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Welcome to the machine How web-based technologies affect team collaboration?

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No matter how large an organization might be, it cannot achieve fast or significant development on its own. Collaboration has become a fundamental element: collaboration with customers, with suppliers and internal and external stakeholders. This phenomenon fades the boundaries of companies away, giving soil to a higher level of cooperation, as the advent of the Internet has made information readily available in a press of a button. With the absence of information disparity organizations thrive to continue to innovate in order to sustain its corporate competencies. Traditionally, innovation has always been made within a small-dedicated group within an organization. More recently, some of major corporations have discovered that innovation is the responsibility of the entire organization and the best ideas are most likely to come from the collaboration of people of diverse background, culture, experience, and age. Unlikely to the traditional face-to-face collaborations, modern meetings can take a virtual form that participants are completely separated from physical location and time zones. Social ties are not anymore established only at the canteen's coffee table but through computer assisted communication systems. Recent studies on global collaboration are concentrated mostly under the domain of Group Decision Support System (GDSS) on communication efficiencies, problem solving, and decision-making.

In this paper the results of an experiment on how inter-departmental communication can proceed to render higher decision quality, productivity and satisfaction is demonstrated. 175 team members of 45 student teams have worked in technologically and demographically diverse groups. The factor variables were the task/technology fit, productivity, decision quality, satisfaction and key competencies. It has been proven that modern web-2

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based social technologies called wikis may facilitate such collaborations and massive knowledge share.

Keywords: diverse teams, decision-making, GDSS, task/technology fit, wiki collaboration technologies.

JEL codes: M12, I29, O39, C92.

Introduction

Created by Ward Cunningham in 1995, wikis are web-based hypertext applications intended for collaborative writing. In addition to writing and viewing their own pages in real time, people who use a wiki can see pages others have published and hyper-textually link to them without having to wait for an editor to assemble the various components developed individually on multiple PCs. Second, during the writing process, content can be displayed immediately to other team members, who can immediately add their own contributions and see others' revisions without having to wait for an editor to assemble the various elements from people working on other PCs (Lin et al. 2012).

Wikis can facilitate knowledge management by formatting collaboration. As McAfee argued, "The technologists of Enterprise 2.0 (e.g., wikis) are trying hard not to impose on users any preconceived notions about how work should proceed or how output should be categorized or structured. Instead, they're building tools that let these aspects of knowledge work emerge" (McAfee 2006). Tacit knowledge is unstructured, subjective, abstract, and without a fixed format. Wikis have evolved as a tool capable of matching these various characteristics (Lin et al. 2012).

Literature review

Recent trends in Web2 and Wiki technologies

Web 2.0 technologies enable remarkable interactivity and create many new collaboration models such as Wikipedia or InnoCentive. What encourages us is not only its popularity but its idiosyncrasy; simple and parallel editing, version control, and real-time updates (Trkman and Trkman 2009). Bean and Hott (2005) pointed out "bottleneck effect" where updates are delayed through centrally managed entry. Instead of being served as a control centre, wiki serves as a platform and central repository. This makes asynchronous cooperation and cross-time zone operations possible, and conflicts can be solved in an asynchronous and location independent setting.

First, in a typical corporate hierarchy, opinions from higher ranked officers may be valued more. Wiki provides an equal opportunity that allows all opinions to be heard. It also permits efficiency. As Bean and Hott (2005) commented, rather than the back-and-forth exchanges of e-mail attachments or discussion boards, wiki allows direct exchanges of opinions centrally and stored permanently.

Second, unlike blogs or micro-blogs available today, wiki allows bi-directional communication, which makes it a dynamic process that closely resembles the real life communication exchange. Mattison (2003) pointed out that compared to blogs where articles are written mainly by individuals, wiki is a groupware where authors have a chance to see others' writings and offer their own thought. Most wiki provide forums where authors can discuss and resolve conflicting opinions before they are posted.

Lastly, the entire methodology is built on trust, which means all entries are assumed to be genuine and correct and filters are established only when necessary. The assumed trust and the way wiki encourages continuous enhancement of facts, in turns harness the power of diverse individuals to create collaborative works globally (Shu and Cheng 2012).

In the past 20 years, many organizations have begun to understand the importance of companywide knowledge management as a key to competitiveness and productivity (Stratford and Davenport 2008). A wiki is a readily available and convenient tool for knowledge management and collaboration. Many organizations such as Motorola use wiki as an internal knowledge management system (Chu and Kennedy 2011; Shu and Yu-Hao 2012). IBM has also used wiki to manage and obtain product knowledge and insights through its component broker (Hasan and Ptaff 2006). Organizations need to focus on their own organization learning to sustain growth in order to compete favourably in the global market (Argyris 1997). Wikis have been successful in helping companies converge scattered information into a streamlined and easily accessible knowledge base (Hasan and Ptaff 2006). Wikis enable people to work collaboratively in the creation and storage of knowledge (Wagner and Bolloju 2005), the accumulation of knowledge, which allows innovators to absorb and use of knowledge to generate innovation (Cohen and Levinthal 1990), and the organizational body of thoughts which can be collected. These are important for studying the organizational learning and knowledge creation (Lam 2004).

The different perspectives of understanding diversity in work-groups

The increasing dilemma in organizations is the growing presence and need to manage diversity in work-groups: namely how can the unavoidable symptom of different faces of diversity turned to a potential benefit? Traditional management techniques had used the assumption of a much more homogenous work-force. And for quite a long period of time the techniques seemed to work well-enough. However with the internationalization of markets, the radically changing motivation and attitude of the work-force, and the equity legislation in many countries, those techniques do not seem to be valid anymore for today's organizations.

As Maznevski (1994) argues, any group of people can be described by its diversity. Two basic types of diversity sources can be identified:

Role diversity, which includes occupation, organizational position, specialized knowledge and skills, and family role. Diversity along this dimension seems easy to understand even in the everyday practice of a company. Moreover, in business settings role type of diversity is often consciously created in decision-making teams. These explicit roles and the behaviours, attitudes and norms associated with them are publicly recognized.

In spite the public relevance of role diversity, *inherent diversity* is less obvious and visible. This dimension includes age, gender, nationality, cultural values, personality and information processing and decision-making style. By being less explicit, the impact and consequences of inherent diversity are also more challenging to understand. Interestingly gender seemed to become a role-related source of diversity recently. Research has demonstrated that women and men bring different perspectives, better ideas to a group thus generating different solution possibilities and better performance (Dyson et al. 1976; Hoffman and Maier 1961; Ruhe 1978). Culturally diverse groups also generate more ideas of higher quality in brainstorming processes (Adler 1990; McLeod and Lobe 1992). Mobilizing the energy and synergy of people from various cultures working as a team can lead to more creative approaches to the problems and challenges faced by corporate teams (Marquadt and Horvath 2001). The summary of task-related effectiveness of diverse teams is demonstrated on Table 1.

Another perspective of diversity takes the individuals cultural background as the main source of classification. Adler (1990) focuses on the cultural background of the individuals in the construction of teams. In *homogeneous groups* all members share the same cultural background. Therefore members of homogeneous groups generally perceive, interpret, and evaluate the world in a very similar way. Homogeneous nature of the team can be perceived by professional and national culture and other inherent diversity characteristics. When all but one member of a certain group share the same diversity characteristics then *token groups* are taking over. Managing token groups can be a real challenge even if the leader of the team is the one culturally/professionally etc. different member, which is often the case in business reality. This situation requires a high level of leadership and cultural and managerial intelligence, where authority and power are in contrast with the majority of the members. In *bicultural groups*, two or more members represent each of two distinct diversity characteristics. This bicultural situation happens very often in the case of mergers and acquisitions (M&A), when experts and managers from two companies try to integrate the cultures of the two merging organizations or in product development teams with engineers and marketing people on board. Such bicultural interactions raise the most cultural conflicts. Following the diversity framework of Adler (1990), in multicultural groups, three or more culturally or otherwise diverse backgrounds are represented. The latter is the type, which is mostly referred to as diverse group in this study.

The effectiveness of diverse teams

Hundreds of studies have already focused on the effectiveness of groups' problem-solving (Bettenhausen 1991; Hill 1982; Shaw 1983). However most studies did not have much focus on diverse teams. The ones which have examined the impact of diversity on group problem-solving have produced inconsistent results (Watson et al. 1993). As far as decision-making is concerned, empirical studies have contrasting results. While diversity in membership (inherent and role-related as well) is desirable for decision-making tasks for the increasing number of solutions or alternatives offered, in the meantime diversity also appears as a serious obstacle to smooth interaction processes, often resulting in decreased performance (Adler 1990; Maznevski 1994).

Ling (1990) argues two advantages of diverse composition in decision-making teams, such as specific and general. Most of the time the task of the group requires more knowledge and skills than any individual member would possess. Therefore, out of necessity the individual contributions will complement each other. In this case the specific advantages of role-related diversity are used. General advantages are less easy to tackle, simply because diversity itself supports the process and increases the potential productivity of the group.

Table 1. The Effective Managing of Diversity in Work Groups

	EFFECTIVE	INEFFECTIVE
TASK	Innovative	Routine
STAGE	Divergence (earlier)	Convergence (later)
CONDITIONS	Differences recognized Members selected for task-related abilities Mutual respect Equal power Superordinate goal External feedback	Differences ignored Members selected on basis of ethnicity Ethnocentrism Cultural dominance Individual goals No feedback (complete autonomy)

Source: Adler 1990

These teams can also help to minimize the risk of uniformity and pressures of 'group-think' that can easily occur in long-standing homogenous teams (Schneider and Barsoux 2003).

In conclusion, studies have demonstrated that diverse groups have the potential to perform well, they can generate more and better alternatives and criteria than homogenous groups. However when it comes to solutions and implementation their performance falls behind the homogenous groups (Kumar et al. 1991; Ruhe and Allen 1977). Overall, most research seem to suggest as little diversity as possible for decision-making teams. Where diversity proved to enhance effectiveness, the common element seemed to be the conscious integration of that diversity (Maznevski 1994). Once diversity is integrated, diverse teams can achieve their potential (Hurst et al. 1989). On the process stage effectiveness and considerations of diverse teams, see Table 2.

Table 2. Diversity and the Group's Stage of Development

Stage	Process	Diversity makes the process	Process based on...
Entry: Initial group formation	Trust building (developing cohesion)	More difficult	Using similarities and understanding differences
Work: Problem description and analysis	Ideation (creating ideas)	Easier	Using differences
Action: Decision making and implementation	Consensus building (agreeing and acting)	More difficult	Recognizing and creating similarities

Source: Adler 1990

Performance parameters of teamwork/collaboration

In this research and during the planning of the experiment the methodology and experiment procedure developed by Shu and Yu-Hao (2012) and Shu and Yu-Hao (2011) at National Central University, Taiwan were followed. In this study the Hungarian results of our comparative Hungarian-Taiwanese research experiment are demonstrated. The terminology and task classification of Shu and Lee (2003) has been used in the paper. Thus teamwork was featured with the following performance parameters and factors as a priori variables in further analysis.

Task/technology fit

Although wikis demonstrate different technology characteristics, which may be proven to be superior in terms of productivity, decision quality, and satisfaction in collaboration, they may not be superior in all types of tasks. Goodhue (1998) has demonstrated that different technologies may fit into different task categories.

According to (McGrath 1984), collaborative tasks can be divided into two classifications: intellective tasks and preference tasks; the former is the task to solve a problem that has an anticipated outcome. The latter is a task that an outcome is uncertain. The final agreement must rely on team members' values and beliefs. Zigurs and Buckland (1998) believe team members will, under different task classifications and collaborative technologies, collaborate differently and cause difference in task fit. The nature of the preference task makes us to infer that it is more likely to incite discussion within the group, different opinion exchange, and alternative interpretation on the task, which makes the need for sound collaborative platform more prominent.

In Goodhue (1998) task/technology fit (TTF) model, the usefulness of tools in performing a task is highly correlated with how well the task collocates with the tools functionality. The main thrust of TTF theory is that any science and technology must collocate in unison with the needs of mission before any measurable performance is possible. For example, collaboration between team members under a collaborative support system can solve problems more efficiently because it is not subjected to time and geographical constraints (Dennis et al. 1999; Jessup and Valacich 1993; Klein and Dologite 2000).

We believe TTF is appropriate for our study. First, wiki and traditional collaboration differs in synchronization. It is our goal to find out which technology mode fits better on tasks requiring extensive asynchronous collaboration.

Second, TTF differs from the utilization models such as UTAUT (Venkatesh et al. 2003) in that it is a direct measurement of performance. As Goodhue stated, "Utilization of a poor system (i.e., one with low TTF) will not improve performance, and poor systems may be utilized "extensively due to social factors, habit, ignorance, availability, etc., even when utilization is voluntary." When the technology use is not voluntary, then it is treated as a contaminant in a utilization model, which makes the model less credible as measure performance (Goodhue and Thompson 1995).

According to Goodhue (1998) as Shu and Yu-Hao (2012) refers Technology/Task Fit (TTF) is related to the usefulness of tools used in performing a task which is highly correlated with how well the task collocates with the tools' functionally. The main trust of TTF model is that any science and technology must collocate in unison with the needs of mission before any measurable performance is possible. Goodhue is the first scholar to conceive the Task/Technology Fit Theory (TTF), which stated that the degree of task/technology fit determines how helpful an information technology is to a user while performing tasks. Goodhue pointed out that an information technology is said to have a good fit whenever it is able to reduce operating costs, provide easier user experience, and better performance outcome (Goodhue 1988). In other words, a user must believe that the information system is useful and able to provide considerable benefits to his/her assigned task (Greenstein 1998). Collaboration between team members under a collaborative support system that can solve problems without time and geographical constrain would be more efficient and favourable (Dennis et al. 1999; Katz and Shapiro 1994; Klein and Dologite 2000).

Productivity

In mathematical terms, productivity can be calculated as the ratio between inputs and outputs (Belanger et al. 2001). Yet not all aspects of input and output are measurable (Brynjolfsson and Yang 1996). Outputs such as quality of life, fun, and convenience are nearly impossible to quantify or measure directly.

Consequently, the respondents' beliefs about the effectiveness of using wikis or not using wikis in the performance of tasks and their perceived productivity should be measured. Thus, previous researches that have shown strong links between self-judgments and the quality of performance were strongly relied upon (Kauffman and Weill 1989; Kelley 1994). Productivity will be measured in two ways. The first is a questionnaire based on Shu and Chuang (2012). The second is an objective measurement, which will count the number of generated ideas.

Decision Quality

Much of the studies on group decision quality came from the study of Group Support Systems (GSS). Benbasat and Lim (1993) quantitatively integrated the results of several experimental studies on GSS usage and found that it has a positive effect on decision quality. Their founding was further supported by Nunamaker et al. (1996) that in laboratory studies that group using GSS produce higher quality ideas than those using standard meeting techniques.

Quality is often used to measure the final results in collaborative research. It refers to team members' own feelings towards the team output during the decision-making process (Chen 2003). It can also be equate to members' own evaluation of the final decision outcomes (Chizmar and Zak 1983). Decision quality will be measured by a questionnaire based on Shu and Yu-Hao's study (2012).

Satisfaction

Satisfaction may be defined as an application's ability to meet the expectation of the users. It is by far a subjective term that varies with one's perceptions and attitudes toward its eventual benefits and outcomes. Past studies have indicated that satisfaction is closely moderated by the aspect of an application's ease of use or the precision of the user-machine interface (Adam Mahmood et al. 1999). Satisfaction often used to measure the effectiveness of a collaborative process or result (Church and Gandal 1992, 1993).

Past researches also suggested that care must be taken when formulating satisfaction metrics, because measurement of satisfaction and quality are similar, but in practice, high degree of satisfaction may or may not necessarily equates to high quality (Jonscher 1983). Satisfaction will be measured by a questionnaire based on Shu and Yu-Hao's study (2012).

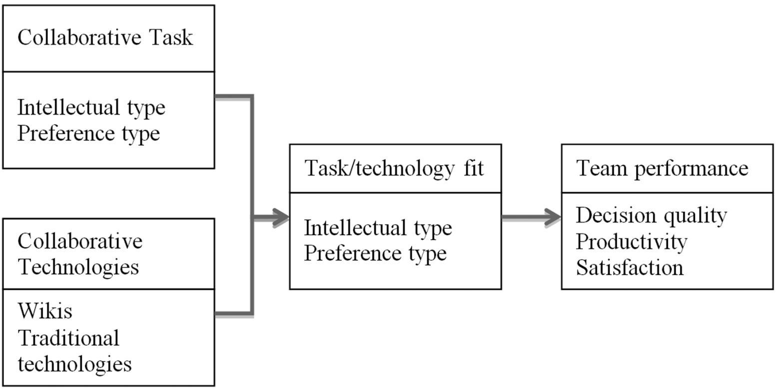
Key capabilities

In this sense some typical capabilities and competencies of team members were measured regarding to teamwork and collaboration with other team members as suggested in literature (Lin et al. 2012; Shu and Cheng 2012; Shu and Lee 2003; Shu and Yu-Hao 2012). The ability of knowledge sharing and absorption potential, learning and knowledge transfer, shared knowledge creation, access to knowledge during teamwork, the integration of knowledge from different sources, filtering knowledge and many efficiency issues, such as learning efficiency, problem-solving efficiency, learning from mistakes were measured, so as the evolution of teamwork and collaboration and the ability of knowledge utilization.

Research methodology and experiment design

Research model and hypothesis

In this paper and during the whole research process (including planning and implementing) the methodology presented in Lin et al. (2012); Shu and Lee (2003); Shu and Yu-Hao (2012) were followed. This methodology is based on the separation of collaborative tasks to intellectual type and preference type tasks on the one hand, and the separation of collaborative technologies to traditional (face-to-face meetings) and wiki (web2)-based technologies on the other. In this sense the research need to measure the fit of the two dimensions of tasks and technologies and the team performance.



Source: Shu and Lee 2003

Figure 1. Research model

Goodhue and Thompson (1995) in their task/technology fit (TTF) model argued that the usefulness of tools in performing a task is highly correlated with how well the task collocates with the tools' functionality. The main thrust of TTF theory is that any science and technology must collocate with the needs of the mission before measurable performance is possible. In other words, potential users must be thoroughly convinced that a technology is capable of assisting them in completing their mission before it is adopted (Greenstein 1998). For example, collaboration between team members under a collaborative support system that can solve problems with no time and geographical constraints would be the most efficient (Banker and Kemerer 1989; Katz and Shapiro 1994).

Zigurs and Buckland (1998) have shown that groups adopting a group support system are more motivated to express their ideas than groups that do not. This is probably because the group members can avoid the possibility of face-to-face confrontation, which might lead to coercion and embarrassment. Additionally, systems that support parallel editing and allow multiple participants to instantly share and express their opinions, ideas, and information could be far more efficient than conventional systems in which editing and expression are sequential (Berndt 1992).

Based on these arguments, we proposed the following hypotheses:

Hypothesis 1*: In the context of inter-group collaboration, wiki offers a better task/technology fit than conventional processor.*

Hypothesis 1a: *In the context of inter-group intellective tasking, wiki offers a better task/technology fit than conventional processor.*

Hypothesis 1b*: In the context of inter-group preference tasking, wiki offers a better task/technology fit than conventional processor.*

Christensen and Jorgenson (1969) argued that the amount of information a member of a team can contribute is an important indicator of the quality of the group collaboration. Christensen and Greene (1976) further defined productivity as the quantity of output data that a collaborative team can produce. Grover et al. (1998) used perceived productivity as the dependent variable in their study of IT diffusion, primarily because previous studies of IT and productivity yielded ambiguous results, largely due to measurement issues. In our model, neither the inputs nor the outputs in either the intellective or the preference task are measurable. Thus, we defined productivity, in the context of inter-group collaboration, as the perceived adequacy of the acquired and assimilated information for completion of the task at hand. Based on the above argument, we argued the following hypotheses:

Hypothesis 2*: The better the task/technology fit, the better a team's productivity.*

Hypothesis 2a*: The better the task/technology fit, the better a team's productivity in intellective tasks.*

Hypothesis 2b*: The better the task/technology fit, the better a team's productivity in preference tasks.*

Decision quality is often used as a metric to measure the results of collaborative studies. Fan et al. (2004) argued that decision-making quality is a good measure of group communication performance. Salas et al. (1992) agreed with Fan et al. that output quality is an important indicator of performance. Quality is defined as team members' feelings about the team's output during the decision-making process (Chen 2003), has also been used to measure the final results of collaborative research. Quality can also refer to members' evaluation of the outcomes of the final group decision (Chizmar and Zak 1983).

Hypothesis 3*: The better the task/technology fit, the better the quality of the team's decision.*

Hypothesis 3a*: The better the task/technology fit, the better the quality of the team's decision in intellective tasks.*

Hypothesis 3b*: The better the task/technology fit, the better the quality of the team's decision in preference tasks.*

Satisfaction, defined as the manifestation of good feelings that the team members experience during the course of collaboration, is often used in studies of collaboration to measure the success of a process or outcome (Church and Gandal 1992, 1993). It is often associated with group members' positive evaluation of their collaborative efforts. According to the above literature, the following hypotheses can be defined:

Hypothesis 4*: The better the task/technology fit, the greater the group satisfaction.*

Hypothesis 4a*: The better the task/technology fit, the greater the group satisfaction in intellective tasks.*

Hypothesis 4b*: The better the task/technology fit, the greater the group satisfaction in preference tasks.*

The research experiment also focuses on the performance improvement due to wiki usage during the procedure. It is our intention to prove, that experimental groups have greater improvement in all collaboration performance factors than control groups – and this is also influenced by their previous attitudes to teamwork and wikis.

Hypothesis 5a*: If a team member's attitude to teamwork is positive, they will reach higher improvement in all performance parameters due to wiki usage during the experiment and vice versa than those, who did not use wikis.*

Hypothesis 5b*: If a team member's attitude to wiki usage is positive, they will reach higher improvement in all performance parameters due to wiki usage during the experiment and vice versa than those, who did not use wikis.*

Experimental design and procedure

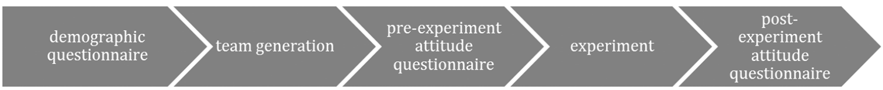
The research was implemented at Budapest Business School, Faculty of Finance and Accountancy among part-time master students of finance and accounting specialization. A demographic survey was carried out among participants before the experiment procedure to detect their attitudes and habits of teamwork and wiki usage. The usage frequency of wiki platforms (social sites, cloud computing devices, on-line collaboration tools) by each participant was measured in their work and dichotomous variables were defined to classify them whether they are wiki users or not. Teamwork habits were also measured: how often and how many times participants work in teams, and dichotomous variables were defined to classify them whether they are team workers or not.

Having these results made it possible to form teams of four, with special regard to their demographic features – as detailed in the sample allocation and distribution part of this paper. Having all the teams formed the first pre-experiment survey were implemented, testing the attitudes of collaboration in several dimensions.

At this stage of the research all clusters of teams were divided randomly into two: experimental teams and control teams. For the 22 experimental teams a 60 minutes training on "Modern web2 based applications for on-line teamwork and mass collaboration" were hold and some specific freeware applications (Skype, Dropbox, Google Drive, etc.) were demonstrated. The intention was to make them committed to solve their team tasks on-line without face-to-face communication. To ensure this, the experiment description required them to make screenshots while using wikis. Control groups had no information about the research; those teams just got one of the experiment case studies to solve.

There were three kinds of experiments projects (Apple, Facebook and Google case studies) with 4-4 tasks: two intellectual and two preference type tasks in each projects (Intellectual task for closed ended problems, that have a certain solution, and preference tasks for open ended problems, that do not have only one single solution). In our experiment intellectual task refers to the net present value of the company, what are the determinants of this value and what capitalization trends do they have. While preference type tasks expect creative solutions: market conditions and bargaining power of the company, strengths and weaknesses of the companies and what are the advantages and disadvantages of the current brand strategies. The projects were distributed to groups randomly and had 4 weeks to complete the projects and present the results in a 30.000-35.000-character assignment document.

After this experiment session the same questionnaire (the one used before the experiment) were distributed again, however all the questions were focused on the specific tasks in projects this time. Thus the experiment resulted in two surveys: a pre-test for general attitudes and a post-experiment for project experiences.



Source: own research

Figure 2. Process of research

Sample allocation and distribution

The sample consists of 175 participants. The gender mix distribution represents other programmes of the school as well: 68% female and 32% male.

The bases of the research experiment are teams that were generated by two dimensions. In a previous sampling some demographic characteristics of all participants were defined based on their teamwork experiences and wiki usage experiences, habits and generated two factors: attitude of teamwork and familiarity with wiki applications. According to these two dimensions 175 participants were divided into 45 groups with 4 members (in average) and at least two members were unknown to each other and any other member of the team. In Table 3 the distribution and the number of teams in each category (and all participants) are shown: we had 8 groups (with 31 members as total) who do not work in groups and do not use wikis; 10 groups (with 39 members as total) who usually work in team but do not use wikis; 4 groups (with 16 members as total) the opposite of this previous; and 14 groups (with 56 members as total) who are familiar with wikis and teamwork as well. We also had 9 miscellaneous groups (with 33 members as total). This covers 45 groups and 175 individuals as total.

Table 3. Construction of the participant teams

		Team workers			**Total**
		no	**yes**	**misc.**	
Wiki user	no	8 (31)	10 (39)	3 (12)	21 (82)
	yes	4 (16)	14 (56)	3 (10)	21 (82)
	misc.	0 (0)	0 (0)	3 (11)	3 (11)
Total		12 (47)	24 (95)	9 (33)	45 (175)

Source: own research

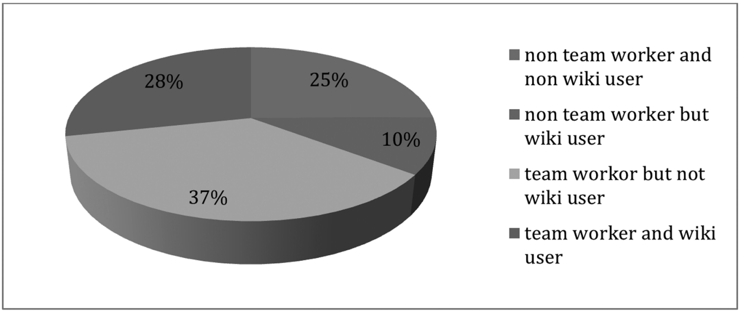
To ensure that the sample size was large enough to minimize Type I error and Type II error, an analysis were performed to determine the optimal sample size for each cell of the design, using the formula described by List et al. (2010):

$$n = 2\,(t_{\alpha/2} + t_{\beta})^2 - \left(\frac{\sigma}{\delta}\right)^2,$$

where n is sample size, t_α is t-value (type I error), t_β is t-value (type II error), σ is population standard deviation, and δ is the minimum detectable mean outcome difference between the experimental and control conditions.

Setting power at 0.80 and 0.90 and the criterion alpha level at 0.05, the ideal minimum treatment cell sizes were determined between 16 and 21 respectively. As the number of participants in each cell of our study was minimum 16, it could be concluded that our sample was large enough to detect the desired effects.

The measured characteristics of the sample (team members) are defined by wiki usage experiments and teamwork experiments.



Source: own research

Figure 3. Demography of sample based on wiki usage and team working

Data analysis methodology, model reliability and validity

Having the result of pre- and post-experiment surveys, an exploratory factor analysis (EFA) were performed with principal components extraction and VARIMAX rotation with Kaiser normalization on both dataset (pre and post) on each 37 measured variables to identify latent factors of a priori variables.

Table 4. Rotated component matrices of EFA

PRE	Component					POST	Component				
	KEY	FIT	DQ	SAT	PRO		KEY	SAT	FIT	PRO	DQ
k_8_pre	.826	-.025	.080	.100	.143	k_8_post	.837	.270	.109	.147	.000
k_17_pre	.808	-.038	-.012	.056	.065	k_7_post	.799	.253	.060	-.106	.121
k_16_pre	.807	-.087	.133	-.011	.147	k_2_post	.764	.165	.135	.292	-.017
k_14_pre	.806	.078	.020	-.005	.099	k_11_post	.762	.018	.165	.400	-.044
k_7_pre	.801	.106	.100	.056	.052	k_6_post	.719	.284	.120	-.076	.209
k_4_pre	.788	-.084	.053	.194	.051	k_14_post	.701	.024	.302	.295	-.016
k_2_pre	.781	.043	.117	.138	.041	k_10_post	.688	.308	.006	.168	.201
k_15_pre	.769	-.033	.151	.113	.055	k_9_post	.681	.403	.159	.203	.087
k_3_pre	.763	.027	.018	.201	.001	s_2_post	.234	.867	.213	.146	.015
k_9_pre	.763	.157	.009	-.001	.097	s_5_post	.248	.857	.261	.044	-.015
k_6_pre	.760	.062	.096	.101	.081	s_3_post	.291	.831	.216	.168	-.011
k_11_pre	.742	.130	-.074	.052	.031	s_1_post	.391	.691	.329	.225	.123
k_10_pre	.719	.271	-.017	.023	.142	f_5_post	.227	.236	.867	.038	.101
k_5_pre	.690	.106	.126	.171	.191	f_3_post	.156	.358	.796	-.004	.168
k_12_pre	.536	.170	-.033	.117	.371	f_2_post	.106	.209	.796	.080	.220
f_2_pre	.100	.872	.011	.057	-.110	p_3_post	.297	.096	-.122	.802	.000
f_3_pre	-.012	.733	.279	.108	.061	p_4_post	.163	.298	.233	.764	.044
f_5_pre	.119	.724	.245	.245	.018	d_4_post	.048	.070	.129	-.008	.876
d_2_pre	.134	.217	.922	-.001	-.003	d_2_post	.145	-.047	.222	.038	.826
d_1_pre	.118	.239	.895	.095	.059						
s_2_pre	.188	.183	.028	.869	.140						
s_4_pre	.209	.180	.066	.837	-.019						
p_4_pre	.136	-.077	.036	.225	.874						
p_5_pre	.218	.001	.028	-.114	.839						

Source: own research

As the 5-5 latent variables were expressed [task/technology fit (FIT), productivity (PRO), decision quality (DQ), satisfaction (SAT) and key competences (KEY)] out of the 37-37 measured variables a confirmatory factor analysis (CFA) was performed to test the fit of the clausal models (pre and post) as Jöreskog (1969) suggests.

In order to get the best fit of the model, numerous iterations were performed and the results of the last are demonstrated here, which was the most significant and showed the best fit.

All required tests were performed as well which are necessary for the interpretation of the results, with special regard to reliability analysis [Cronbach's α for internal consistency of the scales, Kaiser-Meyer-Olkin test (KMO), Bartlett's spherical test, and we measured the total variance expressed (TVE) by the factors], convergent validity [range of factor loadings, composite reliability (CR) and average variance expressed (AVE) by the factors], discriminant validity [correlation of the scales, maximum shared variance (MSV), average shared variance (ASV) and square root of AVE], and fit tests [absolute fit (AF), incremental fit (IF), parsimonious fit (PF)].

Reliability Analysis

The best-fit models with their five latent factors have 24 and 19 variables out of the measured 37. After this reduction the inner consistency of the scales is still high as Cronbach's α measures: 0.691 is the lowest value which remains above desired values referred by Cronbach (1951).

The factorability were also tested and found both KMO measures above 0.8, meaning that the data set is "meritorious" for factor analysis (Kaiser 1974). Also Bartlett's spherical tests are significant (Snedecor and Cochran 1989) in all constructs and TVE is desirable high. In this sense no reliability issues are present: all constructs are suitable.

Table 5. Reliability Analysis

Construct	PRE-EXPERIMENT				
	# of var. (measured)	Cronbach's α	KMO	Bartlett sig.	TVE
Technology/task fit	3 (5)	0.764	0.864	0.000	68.932
Productivity	2 (5)	0.751			
Decision quality	2 (5)	0.907			
Satisfaction	2 (5)	0.806			
Key competences	15 (17)	0.951			
Construct	**POST-EXPERIMENT**				
	# of var. (measured)	**Cronbach's α**	**KMO**	**Bartlett sig.**	**TVE**
Technology/task fit	3 (5)	0.885	0.897	0.000	76.694
Productivity	2 (5)	0.691			
Decision quality	2 (5)	0.714			
Satisfaction	4 (5)	0.938			
Key competences	8 (17)	0.928			

Source: own research

Validity

It is absolutely necessary to establish convergent and discriminant validity when doing a CFA as Carmines and Zeller (1979) suggest. If factors do not demonstrate adequate validity and reliability, moving on to test a causal model will be useless – no interpretation will be correct.

There are a few measures that are useful for establishing validity: Composite Reliability (CR), Average Variance Extracted (AVE). The thresholds for these values are as follows: CR > 0.7; CR > AVE; AVE > 0.5 (Hair et al. 2010).

Having a closer look at the measures of convergent validity more preciously, Fornell and Larcker's (1981) recommendations were followed: convergent validity is achieved, when the following three conditions are met: (a) all the standardized factor loadings exceed 0.5; (b) the composite reliability is higher than 0.6; and (c) the average variance expressed exceeds 0.5.

Convergent reliability was achieved by both conditionality for all construct in both cases (pre and post).

Table 6. Measures of Convergent Validity

	PRE-EXPERIMENT			POST-EXPERIMENT		
	Composite reliability	AVE	Range of item loadings	Composite reliability	AVE	Range of item loadings
SAT	0.809	0.681	0.869 – 0.837	0.934	0.780	0.867 – 0.691
FIT	0.766	0.523	0.872 – 0.724	0.889	0.729	0.867 – 0.796
PRO	0.772	0.634	0.874 – 0.839	0.700	0.542	0.802 – 0.764
DQ	0.908	0.832	0.922 – 0.895	0.749	0.608	0.876 – 0.826
KEY	0.950	0.561	0.826 – 0.536	0.920	0.591	0.837 – 0.681

Source: own research

Fornell and Larcker (1981) also set the rules of achieving discriminant validity. It happens when (a) the square root of the AVE of a construct is greater than the correlation between that construct and another construct; (b) when MSV < AVE and (c) ASV < AVE. Table below shows that discriminant validity was achieved by all these criterion for all constructs, so no validity issues were presented.

It is necessary to determine whether the model-in-use provides the best of the available choices (Fornell and Larcker, 1981). The three kinds

Table 7. Measures of Discriminant Validity

PRE-EXPERIMENT

	AVE	MSV	ASV	SAT	FIT	PRO	DQ	KEY
SAT	0.681	0.203	0.118	(0.825)				
FIT	0.523	0.263	0.128	0.451	(0.723)			
PRO	0.634	0.108	0.050	0.289	-0.003	(0.796)		
DQ	0.832	0.263	0.094	0.211	0.513	0.084	(0.912)	
KEY	0.561	0.140	0.088	0.374	0.213	0.329	0.245	(0.749)

POST-EXPERIMENT

	AVE	MSV	ASV	SAT	FIT	PRO	DQ	KEY
SAT	0.780	0.441	0.291	(0.883)				
FIT	0.729	0.387	0.219	0.622	(0.854)			
PRO	0.542	0.349	0.200	0.563	0.351	(0.736)		
DQ	0.608	0.162	0.062	0.141	0.402	0.099	(0.780)	
KEY	0.591	0.441	0.263	0.664	0.452	0.591	0.241	(0.769)

(Square roots of AVE)

Source: own research

of model fit (absolute fit, incremental fit and parsimonious fit) for our data is presented in table below using the threshold reference recommendations of Schreiber et al. (2006), Wheaton et al. (1977), Tabachnick and Fidell (2007) and Mulaik et al. (1989).

In this context the results of all tests in both dataset meet the acceptable levels of model fitting criteria as shown in Table 8.

According to these tests, validity and reliability analyses shown above both pre-experiment model and post-experiment model is the best of the available constructs, interpretable and applicable for further research to draw conclusions.

Hypothesis test

Post-experiment analysis

The next step was to test the hypotheses. First the Shapiro-Wilk statistic were used to test normality and Levene's statistic to test homogeneity of variances of the sample. The sample was found to follow normal distribution and the variances are homogeneous for

Table 8. Measures of Model Fit

Statistic	Value		Threshold	Result	
	PRE	POST		PRE	POST
Absolute fit					
χ^2/df	1.653	1.790	≤ 3	good	good
GFI	0.849	0.865	> 0.8	good	good
RMR	0.028	0.044	< 0.08	good	good
RMSEA	0.062	0.068	< 0.1	good	good
Incremental fit					
TLI	0.934	0.94	> 0.9	good	good
IFI	0.946	0.952	> 0.9	good	good
CFI	0.945	0.952	> 0.9	good	good
Parsimonious fit					
PGFI	0.654	0.633	> 0.5	good	good
PCFI	0.791	0.744	> 0.5	good	good
PNFI	0.730	0.730	> 0.5	good	good

Source: own research

post-experiment data. Thus, equal-variance version of t-tests was employed to test the hypotheses.

Performing the tests the decision can be made whether the performance of the experiment sample or the control sample was better. In Table 9 the results are summarized. In all constructs and all tasks experiment groups performed better.

This difference was significant in all cases, except in some issues regarding to intellectual tasks (productivity, decision quality and satisfaction).

Analysing the differences between pre- and post-experiment data

When analysing the results of post-experiment result the difference of post-experience and pre-experience datasets were generated to

Table 9. Post-experiment comparison between experimental and control groups regarding to task type

Construct	Task	Group	Mean	SD	t-value	p-value
Task / Technology Fit	Overall	Experimental/Post-test	4.231	0.41	6.621	0.000***
		Control/Post-test	3.269	0.823		
	Intellective	Experimental/Post-test	4.013	0.275	3.675	0.001**
		Control/Post-test	3.313	0.807		
	Preference	Experimental/Post-test	4.45	0.41	7.112	0.000***
		Control/Post-test	2.875	0.901		
Productivity	Overall	Experimental/Post-test	4.425	0.447	3.314	0.001**
		Control/Post-test	3.9	0.897		
	Intellective	Experimental/Post-test	4.3	0.47	0.551	0.585
		Control/Post-test	4.2	0.661		
	Preference	Experimental/Post-test	4.55	0.394	3.911	0.000***
		Control/Post-test	3.6	1.012		
Decision quality	Overall	Experimental/Post-test	3.706	0.607	2.415	0.018*
		Control/Post-test	3.363	0.665		
	Intellective	Experimental/Post-test	3.513	0.676	0.562	0.578
		Control/Post-test	3.4	0.587		
	Preference	Experimental/Post-test	3.9	0.469	2.912	0.006**
		Control/Post-test	3.325	0.748		
Satisfaction	Overall	Experimental/Post-test	4.333	0.585	4.229	0.000***
		Control/Post-test	3.583	0.957		
	Intellective	Experimental/Post-test	4.283	0.575	1.392	0.172
		Control/Post-test	4.017	0.635		
	Preference	Experimental/Post-test	4.383	0.605	4.585	0.000***
		Control/Post-test	3.15	1.04		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own research

measure the improvement (or decline) of each construct in each group. The constructs were cut with demographic variables: the habit of usage of wiki applications, the teamwork attitude and their current specialization.

Productivity and decision quality have significantly declined during the experiment for those, who were not familiar with teamwork meaning

Table 10. Inter-experiment comparison between experimental and control groups regarding to wiki usage

Construct	Demo	Group	Mean	SD	t-value	p-value
Task / technology fit	Wiki user	Experimental/diff	0.074	1.612	-0.156	0.438
		Control /diff	0.124	0.987		
	Non wiki user	Experimental/diff	-0.062	1.292	0.006	0.498
		Control/diff	-0.063	0.979		
Productivity	Wiki user	Experimental/diff	-0.127	1.540	0.063	0.475
		Control /diff	-0.151	1.548		
	Non wiki user	Experimental/diff	0.086	0.917	-0.028	0.489
		Control/diff	0.092	1.278		
Decision quality	Wiki user	Experimental/diff	0.074	1.122	0.445	0.329
		Control /diff	-0.059	1.301		
	Non wiki user	Experimental/diff	-0.186	1.181	-1.399	0.082
		Control/diff	0.169	1.396		
Satisfaction	Wiki user	Experimental/diff	0.086	1.301	-0.343	0.366
		Control /diff	0.195	1.300		
	Non wiki user	Experimental/diff	0.153	1.240	1.787	0.038*
		Control/diff	-0.329	1.496		
Key capabilities	Wiki user	Experimental/diff	0.153	0.741	0.623	0.268
		Control /diff	0.024	0.923		
	Non wiki user	Experimental/diff	0.051	0.716	1.123	0.132
		Control/diff	-0.170	1.225		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own research

that those seemed to have problems with wiki applications in context of effective decision-making and productivity.

The opposite effect can be measured in these groups in key capabilities as experiment groups had significant improvement in this construct, meaning that wiki groups had better knowledge share, absorption, filtering and learning capabilities during the experiment.

Table 11. Inter-experiment comparison between experimental and control groups regarding to teamwork habits

Construct	Demo	Group	Mean	SD	t-value	p-value
Task / technology fit	Team worker	Experimental/diff	-0.061	1.454	-0.776	0.220
		Control /diff	0.116	0.922		
	No team worker	Experimental/diff	0.138	1.362	0.817	0.209
		Control/diff	-0.129	1.045		
Productivity	Team worker	Experimental/diff	0.112	1.317	1.090	0.139
		Control /diff	-0.169	1.343		
	No team worker	Experimental/diff	-0.302	0.795	-1.817	0.037*
		Control/diff	0.213	1.416		
Decision quality	Team worker	Experimental/diff	0.034	1.099	0.401	0.345
		Control /diff	-0.062	1.330		
	No team worker	Experimental/diff	-0.381	1.277	-1.865	0.033*
		Control/diff	0.266	1.389		
Satisfaction	Team worker	Experimental/diff	0.058	1.214	0.959	0.170
		Control /diff	-0.208	1.574		
	No team worker	Experimental/diff	0.305	1.380	0.984	0.165
		Control/diff	-0.040	1.272		
Key capabilities	Team worker	Experimental/diff	0.081	0.732	-0.151	0.440
		Control /diff	0.104	0.836		
	No team worker	Experimental/diff	0.123	0.718	1.760	0.041*
		Control/diff	-0.348	1.366		

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Source: own research

Results and discussion

Having the results of all statistical tests the hypotheses should be answered. Hypothesis group 1 was confirmed, so one can conclude, that in the context of inter-group collaboration wiki applications offer a better task/technology fit for preference type tasks and intellectual type and in overall cases as well.

Hypothesis group 2 was partly confirmed as H2a were rejected: there were no significant evidence found that team productivity is higher in wiki user groups in solving intellective tasks. However the connection in solving preference type tasks and in overall cases could be significantly confirmed.

The same was the case in context of team's decision making: H3a hypothesis were rejected, however the fact that wiki user groups reached better decision quality through the experiment in preference type tasks and in overall cases could be significantly confirmed.

Similar conclusions could be drawn in hypothesis group 4, as H4a is rejected: the better the task/technology fit the greater the group satisfaction in preference type tasks and in overall cases – but not significantly better in intellectual type tasks.

Therefore in case of H2a, H3a and H4a it can be argued that in accordance to the reviewed literature (Adler 1990; McLeod and Lobe 1992; Marquadt and Horvath 2001) diversity only provides better performance when it is integrated into the process. Thus wikis provide a good framework of collaboration for more divergent tasks (i.e. preference tasks in this study), whereas in case of more routine and procedure based tasks (i.e. intellective tasks) performance has not increased significantly.

Hypothesis group 5 have many cases after the split of all the performance indicator variables by wiki dichotomous and teamwork dichotomous demographic variables. Due to this splitting very few significant differences were found in post/pre experiment differences by experimental and control groups. However it can be argued that non-wiki users who did not use wiki applications before the experiment and now were forced to use them had significantly greater satisfaction with the teamwork than those in control groups.

The opposite was found regarding to decision quality and teamwork: those who did not work in team before have significant decline in decision quality during the experiment due to the wiki usage than those who were in control groups (and was not asked to use wikis during the experiment). However these groups of non-team workers have significantly higher improvement in key capabilities of teamwork than those in control group. This means, that non-team workers can improve

Table 12. Hypothesis test results

Hypothesis	Method	Test result	Conclusion
H1	t-test of post-exp data split by task type	***	Confirmed
H1a	t-test of post-exp data split by task type	**	Confirmed
H1b	t-test of post-exp data split by task type	***	Confirmed
H2	t-test of post-exp data split by task type	**	Confirmed
H2a	t-test of post-exp data split by task type	Rejected	
H2b	t-test of post-exp data split by task type	***	Confirmed
H3	t-test of post-exp data split by task type	*	Confirmed
H3a	t-test of post-exp data split by task type	Rejected	
H3b	t-test of post-exp data split by task type	**	Confirmed
H4	t-test of post-exp data split by task type	***	Confirmed
H4a	t-test of post-exp data split by task type	Rejected	
H4b	t-test of post-exp data split by task type	***	Confirmed
H5a	t-test of the difference of post-exp and pre-exp data split by wiki usage	*	Partly confirmed
H5b	t-test of the difference of post-exp and pre-exp data split by teamwork	*	Partly confirmed

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own research

their key capabilities due to usage of wiki applications during the experiment.

However no other significant differences were found in variances in these two contexts; tables 10 and 11 show some major (but not significant) differences in performance indicator means of both experimental and control groups.

Managerial implications

Having the results of our experiments it can be argued, that wiki applications can significantly improve task and technology fit in teamwork, for any kinds of tasks. Wikis also foster higher productivity, better decision quality and higher satisfaction for preference type tasks.

In contrast wiki applications are not very useful for intellectual type tasks: collaborative tasks which have an anticipated outcome and an already known process to use for problems solving are not the field to use wikis, more traditional methods would apply. Therefore these applications appear to be very useful for preference type task; but cannot replace face-to-face problem solving methods, when the details of communication and implementation become vital. This argument is in full accordance with the literature reviewed (Adler 1990; Maznevski 1994).

Another factor hindering the productivity of teamwork, when members have no positive attitudes to use wiki applications and are not keen on teamwork.

Limitations and further research directions

However all major recommendations in literature for sample size and distributions were considered, for experimental procedure (test and control groups) and latent variables construction (reliability and convergent and discriminant validity and model fit) and for applicable hypothesis test methods, there are still some basic limitations to this research. Firstly the sampling limitations: the sample of this experiment was part-time higher education business students with financial and accounting specialization, which is an undeniable constraint. The sampling procedures are needed to be extended.

Secondly a systematic problem occurs: it seems complicated to ensure that experimental groups do use wiki applications during the experiments whereas control groups are supposed not to do so.

Further plans are focused to eliminate these limitations and fine-tune the whole experiment procedure. A longitudinal analysis seems a viable option to carry out in a years time resolving the limitations of the procedure and sample and providing an opportunity for both for a dynamic and intercultural (ie. Taiwanese and Hungarian) comparative study.

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