assumed for implementing user training, system maintenance, user support and other additional operation charges such as electricity for both the design company and the general contractor companies are shown in Table 5

Concept	Amount
Full Time Engineer (FTE) in charge of user training, system maintenance	\$100,000/year

Table 5: Estimated operation and implementation costs required for the implementation SMART Board collaboration technology.

Benefits from the implementation of Collaboration Technology.

General Contractor

A pro-forma financial model was used to evaluate the economic impact of SMART Board collaboration technology on GC1, considering a base line case and the economic benefits and costs from implementing smart collaboration technology.

The implementation costs and operation expenses shown in Table 4 and Table 5 were used for calculating the pro-forma for GC1. The benefits assumed from the use of the collaboration technology as follows:

- We assumed a reduction on the costs of contracted work of 1%.
- We used a conservative assumption of no increase in sales as a result of the implementation of collaboration technology. This is especially conservative considering that one of the key benefits identified in the online survey was a better understanding of client requirements, possibly resulting in an increase in sales.

	Rate	Baseline (\$K)	Change in Rate	Year-1 (K\$)
Revenue	100%	300,000	0.0%	300,000
Cost of contracted work	83%	249,000	-1.00%	246,000
Cost of self-performed work	10%	30,000	0.033%	30,100
Gross Margin		21,000		23,900
Sales, G&A	2%	6,000		6,000
IT investment (K\$)		37		
Amortized costs of IT (3 yr.)				12
Net income		15,000		17,888
Time to payback (weeks)				1
Net Income change (%)				19.3

Table 6 shows a pro-forma financial model for GC1. The pro forma assumes that, following investment in collaboration technology, there is no change in revenue; cost of contracted work goes down by 1% due to the benefits described above and the cost of self-performed work marginally increases with the addition of technology support staff. With these conservative assumptions, the implementation of collaboration technology in a GC company results in a payback period of weeks, due to an increase of about 19% in the company's net income.

As shown in Table 6, the estimated economic impact of collaboration technology in GC1 results in an increase of net income of 19.3%. The absolute economic benefit for the GC1 is \$2.88 MM per annum, while the implementation costs would be \$112,000.

Sources of benefits for GC1

The most important benefits categories identified by GC1, from most important to the least important, are:

1. Better engagement of team members
2. Reduced latency of communication among stakeholders

3. Better understand of client requirements
4. Shorter project meetings
5. Fewer RFIs
6. Quality Conformance
7. Safety

The data do not allow us to infer the economic impact from these reported benefits. Accordingly, in Figure 6, we used the TEI method as it was designed and make conservative assumptions about the impact on revenue (assumed no impact, either up or down), cost of contracted work (conservatively = 1%) and cost of self-performed work (conservatively increased by the addition of one full time support staff member to oversee technology use and facilitate its use in collaboration).

Design Company

A pro-forma financial model was used to evaluate the economic impact of collaboration technology on a design company, considering a base line case and the following assumed economic benefits from the use of the collaboration technology.

- A reduction in the cost of self-performed work of 0.20%. The data shown in Table 7 considers also the costs of operation and implementation shown in Table 5. Therefore, it results on an overall net reduction in the cost of self-performed work is of 0.15%
- We used a conservative assumption of no increase in sales as a result of the implementation of collaboration technology. This is especially conservative considering that one of the key benefits identified in the online survey is a better understanding of client requirements, possibly resulting in an increase in sales.

The pro-forma financial model is shown in Table 7

	Rate	Baseline (\$K)	Change in Rate	Year-1 (K\$)
Revenue	100%	200,000	0.0%	200,000
Cost of contracted work	10%	20,000	0.00%	20,000
Cost of self-performed work	84%	168,000	-0.15%	167,700
Gross Margin		12,000		12,300
Sales, G&A	2%	4,000		4,000
IT investment (K\$)		37		
Amortized costs of IT (3 yr.)				12
Net income		8,000		8,288
Time to payback (weeks)				6.7
Net Income change (%)				3.6

Table 7 shows a pro-forma financial model for the design company. The pro-forma assumes that, following investment in collaboration technology, there is no change in revenue and the cost of self-performed work goes down by 0.15% due to the benefits perceived by the design company. With these conservative assumptions, the implementation of collaboration technology in a design company results in a payback period of weeks, due to an increase of 3.6 % in the company's net income.

As shown in Table 7 the estimated economic impact of collaboration technology in the design company results in a net income increase of 3.6 %. The absolute economic benefit for the design company is \$288 K per annum, while the implementation costs are \$112 K.

Sources of benefits for the surveyed design company.

The most important benefits categories identified by the design company, from most important to the least important, are:

1. Better engagement of team members
2. Better understand of client requirements
3. Reduced latency of communication among stakeholders
4. Quality Conformance
5. Shorter project meetings
6. Fewer RFIs
7. Safety

As in the case of GC1, the data do not allow us to infer the economic impact from these reported benefits. Accordingly, in Table 7 we used the TEI method as it was designed and make conservative assumptions about the impact on revenue and operation costs in the design firm.

Complementary findings: The potential of increasing user maturity in the use of collaboration technology.

We carried out an analysis to determine the effect of increasing user maturity and potentially the benefits perceived by the use of collaboration technology. From the results of this study, it is clear that an increase in maturity, i.e., level of training, user receptivity and an increase in the breath of uses of the technology can lead to considerable increase in the benefits perceived from the use of the technology.

We assumed:

1. The investment costs on technology remain the same. The increase in maturity is achieved through improved implementation practices and uses of the technology.
2. A conservative assumption that no increase in sales result from the use of collaboration technology.
3. Gross margin for general contractor is 7%
4. The cost of self-performed work / revenue ratio remains constant for all cases

Figure 11 shows a family of payback curves. The different curves represent different GC payback periods as assumed cost of contracted work varies in the range of 1-2% improvement.

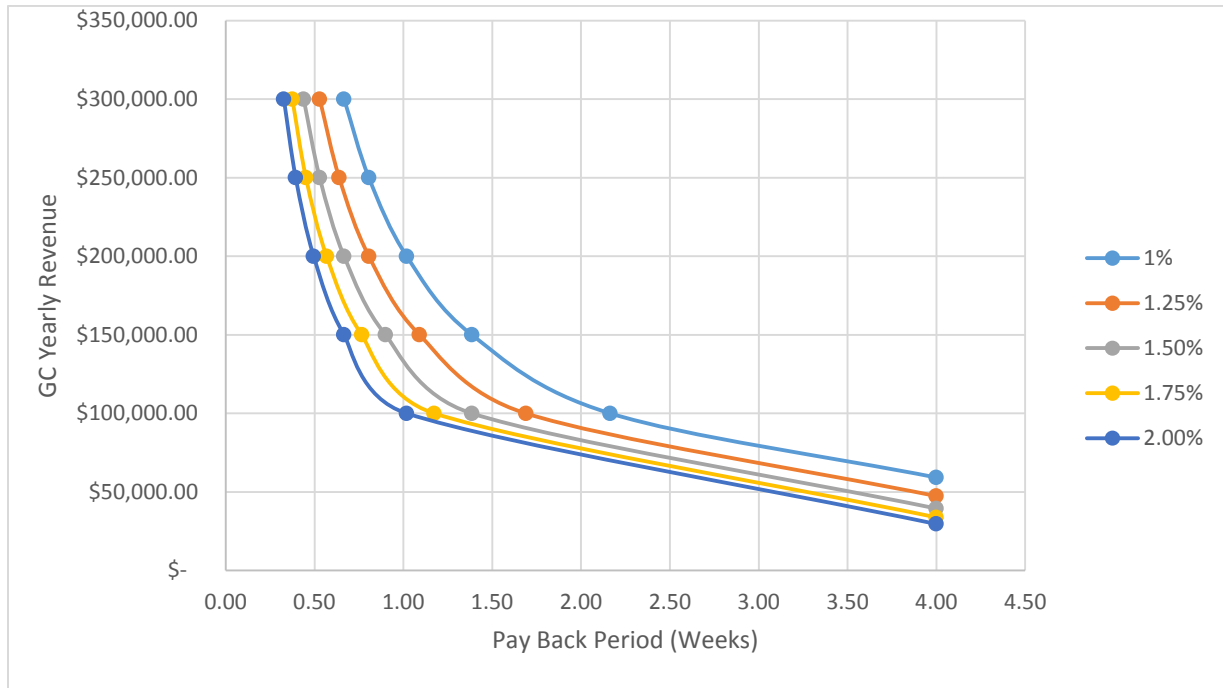


Figure 11: Family of predicted payback periods with levels of user GC cost of contracted work that range from 1 to 2% reduction. This what-if analysis suggests high sensitivity of payback period with reduced of contracted work, which follows increased maturity. The dramatic sensitivity of payback period to cost and maturity suggests the potential value investment in collaboration technology.

7. Conclusions

This study shows two independent but complementary findings on the use of collaboration technology by industry and academia. The data we gathered from the surveyed companies and students at Stanford University suggests a considerable increase in the benefits perceived by the use of collaboration technology as the user maturity level increases. The relationship between user maturity and benefits perceived appears to have a strong dose-response behavior, especially with lower levels of maturity.

According to this study, an investment in SMART Board collaboration technologies can easily be justified as a good investment decision given the estimated TEI this collaboration technology in GCs and design companies. With our assumptions, we estimated an increase in net income due to the implementation of collaboration technology of 19.3% in GCs and 3.6% in design companies. Additionally, an investment decision by smaller GCs with lower yearly revenues can also be justified with better management practices and higher levels of maturity in the implementation of the technology. .

While there is no causal relation between the main benefits identified through the online survey and the estimated TEI of implementing the collaboration technology, all of the user groups identified a reduced latency of communication and a better understanding of client requirements among the three top benefits of implementing the collaboration technology. Therefore, the data suggests that these two benefits play an important role in the TEI of implementing collaboration technology

Finally, an opportunity to maximize the benefits from the use of collaboration technology is identified through better implementation practices of SMART Board collaboration technology in adopting companies. Specifically, we considered the implementation of formal technology use trainings, increasing the user receptivity to new technology and the breadth of uses of the technology during collaborative sessions as important points to increase the user maturity level and thus the level of benefits perceived from the implementation of the technology. A wider spectrum of companies could benefit from the use of collaboration technology if they are capable of effectively understanding and using the technology.

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