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A gaming system experience for work in heterogeneous, self-directed teams

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Abstract
In the face of increased complexity in the social, commercial and operational contexts of their operations, many organisations are endeavouring to change from the bureaucratic model of the Industrial Age to a community of self-organising teams more suitable for the Knowledge Age. In defence operations, this involves a change from a command and control model to a more network centric and distributed model of decision making for teams in the field. However, managers are often confused as to how best to prepare workers to operate in loosely coupled networks of self-directed teams. There is also a need for more knowledge about the capabilities that are required for success in settings that are socially organized in these new ways. In order to further both research and practice in this area, this paper is an informed demonstration of how a particular online gaming may be a constructive way to prepare people to operate appropriately in a network-centric environment. Critical concepts, on which this work is based, include: the network-centric paradigm, self-directed teams, complex activity, knowledge work and shared situational awareness. Findings are presented from a set of gaming sessions, comparing the capabilities of homogeneous and heterogeneous teams, to demonstrate the potential for learning appropriate to such teams of knowledge workers. The conclusions are: firstly, that heterogeneous teams are potentially able to perform complex activities better than homogeneous ones, once they have learnt cooperative team skills; and, secondly, that the particular online team gaming environment used in this research has the capacity to enable such learning.

Keywords
heterogeneous, gaming, self, system, directed, teams, experience, work

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A Gaming System Experience for Work in Heterogeneous, Self-directed Teams

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Abstract. In the face of increased complexity in the social, commercial and operational contexts of their operations, many organisations are endeavouring to change from the bureaucratic model of the Industrial Age to a community of self-organising teams more suitable for the Knowledge Age. In defence operations, this involves a change from a command and control model to a more network centric and distributed model of decision making for teams in the field. However, managers are often confused as to how best to prepare workers to operate in loosely coupled networks of self-directed teams. There is also a need for more knowledge about the capabilities that are required for success in settings that are socially organized in these new ways. In order to further both research and practice in this area, this paper is an informed demonstration of how a particular online gaming may be a constructive way to prepare people to operate appropriately in a network-centric environment. Critical concepts, on which this work is based, include: the network-centric paradigm, self-directed teams, complex activity, knowledge work and shared situational awareness. Findings are presented from a set of gaming sessions, comparing the capabilities of homogeneous and heterogeneous teams, to demonstrate the potential for learning appropriate to such teams of knowledge workers. The conclusions are: firstly, that heterogeneous teams are potentially able to perform complex activities better than homogeneous ones, once they have learnt cooperative team skills; and, secondly, that the particular online team gaming environment used in this research has the capacity to enable such learning.

Keywords: Gaming, Network-Centricity, Knowledge Worker, Activity Theory, Complexity Theory, Situation Awareness.

1. INTRODUCTION

Despite the advances of science, technology and civilisation in general, the world faces a challenging and uncertain future. Huge national and international resources have been expended on security against unpredictable threats of terrorism while climate change is bringing increased severity of natural disasters. At the same time the global market place has made the business world more diverse, interconnected and volatile. In the face of the increased complexity in the social and commercial context of their operations, many organisations are endeavouring to change from the bureaucratic model of the Industrial Age to a community of self-organising teams more suitable for the Knowledge Age. In this regard, some successful companies (e.g. Peltokorpi &Tsuyuki 2006) see themselves as a hybrid of a formal hierarchy and a more organic network supported by new social technologies. The nodes of these networks are often semi-autonomous, self-directed teams with the agility and flexibility that is needed for an organisation to carry on business as usual and also have the capability to respond appropriately to unanticipated, disruptive events. This arrangement can be designated as the 'network-centric' paradigm (Warne et al 2005).

Most managers are only familiar with staff training programs that are structured in a way that reinforces the existing hierarchic command-and-control paradigm. In the flatter forms of modern organisations that are emerging with at least a partial network-centric configuration there is a call for substantial changes in the ways people work and in the experiences that enable them to work effectively. These include experiences in and capabilities for decentralised decision-making; greater tolerance of ambiguity; safe ways to explore, experiment and rehearse possibilities, permeable internal and external boundaries; empowerment of employees; self-organising units, and self-integrating coordination mechanisms to support agile team work (Daft & Lewin 1993). The situation is described by Allee (2003 p 4) in the following way. "The centre of power is shifting out to the edges. Decisions are moving out from corporate headquarters to individual business units. Business units in turn distribute power and decision-making to self-managed teams and profit centres." While this can enable a swift local response to external events, it places new responsibilities on individuals to work cooperatively in well-coordinated collective activity that is aligned with desired operational outcomes but flexible and adaptive (Warne et al 2005). In order to further both research and practice in this area, this paper is an informed demonstration of how a particular online team game may be a constructive way to prepare people to operate appropriately in this network-centric environment.

The paper begins by outlining and discussing the critical concepts on which this work is based, including: the network-centric paradigm, self-directed teams, complex activity, knowledge work and shared situational awareness. An online gaming environment is then briefly described which has been developed through

research to provide a way for people to learn and acquire the capability to work in self-directed teams. New findings are presented from the most recent set of gaming sessions, comparing the capabilities of homogeneous and heterogeneous teams, to demonstrate their potential for learning appropriate to networked teams.

2. BACKGROUND THEORETICAL CONCEPTS

The following three complex clusters of concepts, derived from previous research, underpin the study presented later in the paper:

- The network-centric paradigm where arrangements of loosely coupled self-directed teams are underpinned by social technologies
- Understanding complex activity as a dialectic of thinking and doing mediated by tools in a community, as understood by Complexity Theory and Activity Theory.
- Shared situational awareness (SSA) leading to effective decisions and actions in knowledge work.

The network-centric paradigm allows organisations to change their culture from one determined by a command and control, rule-based hierarchy to one which supports loosely-coupled, self-managed teams making cooperative decisions through the sharing of information and knowledge (Warne et al 2005). In the ongoing, dynamic, changing environment of modern human enterprise the informal social networks have a vital role to play within, and across, formal organisational structures. New social technologies enable network centric approaches, however, effective network-centricity is essentially about knowledge, people, and communities. While the technical component enables, the organisational and behavioural components generate value. The network-centric environment implies new ways of knowledge working, with consequences for the organisation's infrastructure, processes, and culture.

This preliminary research aims to show how the emergence of viable self-directed teams interconnected in a network-centric configuration can be encouraged by engaging workers to explore this behaviour in a non-threatening team game-based environment.

Activity Theory is rooted in the work of Vygotsky (1978) and Leontiev (1981). Vygotsky defined human activity as a dialectic relationship between subject and object, i.e. a person working at something. This is a dynamic, purposeful relationship where the 'always active' subject learns and grows while the object is interpreted and reinterpreted by the subject in the ongoing conduct of the activity. Thus thinking and doing are together integral to this view of human activity. The mental processes involved in an activity can only be understood in terms of the tools and signs that mediate them. There are three types of tools which mediate activities, namely:

- primary or physical tools, such as technology,
- secondary or psychological tools such as language, ideas and business models, and
- tertiary tools, such as contexts, environments and communities.

A self-directed team can thus be considered to undertake collective activities where a synthesis of learning and doing underpins the current concept of knowledge work. The social environment or organizational culture and technical resources can be considered as a complex suite of tools that are ideally designed to support the collective activity. In a self directed team there are often several motives for the higher-level *activity*. In Collective activity, these motives may be in conflict giving rise to unintended outcomes from many such activities. This situation is compatible with ideas from Complexity Theory. According to Snowden (2002), in complex situations it is not possible to predict or determine outcomes in advance. Cause and effect are only seen in hindsight. He describes how meaningful patterns of behaviour emerge that can be encouraged, but not mandated or controlled. Snowdon suggests that attractors and barriers can be used to enhance the likelihood of desirable outcomes, and indeed innovation and organisational learning.

Situational Awareness (SA) is popularly described as knowing and understanding what is going on around you and predicting how things will change (Wikipedia). A more formal definition of SA is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of the status in the near future" (Endsley et al 2003p 13). It has also been defined as the "continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture in directing further perception and anticipating future events" (Vidulich et al 1994 p 11). Endsley (1995) further describes SA as dynamic and affected by attention and workload stress. According to Endsley (Endsley et al 2003 p 197), shared situational awareness (SSA) is defined as the degree to which team members have the same SA on shared SA requirements. She goes on to say that rarely would a team require entirely the same SA in all members.

Endsley (1995) defined SA, and implicitly SSA, as having three levels:

- Level 1: perception of elements
- Level 2: comprehension of current situation
- Level 3: projection of future status

From the SSA perspective, these levels are not unlike the three types of tools described in Activity Theory. Level 1 requires information sharing among team members supported by a physical tool. Level 2 SSA requires knowledge sharing through co-created mental models of the state of play so that knowledge is understood as 'information made actionable'. Level 3 takes knowledge into the realm of the 'big-picture' with understanding, insight and wisdom needed. This

interpretation of SSA is translated into the design of the game used in the study presented below. Team members become knowledge workers[1] who share information during the game to support collective knowledge for each decision and action leading to the evolution of cooperative purpose and strategic understanding.

3. OVERVIEW OF GO TEAM*

Go*Team is based on the ancient Chinese game of Go that has proved its value over the centuries as an engaging and challenging strategy game.

Go*Team is an online client-server implementation of Go for teams that can be put together to suit the aim of a particular experiment or training program. Team members each play on their own computer on a network and can be co-located or dispersed. Teams can be homogeneous or heterogeneous based on skills, personality types or any other criteria. They can be chosen to have complementary or conflicting skills. They may have already worked together as a team, could have just been introduced or could be assigned to a client machine not knowing who their team-mates are. The composition of teams can thus be varied considerable as can the pre game training of individuals and teams. There is also no preset command structure built into the Go*Team game. As far as the game software is concerned all team members are peers; with no predetermined roles and there is no 'team leader' with more power or capabilities than other team members.

An important part of Go*Team is that individual players in a team have only a local view on their computer screen of the overall Go*Team "world" in which they are embedded. The client screens for each player (i.e. team member) show only a partial view of the board (see the different stones on the two screens of Figure 1) so that there is a need for team members to communication their view of the board to others for shared situation awareness as well as to discuss moves and strategies. Players on the same team make use of modern communication tools such as email, voice over IP, chat rooms and the like, to effect the cooperation and coordination they need to successfully play the game. This modification introduces the problem of information sharing and integration into the game so that it is necessary that players share what they can see with other team members in order to develop an integrated overall picture of the state of the board.

Unlike standard Go, teams playing Go*Team no longer have to take turns; a team's next turn can be taken by any of its members after a "relaxation time", specified via the server, regardless of whether or not the opposing team has done anything in the interim. During the team's relaxation time no play is possible so that team members are forced to take time to communicate, sending information on stone locations and discussing future plays. Each player has the ability to place various types of 'markers' on their local view of the Go*Team board. They can use these markers to record where they know, or think they know, stones belonging to the other members of their own team as well as those of the opposition (see Figure 1). Even if they can accurately achieve this in the time available, they then have to decide not only what is the best next move, but also who makes it.

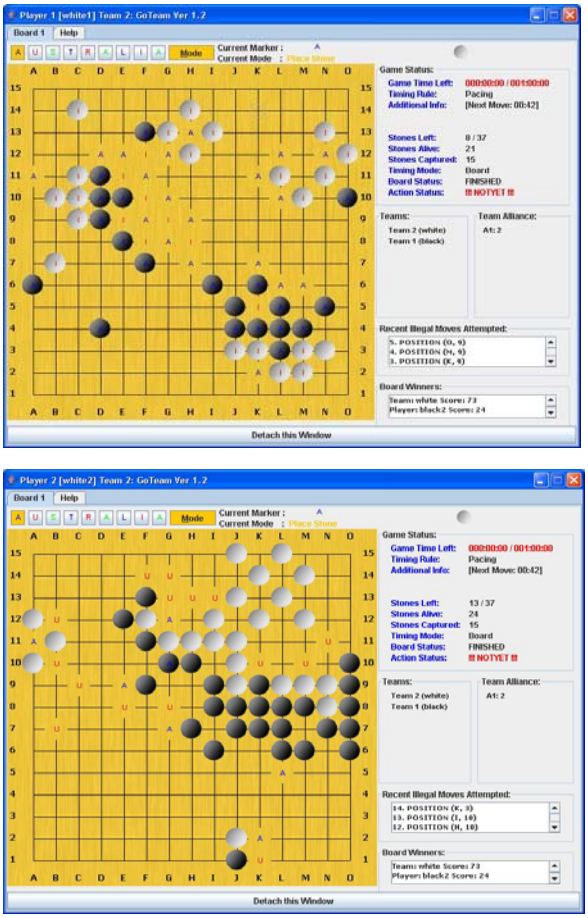

Figure 1: The boards of two players on the Black team showing different sets of stones visible to each player and positions of non-visible stones marked from information sent by other team members

There are a number of variables and factors that can be determined, set, changed and/or measured when playing Go*Team for the purpose of research. Some of these can be set before or during the course of the game (eg the size of the board, team composition, relaxation time). Factors can be introduced during the game to simulate hostile external events such as a breakdown in communications or distraction of some players. Some variables (e.g. stones played and captured, situation awareness, messages sent etc) are recorded and the results analysed and interpreted.

Unlike traditional Go, there may be many opposing teams and more than one board although games to date have been with two teams on one board. Team members can be allocated different numbers of stones each making up the standard issue to each team. The mode of communication between team members can

[1] Someone who adds value by processing existing information to create new information which could be used to define and solve problems (Drucker 1959, 1994)

also be varied from verbal, to online chat, to video. The relaxation time can be set to any value and can be varied at any time during the game. This may for example increase boredom if lengthened or increase stress levels if shortened to a point where a sudden large reduction would constitute an extreme event.

4. RESEARCH FINDINGS

Most early research with Go*Team has aimed at developing and refining the design of Go*Team sessions and developing the network centric paradigm for team work (Hart et al 2006, Crawford & Hasan 2006, Jagiello et al 2006, Warne et al 2006). A series of Go*Team sessions in 2006 investigating SSA and cooperative behaviour has more recently been reported (Hasan et al 2007a, 2007b).

This research has determined the effect of the various settings (i.e. independent variable such as team size and composition, board size, relaxation time, communication mode etc) and appropriate session protocols (pre-brief, game directions, de-brief etc). The sessions in the initial development trials involved two opposing teams of three or four each using online chat for communication and game times around one hour.

Reported here are new findings from the most recent series of three Go*Team sessions, which had the purpose of comparing the performance and development of a heterogeneous team with one that was homogeneous. While it was not expected that this one series of sessions would give conclusive results it would be expected add to our understanding of the challenging issues of how diversity within teams can be leveraged to advantage.

Team performance, as determined by stones captured in the three sessions of the series, is shown in Table 1. The heterogeneous team (White) performed poorly in the first game, better in game 2 and was quite competitive in game 3 performing as well as the opposition. Black was dominant in games one and two but showed no improvement in game three.

Table 1: The number of opposition stones captured by each team during each session

	Game 1	Game 2	Game 3
White	0	5	18
Black	9	22	20

The performance data for each player in terms of number of stones played, self reported level of confusion and the accuracy of correct markers placed as a result of communication within the team are shown in Tables 2 and 3. The results clearly show the differences between individuals and also the teams. In general performance improves over the three sessions. The Black (homogeneous) Team results indicate superior initial performance in all three variables. However, the heterogeneous White Team performance improves to a competitive level by the third session though reported levels of confusion are much higher.

Table 2: Data for each player in each game of the series. Stones Played, Levels of Confusion

	Stones Played			Confusion Level		
Session	1	2	3	1	2	3
Player						
W1	37	31	36	31	42	51
W2	2	13	18	39	42	57
W3	5	8	33	40	36	78
B1	18	20	34	45	79	105
B2	5	12	21	36	61	116
B3	36	23	33	43	51	54

Table 3: Data for each player in Correct Markers

	Correct Markers		
Session	1	2	3
Player			
W1	14	33	44
W2	23	54	93
W3	25	46	96
B1	65	75	142
B2	66	70	124
B3	46	46	70

Table 4 below shows the results in terms of an objective indication of communication (Number of Messages Sent) and a derived variable Situational Awareness (Correct Markers as a percentage of Stones Played).

Table 4: Data for each player for Situational Awareness and Messages Sent

	Situation Awareness			Messages Sent		
Session	1	2	3	1	2	3
Player						
W1	13.6	39.3	25.1	31	42	55
W2	22.3	64.3	53.1	39	41	46
W3	24.3	54.8	54.9	40	34	78
B1	63.1	89.3	81.1	45	78	105
B2	64.1	83.3	70.9	56	59	116
B3	44.7	54.8	40.0	43	50	51

Notably, the improved performance of the White Team, relative to the Black Team, occurred despite sending fewer messages and lower levels of Situational Awareness as defined in this research.

Overall the content of the team chats during games and the debriefing sessions were typical of the co-operative behaviour in network-centric arrangements of self-directed teams. Players were obviously motivated to cooperate with each other and saw this as the best way to achieve team success. The debriefing discussion revealed the complex nature of the activity. Even when the Black team was winning comfortably, players indicated that they were still in confusion as to where all the stones were and what was the best next play. The 40 second relaxation time seems to put the playing of Go*Team and communicating via Chat into an uncertain environment typical of complex activity.

In this series of sessions, it was expected that initially, all things being equal, the heterogeneous team would have difficulty working together and the homogeneous team would perform better. This was indeed the case. Also, as expected, through the reflection after each session, the heterogeneous team improved their cooperative skills and thus eventually perform better as a team taking advantage of their different capacities. An unanticipated result of the study was that this improvement did not come with more communication or situation awareness as these were still much lower in the heterogeneous (White) team than their homogeneous opponents at least measured on a quantitative basis. In regard to the three levels of SA described above (Endsley 1995) these played out in the following way. In Session one both teams were struggling at SA level one, perceiving the elements (ie positions of stones) of the activity. In Session two the homogeneous (Black) team was getting to SA level two, as some of their Chat messages and comments in the debriefing revealed an understanding of the overall situation. Going by some of the Chat messages, by Session three both teams were at least at SA level 2 with some indication of SA level 3. Indeed, the picture of the board in Figure 5 shows the heterogeneous team (White) in the better position to move forward and capture more territory

5. DISCUSSION AND CONCLUSIONS

This small study cannot give conclusive results. However two aspects of the results are theoretically valid and consistent with a large body of qualitative research in business that suggests the benefits of heterogeneous teams as operational units for maximum adaptability. These are: firstly, that heterogeneous teams are potentially able to perform complex activities better than homogeneous ones once they have learnt cooperative team skills; secondly, that a team gaming environment, such Go*Team, has the capacity to enable such learning.

As demonstrated by this study, Go*Team embeds players in the typical environment of self-directed teams. To be successful as teams, members need skills to cooperate, often with others from different backgrounds, within a competitive culture. Shared situation awareness at all three levels becomes a challenge in the Go*Team game where effective collective action necessitates a holistic view of the game activity. It requires not only information flows between team-members, but also the synthesis of that information by players into knowledge that results in actions towards an agreed the common purpose of the activity. Adaptability and flexible are needed both by people and the technologies that support them.

Playing Go*Team is a complex activity calling for different ways of thinking and working where detailed planning is not possible but the team must be satisfied to allow solutions to emerge through sensible decision making and action. In this situation, the language and concepts of Activity Theory and Complexity Theory are useful. Activity Theory views ‘what people do’ as collective activity where there is a dialectic relationship between the subjective and objective aspects of work in which thinking and doing are both critical (i.e. knowledge work). Such activities have a dynamic relationship with the primary, secondary and tertiary tools that both enable the activity and are transformed by the activities for which they are used. Go*Team software and session protocols are tools for team training that have evolved through this process. The gaming situation also allows the possibility of collecting complex sets of quantitative data objectively through the system. Gaming systems have potential as tools for further research on the dynamics of self directed teams and the particular benefits of homogeneous and heterogeneous formations.

In such situations, Complexity Theory would suggest that it is more efficient and effective to assume that desired outcomes can be encouraged but not mandated. This is the case in Go*Team games, as decisions to place a stone are only occasionally made explicitly to capture or block the imminent threat of the opponent. More frequently plays are made only in hope of improving the team’s position. However the team that learns to do this well performs better overall.

There is usually a challenge in bringing together a diverse group of people with complementary skills and experience to form a team that will undertake complex activities. Homogeneous teams usually form more quickly but members bring a limited range of human resources to the team and there is often competition between members for similar rewards. In heterogeneous teams there are a diversity of skills, values and jargon so that communication and mutual respect can be difficult to establish but there is great value if their more varied set of resources can be leveraged. The findings of this study encourage and inform those who want to take up this challenge.

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