**Connectivism and Decision Making in Virtual Learning Teams

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**Abstract**

The study examines informal learning and the effect on decision making in virtual teams. The study uses connectivism, a framework for examining networked learning to examine interaction processes on team decision effectiveness. Two learning protocols were used to manipulate communication and information display processes between teams in a closed online environment. The “hidden profile” decision making exercise was used to examine the influence of communication and display process structures on acquisition, validation, and application of information critical to effective decision making. Results suggest decision effectiveness is greater when virtual teams have regulated communication processes, and the ability to visualize decision making information collectively.

**Introduction**

 As digital technology evolves, it changes the way we live, learn, and work. The ability to adapt and learn in the digital environment is especially critical for businesses and organizations where learning and work activity is increasingly performed online, and where success is often dependent on the ability to solve problems and make decisions through interaction with others. The sociotechnical evolution creates a unique dynamic where learning is often informal, and where knowledge has value as both commodity, and social activity where people share information and cultivate ideas. Previous research has proven that learners in traditional and virtual learning environments process information differently; yet a challenge remains to understand the impact of virtual learning environments on knowledge acquisition that lead to effective decisions, and the processes and strategies that support decision improvement.

**Review of the Literature**

Changes in learning environments create contexts that move beyond individual and interpersonal learning theories to include groups, teams, and large scale organizational structures. Given these conditions, it makes sense that researchers explore new methods for studying networked learning phenomena in a range of forms and configurations (Bell, 2011). This is particularly where evolving learning environments intersect with emerging concepts of work, such as virtual teams. Virtual teams are generally defined by one or more non-collocated members, using synchronous and asynchronous technology, to communicate and collaborate to accomplish a common goal or perform organizational tasks (Townsend, 1998; Majchrzak, Rice, King, & Malhotra, 1999). Virtual teams are often used to solve complex problems and make decisions that may require a wide range of processes to acquire, exchange, and apply information (Ananth, Nazareth, & Ramamurthy, 2011).

 However, a wealth of research shows that teams are challenged by problems that require integration of unique information (Stasser and Titus, 1985). This challenge is compounded by in the networked environment where technology mediated communication can impact the ability to access and share information critical to decision quality. As such, the study has two goals. First, it uses idea of connectivism, an emerging network learning model as a lens to examine the knowledge acquisition and exchange in virtual teams. Second, it employs practical strategy for improving team decision making by structuring team communication processes.

**A Framework For Examining Networked Decision Making**

 Knowledge exists within nodes of information, people, systems, and organization, and is dependent on the ability of individuals to make connections between human and non-human information, ideas, and behaviors that create useful patterns of knowledge which initially appear to be hidden. Connectivism is a set of principles that provide contextual framework for studying networked learning in individuals, groups, and organizations. In connectivism, learning is defined as actionable knowledge that exists within and outside individuals, requires connections to be processed between nodes of specialized information, and where connections between these nodes are more important than existing knowledge. Siemens (2004) posits the guiding principles of connectivism such that:

* Learning and knowledge rests in diversity of opinions.
* Learning is a process of connecting specialized nodes or information sources.
* Learning may reside in non-human appliances.
* Capacity to know more is more critical than what is currently known
* Nurturing and maintaining connections is needed to facilitate continual learning.
* Ability to see connections between fields, ideas, and concepts is a core skill.
* Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.

 Connectivism views decision making is a learning process in itself. The learning environment is chaotic, and requires learners to develop keen sensitivity to changes in the shifting information landscape. Conditions that confirm a decision one day make not hold true the next, so the ability to recognize and adapt to changes in information patterns (strength, consistency, and accuracy) is critical for effective learning. Key goals of learning from a connectivist view are the ability to find current information, filter out confounding and non-essential information (Kop, 2008), and acquire knowledge. But what decision makers need to learn about a problem and the meaning of information towards solution are often unclear (Seimans, 2004).

**Learning Processes in Virtual Work Teams**

 To be effective, decision making teams must often access and aggregate unique, specialized information. Knowledge must be transferred so that information held by one person initially is made accessible and usable across all members. Changes in the information set may lead to a previously unacceptable option to become the optimal choice. As inputs or output requirements changes, teams must adapt by performing alternate acts, and revising understanding of task related cues (Wood, 1986). When hidden information is shared, teams are able to take action upon it to integrate new information with common knowledge and thus increase chances of making accurate decisions (Rentasch, 2011).

 To manage information effectively, teams enable processes for acting upon information. Action processes enable performance of tasks that contribute to goal achievement. This includes monitoring team progress and resources, reviewing team member actions and providing help when needed, and coordinating the timing and sequencing of tasks and task related information. Action processes have a strong task orientation, and often are tied closely to procedures related to team interaction like communication, coordination, and task technology fit and adaptation. Because technology mediation and geographic dispersion of members are highly salient aspects of the virtual setting, communication procedures are perhaps the most widely studied task actions in virtual teams (Powell, 2004). Action processes span the social interaction and task related activity of the team (Guzzo & Dickson, 1996). As a result, current processes are part a product of group past, and an indicator of future outcomes (Arrow, McGrath, & Berdahl, 2000). As such the ability to work effectively with decisions= information has a social and task related communication component, and the processes used to communicate within the team (if found effective) may extend beyond the immediate goal.

**An Empirical Task For Studying Connections in Virtual Learning Teams**

One well documented experimental method for studying information sharing and knowledge acquisition processes in groups is the *hidden profile* problem. In hidden profile studies, the best alternative is not apparent unless the group shares their individual information with each other. When all information is successfully shared and acquired, the full information set make the best choice clear. However, teams often fail to select the best alternative even when all needed information is potentially available. A number of explanations have been have been offered for this effect. First, individuals tend to stick to their initial choice, regardless of additional information acknowledged in the discussion. At the team level, members often hasten towards a decision, reaching a premature consensus before all decision information is revealed. Finally, teams often fail to weight information effectively. This is attributed to groups placing a higher value on information held by a majority of members, and the fact that this information is often presented more consistently during discussion (Brodbeck, Kerschreiter, Mojzisch, & Schulz-Hardt, 2007).

 Based upon the decision making research and ideas set forth in the principles of connectivism it is likely that communication process structures effect information exchange an knowledge acquisition that improve decision outcomes. Extending this, it is suggested that teams using a communication process structure that supports clear connections between information stores and regulated information flow and exchange will lead to improvements in decision outcomes (learning) than teams using an ad hoc communication process.

Hypothesis1: Communication process structuring will be positively related to decision accuracy.

Hypothesis 2: Communication process structuring will be positively related to perceptions of optimal candidate suitability after team discussion.

Hypothesis 3: Communication process structuring will be positively related to the value placed on shared versus unshared decision information.

**Methodology**

 **Participants**

 The study population was students at two Midwestern universities.

Participants were recruited for the study during the 2012 to 2013 academic year. Students were invited to participate using a number of recruitment methods including flyers, mass email, and through 14 in-class presentations to students. Confirmed participants were assigned to four person teams based on scheduling availability. The final number of participants was a sample of 208 individuals comprising 52 teams. To clarify individual characteristics of participants, data for six demographic measures were collected. These included 1) age, 2) gender, 3) ethnicity, 4) prior personal relationship with other team members, 5) prior group work with other participants, and 6) confidence level using internet communication and collaboration technologies.

 **Study Design** The experiment uses a well-studied hidden-profile task structure (Schulz-Hardt, Brodbeck, Mojzisch, Kerschreiter, & Frey, 2006) to examine the independent influence of communication process structure on virtual team decision making. In the experiment team members were part of a personnel committee with the task of selecting an airline pilot from a pool of four candidates. Each pilot candidate in the scenario had a set of ten positive and negative characteristics that were the basis for the decision. Initially each team member was given a partial set of six attributes for each of the four pilots, thus some information was shared and some hidden to members prior to the team discussion.

Participants were assigned to one of two treatment conditions. The process manipulation occurred during the discussion phase, after an individual decision exercise was performed by all participants. The general procedure for all treatment conditions contained an individual decision, team discussion and decision, data collection, and debriefing.

Team members logged in and were presented with four documents which included: 1) the study instructions, 2) a document with attributes for four candidates, 3) a document to make an individual decision about the pilot candidate and, 4) a document for making the team decision.

 Participants were directed to read the study instructions first. The instructions gave information about 1) how to use the chat tool for communicating with teammates and the study supervisor if needed, 2) described the study scenario for a personal committee asked to hire a pilot from a pool of candidates, 3) listed what materials were available and what these contained, and 4) outlined steps for performing three tasks: an individual decision, a team decision, and a final survey. Finally, a link was included to the consent form, and participants were asked to complete this if they had not already done so when the login information was sent.

 Next, participants were asked to read the candidate attributes and perform the pre-discussion decision task. Individuals were given ten minutes to read the candidate attributes document, and then select a pilot based on the attributes available about each candidate. Participants were directed to be able to explain to the team why they chose a particular candidate. To record their decision and online survey was available to their team and team member number, and the candidate they selected. In addition, they were asked to rate the suitability of each candidate on a scale of 1-5 (coded 1-not suitable at all to 5-very suitable).

The assigned team member numbers helped ensure that candidate profiles were distributed correctly so that each participant only had access to candidate information associated with that team member number. It also helped the researcher determine that team a full team of four was present for the study. Similarly, the team number provided a way to make sure that teams were separated into the correct treatment condition. All persons assigned to a given group only saw instructions that reflected the treatment condition associated with that team number.

 After recording individual decisions, the participants were alerted to assemble with the other team members by opening the shared team decision document. This document included instructions for conducting the team discussion based on one of four treatment conditions representing the factors of communication process and information display structure. To ensure sufficient time was given for reviewing and discussing all candidate information thoroughly, no time limit was set. At this point, team members reviewed and discussed the candidate attributes in the manner prescribed in the team decision process instructions. After teams reached agreement, each team member was asked to enter the same pilot candidate selection into a team decision survey and all team members again individually ranked the suitability for each candidate.

 In addition, the team decision form contained a manipulation check to establish that the experimental treatment had taken place. Last, all participants accessed a final survey to input demographic information including:1) age, 2) gender, 3) ethnicity, 4) prior knowledge of team members, 5) prior group work with members, and 6) confidence level using internet communication and collaboration technology. In addition, the questionnaire provided scale questions for recording perceptions of outcome variables for procedural justice, team climate, and information sharing. After measurement data was collected, the each team was debriefed.

 **Experimental Treatment**

In the experimental condition, teams used a structured communication process throughout the activity. Team members elected a monitor for coordinating discussion activity, shared information through orderly turns, and had ability to voice agreement or dissent about candidate information, including the final team candidate decision. It was felt this condition would strengthen action processes of monitoring, feedback, and coordination (Marks, Mathieu, & Zaccaro, 2001) leading to more effective information exchange and more effective decisions.

 This included the designation of a discussion monitor that coordinated the orderly input of candidate attribute information from each team member, and allowed feedback from other members regarding the information. Each member were asked to tell the other whether they saw duplicate attributes, new attributes not seen before, and whether attributes are positive or negative. Next, the monitor removed duplicate attribute, clarified any new attributes entered into the discussion, and the number of positive and negative attributes for the candidate reviewed. If there was disagreement about any information for a candidate teams held a majority vote decides to decide the outcome. If there is disagreement about the final decision, a majority vote decides the outcome. If there is a tie vote, a second vote will determine the choice.
In the control condition, teams had no communication process guidelines for the team discussion or the handling of candidate information. team members were instructed to discuss the attributes of each candidate. No order for candidates to be discussed was specified. Each member was asked to tell the group whether they noted any duplicate attributes, new attributes not seen before, and whether attributes were positive or negative. Members could submit information into the discussion at any time. After all candidates were reviewed and final information submitted, the team was asked to make decision about which candidate was chosen for the pilot job. There were no guidelines for dispute resolution.

 **Measurements** Performance outcomes were measured in three ways, the accuracy of teams in choosing the best candidate from three alternatives, individual perceptions of candidate suitability before and after discussion, and the value placed on shared and unshared information in making the team decision, and.

***Decision Accuracy.*** Decision accuracy was an impartial dichotomous measure of the team’s outcome decision based on the selection of the optimal candidate C (coded 1) from the alternative candidates A, B, and D (coded 0). tested using logistic regression to determine the impact of communication process on decision accuracy outcomes while controlling for the covariates of internet confidence and prior group work with another member. First the criterion variable was entered in step one as the dependent variable. Next the independent and control variables were entered together in step two. The Wald Chi Square is used to determine significance. If the P-value is less than 0.05 the null hypothesis is rejected, indicating a difference between groups. The odds ratio values in the logistic regression output are an indicator of effect size. The odds ratio predicts the likelihood of an outcome for each one unit increase in the independent variable. The beta value indicates which group is responsible for the effect. Higher coded groups generate a positive beta coefficient lower coded groups generate a negative beta coefficient.

***Candidate Suitability.*** Perceived suitability of the optimal candidate (C) and those that appeared equally best before discussion (A, B, and D) was measured using a five-point scale (coded 1-very unsuitable to 5-very suitable). Individual participants were asked to respond to the question "How suitable did you find candidate [A, B, C or D] for the job" before and after discussion to determine whether individual preference for candidates shifted when teams had potential for pooling information.

 ***`Information Exchange.*** The performance measure for information exchange compared members perception of the value of candidate attributes towards making the team decision. Participants individually ranked all 40 candidates attributes on a five-point scale (1-not important at all to 5-very important according to how valuable each characteristic was in making the team decision. The measures were averaged to the team level to provide scores for average value of shared attributes (items available to all members), and the average value for unshared attributes (those items hidden from one or more members but available when pooled during discussion (Postemes, 2008).

**Results**

**Tests for effects of communication process on decision performance.**

 Prior to discussion Candidates A, B and D, had equally positive attributes (4 positive, 2 negative). Candidate C had fewer positive attributes initially (positive and three negative attributes). On the basis of the incomplete profile, three candidates, A, B or D, would seem the best choice initially. In the study, teams in the high communication process condition were expected to select the best candidate more often, and this improvement would be reflected by a shift in individual perceptions of candidate suitability, and a higher value placed on unshared information yields more accurate candidate profiles. Overall, teams in the experimental condition were more successful at selecting the optimal choice (Table 1).

Table 1 *Impact Of Communication Process Structuring on Decision Accuracy*

|  |  |  |
| --- | --- | --- |
|  |  Conditions | Total |
| Decision Accuracy | Experimental | Control |  |
| Incorrect | 15.8% | 21.1% | 36.5% |
| Correct | 30.30% | 27.3% | 63.5% |
| Percentage of Total | 19.2% | 17.3% | 100% |

**Test for decision accuracy**

 Hypothesis one predicted that decision accuracy would be greater in groups using a prescribed communication process structure was supported. A logistic regression analysis was conducted to predict decision accuracy in choosing the optimal candidate choice with communication structuring as the predictor after partialling out the effects of age, ethnicity and internet confidence. A test of the full model against a constant only model just failed to reach statistically signiﬁcance, indicating that the predictors may not accurately distinguish between correct and incorrect decisions 2 = 18.187, p =.052 with df = 10). Nagelkerke’s R2 was .115 indicating an acceptable relationship between prediction and score groupings. Communication process was a reliable predictor of decision accuracy, b =.456, 2 = 8.763, p =.003 with df = 1). The positive beta value for communication process confirmed that the experimental condition groups (coded 1) generated more accurate scores. Teams in the experimental communication process groups were 1.6 times more likely to select the optimal pilot candidate, than those in the control condition. As each additional team adopts the experiment communication process protocol, the odds of making a correct choice slightly increased. A summary of test statistics in found in table two.

Table 2

*Results of Logistic Regression Predicting Decision Accuracy From Communication Process Controlling for Internet Technology Use and Prior Group Work on Team Decision Accuracy*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Predictor | B | Wald2 | p | OddsRatio |
| Communication Process | .456 | 8.76 | .003\*\* | 1.60 |
| Internet Confidence Internet Confidence (1) Internet Confidence (2)  | 1.61.101 | 1.651.63.089 | .436.201.765 | 4.20 1.10 |
| Age Age (1) Age (2) Age (3) | .919.023.034 | 3.111.73.002.004 | .374.188.965.953 | 2.50.977.967 |
| Ethnicity Ethnicity (1) Ethnicity (2) Ethnicity (3) Ethnicity (4) | -.885-1.06-.931-.302 | 2.541.131.45.966.097 | .637.288.229.326.755 | .413.347.394.739 |

 **Candidate Suitability** Hypothesis two was reliably significant. The results indicate communication process structuring was positively related to perceptions of optimal candidate suitability. A repeated measures ANOVA was performed to test for differences between communication process groups regarding the degree of shift in suitability preference for candidate C, the objectively best candidate and candidate D, the most popular choice before discussion. It was expected that pre discussion suitability preferences for candidate D would be similar for teams in both communication process conditions, while teams in the experimental condition would show a decreased perceptions of suitability for candidate D and increased perceptions of the suitability for candidate C after discussion.

 There was no overall significant difference between communication process groups regarding perceived suitability before and after discussions, F(1,206) = 3.51, p < .062. A closer comparison showed teams in the low communication process condition had slightly greater suitability perceptions of candidate D (M=3.51, SE=.092) than the experimental group, (M=3.10, SE=.073) prior to discussion. However, test for shifts in perceived suitability for candidate C based on communication process condition was significant, F(1,207) = 8.22, p < .005. An examination of the means showed participants in the high communication process condition found candidate C more suitable after discussion (M=3.50, SE=.092) than those in low communication process teams (M=3.08, SE= .072). The data suggest that teams in the high communication process condition had stronger perceptions about the suitability of the optimal candidate after discussion condition than teams in the control condition. The effect size showed a small practical significance, indicating that the relationship while present, was minimal, =1.21.

**Evaluation of shared and unshared information**

 Hypothesis 3 was not supported. There were no significant relationship found between communication process condition and the value of shared information, F(1, 208) =1.20, p=.274.

Teams in the high communication process groups placed slightly greater value on unshared information (M = 56.18, SD = 11.46) than teams in the low communication process condition, (M = 54.54, SD = 11.01. The difference in means for the two groups implies unshared information was slightly more salient than for the high communication process condition groups, but the difference was not significantly reliable. In addition, there were no significant relationship found between communication process condition and the value of shared information, F(1, 208) = .194, p=.660. Teams in the high communication process group valued shared information (M = 57.00, SD = 8.60) very similar to those in the low communication process group (M = 57.51, SD = 8.27).

**Summary and Conclusions**

 A review of the results indicated support for two of the three hypotheses in the study. Data analysis showed that teams using a structured communication process will have greater decision accuracy compared to teams operating with ad hoc communication process (Hypothesis 1). This was reflected in a significant difference between group perceptions of the suitability of the optimal choice Candidate C before and after discussion (Hypothesis 2). Counter to predication, communication process structuring did not result in meaningful in difference between perceptions of the value of shared and unshared information (Hypothesis 3).The results of the research demonstrate that communication process structuring affects team learning. Teams using a communication process structure made more accurate decisions. The finding suggests that communication process structure can attenuate the flow of decision information contributing to greater connections between specialized information and more diversity of opinion about the meaning of the decision information in terms of choosing the best candidate. There was also noteworthy relationship between communication process and perceptions of candidate suitability. Prior to team discussion, participants as a whole felt Candidate D was the most suitable candidate. After discussion, teams in the experimental condition favored Candidate C as the most suitable significantly more than those in the control condition. The test indicates support for the idea that communication process structures impact team ability to reevaluate and revise knowledge allowing connections to be made between what is known, and what becomes apparent after new knowledge is acquired.

 Communication process structuring did not yield significant differences in team perceptions of shared and unshared information value. However, experimental groups did have a higher mean for unshared information than control groups suggesting that communication process structuring brings about greater understanding of the contribution of hidden information in generating an accurate view of the full information set.

 The study offers some indication that principles of connectivism are operative in the functioning of virtual team, a work unit that learns through the exchange of information between human and other information sources. This framework is useful in developing process protocols for group learning contexts where selecting an optimal alternatives from the aggregation of diverse information sources is needed. In addition, the results suggest that a communication structure that provides regulated monitoring and feedback of decision information can improve learning in virtual problem solving environments. The study is limited in that participants performed the study in his or her environment, that is there was no control over the type of technology used, or what participants were physically doing during the study. For example, there is no assurance that participants were not multi-tasking at the time, which might have increase cognitive load, or whether delays in participant response that interrupted information flow to the team was caused by the technology or the operator. Even so, it is felt the results support current thought on the role of connectivism and virtual learning, and offers a way to extend the connectivist literature to include more empirical research.

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