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Social Organisation and Cooperative Learning: Identification and Categorisation of Groups and Sub-Groups in Non-Cooperative Games

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Abstract

This paper outlines the results of a modified SYMLOG analysis for group formation, structure and interactions. While collaborative working has been an established working methodology for Education and Computer Science researchers alike, there has been a lack of focus in the latter as to what a group actually is within psychologically complex human communities. Here we discuss why groups can be beneficial to student learning in education, but also how misusing groups has negative effects. This paper presents the results of two board game based experiments. The first experiment used the classic SYMLOG model to show validity of the scenario in data collection and the second testing our Mod-SYMLOG. Results showed that Mod-SYMLOG was effective in capturing group dynamics, with indications of group structure.

1 Introduction

This paper will outline work completed on the designing of Group Model for monitoring student group formation within a classroom environment. In our previous submission we highlighted the issues caused by increased classroom sizes in UK secondary schools and outlined the Intelligent Classroom Tutoring System (ICTS)[17], as direction of research to address this issue. The ICTS attempted to extend the Intelligent Tutoring System (ITS) model from a single learner to a group of learners and supplement human teachers within a traditional classroom environment via the use of Psychological theories of Intra- and Inter-group dynamics and monitoring tools within an immersive or virtual classroom. We shall cover the completed experimental work for the creation of a the Group Model, beginning with a review of SYstem for the Multiple Level Observation of Groups (SYMLOG) methodology from psychology as a starting point for understanding group behaviour. We then modified the SYMLOG (Mod-SYMLOG) classification system, and experimental results for both methodologies.

1.1 Intelligent Classroom Tutoring System

The ICTS framework is designed to assist a human teacher within either a physical or virtual classroom setting, augmented with additional technology for monitoring and interacting with the students and teacher. Our model is split into two components, the individual ITS component, traditionally split into four modules Domain, Student, Pedagogy and Communication[21], and a group component. The feedback loops within the ITS and this ICTS model, which is where the learner, individually and/or as part of a group, is instructed through a series of teaching techniques transferring the domain knowledge via a communication interface and updating the learner model. See figure 1 for a functional illustration of the proposed framework. It is envisioned that he status of a class, would be relayed back to the human and AI teachers, providing details of both individual and group behaviour in real time. This information would then be used to calculate what time of intervention is needed and whether that is delivered from an AI agent or the human teacher. Intervention could be deployed in the form of human interaction or augmenting the classroom.

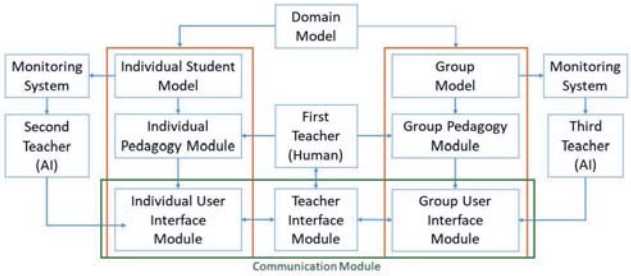

Figure 1: Intelligent Classroom Tutoring System Framework[17]

1.2 Understanding the group and it's importance to learning and development

Educational researchers have tended to agree that group learning is superior to individual learning, both in terms of academic performance and improvement in social skills[13]. However this does come with a caveat, the individuals reaction to working within a group. Studies from Educational Psychology have shown when group based learning was viewed as a positive event, this tends to lead to greater socio-emotional skills in forming personal relationship, improved relationship with learning, and improved academic outcome[2][6][13][23].

Unfortunately, other studies have found that group learning does not always produce a better outcomes than individual learning. A negative group interaction can lead to members associating both learning and social interaction with negative experiences and withdraw from both, potentially even permanently[4]. If the task is not sufficiently defined and structured[2], the individual efforts of learners are not rewarded, and free-riders not penalised[6] then group learning can have a negative impact on learning and social development[6][13].

Negative groups tend to not appear in human experiments as they rely on volunteers, which can lead to a Volunteer Bias, which is a subset of the more general Sampling Bias[22][27]. Volunteers, when compared to non-volunteers, tend to score lower for Neuroticism and higher in Conscientiousness, Agreeableness, Extraversion on psychological tests and, perhaps, have a higher need for social approval[18]. These individuals have a tendency of wanting to please the experimenter or be liked by others. This results in positive feedback between group members which can lead to validity problems when applied to real world scenarios where different personality types interact[18]. The importance of identifying "positive" and "negative" groups, or disruptive individuals within a group, and resolving issues before students develop a resistant attitude towards education, social-interaction or both, cannot be understated[4].

By utilising the mechanics of a board game which encourages dynamic group formation (cooperation) and division (non-cooperation) through social interaction, rather than preassigned roles, we hope to observe and capture negative groups and their formation. If this is found to be possible, then future research can examine training an AI system to detect these patterns.

1.3 Computer Supported Collaborative Learning Research

A significant amount of research has been carried out on supporting group work within real world smart environments[11][26], intelligent classrooms[7] digitising of group based educational techniques[14][19] and feedback from members as metrics of satisfaction[9]. Less has been focused at the structure of the group itself. Attempts to capture groups as an entity include aggregating Bayesian Network based individual student models[25], similar to one of the approaches taken by Economists[16], however researchers in Psychology have shown groups out perform what aggregate methods would suggest[8][28].

Goodman et al in a review of research between 1998 and 2016, posed 6 open research questions. The 3rd question posed stated that "[m]odeling of users takes on a different perspective in an intelligent CSCL. There are attributes of individual students (a student model) and of the whole group of human learners (a 'group model') that need to be tracked to best drive the instructional support"[12]. The view that there is a group and that it is under examined within the research is supported by Stahl, where he states "...it is proposed that CSCL research should focus on the analysis of group processes and practices, and that the analysis at this level should be considered foundational for LS"[24].

It is here, alongside current research, that the authors wish to include a group model. The identification of positive and negative groups, the dynamic relationships that exist between individuals, and changes due to intervention, it is believed, will achieve a more inclusive and positive learning experience.

2 Methodology

For both sets of experiments, the participants played a board game known as Diplomacy. This first pilot experiment was designed to test the applicably of

SYMLOG within the game set up and to run an initial analysis of results to provide a baseline for comparison for the Mod-SYMLOG methodology we have designed.

2.1 What is SYMLOG?

SYMLOG is an attempt to quantify group behaviour by categorising interactions between group members, with each interaction being rated externally, rather than self reflection[10]. I.E. if there is a conversation between two people (Person A and Person B) then Person A (or an external observer) would rate how they perceived Person B and Person B would rate how they perceived Person A. Rating of how individuals interact with a group is not one rating for the whole session, but one or more ratings per interaction (i.e. conversation) with one or more other people within the group[1][10][20]. Bales created a list of adjectives to rate these interactions between individuals within the group[1]. Each interaction can have one or more ratings assigned to it.

When these ratings are collected, groups can be assessed by how well the group is working together by examining the group itself rather than just the outputs from the group, e.g. task completion. This study hopes to establish that the modified version of SYMLOG can model the group evolving dynamically, before further research into automating the the Modified SYMLOG process.

These ratings are then collated and a position within the group is assigned to each individual based on the net outcome of all there interactions (see figure 3 for visual examples).

These adjectives are assigned a combination of letters, based on a three dimensional scale of Up/Down (U/D), Positive/Negative (P/N) and Forward/ Backwards (F/B) and should be based on both verbal and non-verbal communication[10][15]. U/D is the measurement of a persons dominance or submissiveness to the group. P/N is a scale if a person's interactions are friendly or non-friendly within a group. And F/B is a measurement of how the person within the group is working either towards or against either the group goals or emotional status of the group. A few examples of the SYMLOG adjectives are listed below:

- U Individual financial success, personal prominence and power
- UPF Active teamwork toward common goals, organisational unity
- PF Responsible idealism, collaborative work
- N Self-protection, self-interest first, self-sufficiency
- DNB Admission of failure, withdrawal of effort

Adjectives ratings for each member of the group are collected and plotted onto a SYMLOG Field Diagram (SFD), which is a two dimensional axis of P/N and F/B, with U/D represented by the size of the plot point of each individual, i.e. the more dominate they were the larger the radius. Positions on the SFD can then be categorised into various group structures ranging from types of effective teamwork to opposition/destructive groups/group members (see Figure 2).

For example, in Turn 1, Person A received a rating of "DPB" (Quiet contentment) from Person B and "UPF" from Person C. The U and D values cancel each other out (i.e. neutral), as does the F and B values. This leaves Person A with an overall rating of "P." Each axis on the graph was given a numeric range between 0 and 2. So here Person A receives a co-ordinate plot of (1,2).

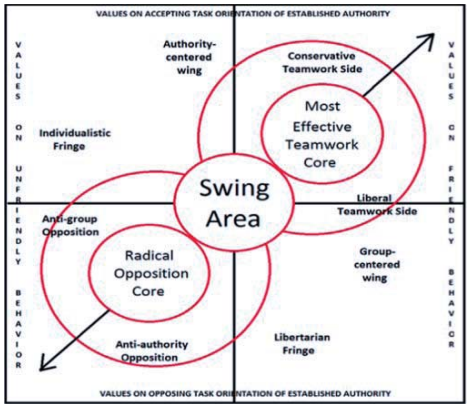

Figure 2: SYMLOG field diagram[3]

2.2 Modifying SYMLOG

This modified SYMLOG (Mod-SYMLOG) replaces the adjective rating system with ratings based on the three axis points, U/D, P/N, and F/B. In this system, person A would rate person B on each of the following scales:

- U/_/D: Dominate, Neutral, or Submissive
- P/_/N: Positive, Neutral, or Negative
- F/_/B: Working towards group goals, Neutral, or working against group goals

So if a person A though person B was being Dominate they would record "U," the coordinates would resolve to (2,1) If person A thought person B was being Positive at the same time, they would record "UP" (2,2) Or if person A thought that B was withdrawing from the group and being negative and activity working to disrupt the group, they would record "DNB" (0,0).

Participants could also rate someone as being partially within these axis. For example if person A thought that person B was being submissive, but only slightly, and working towards the group goals they would record "DF, F" which would resolve to the coordinates (1.5,1).

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3 SYMLOG Experimental Set Up

Developed in the mid-late 1950s, Diplomacy is a turn based game where participants take the part of the Great Powers of Europe in 1900. Each game year consists of 2 phases (Spring and Autumn), each phase has a negotiation turn followed by a movement turn where all participants move simultaneously. At the end of the Autumn turn, participants either gain pieces or lose pieces depending on the outcome of the Spring and Autumn phases. The board is a map of Europe, divided into 52 land regions and 19 sea regions. 42 of the land regions are divided between the Great Powers at the start of the game, leaving 14 neutral land regions. All sea regions are considered neutral. 34 of land regions contain supply centres, 22 belonging to Great Powers, 12 in neutral land regions. Each supply centre provides the player with 1 unit (e.g. if a player controls 4 supply centres they can have 4 units on the board). The winner is the first to control 18 supply centres[5].

In the experimental set up, each participant was asked to fill out a Negotiation Log after each Negotiation turn. The Negotiation Log asked each participant to describe their current diplomatic status with other participants. Table 1 shows an example of the diplomatic status section of the Negotiation Log.

Alliance	None
Non-Aggression Pact	None
Cooperative Other	FRA, ENG
War	None

Table 1: Austro-Hungry Diplomatic status

Participants would then fill in the number of interactions they have had with each other participant and the SYMLOG rating for each. SYMLOG ratings were provided to participants on a separate sheet of paper. An example of this can be seen in Table 2. This example, the Austrian Player rates England and France as “Active teamwork toward common goals, organisational unity” which is represented by the SYMLOG notation “UPF.” Italy is rated as “Responsible idealism, collaborative work” (PF). Turkey is rated as both “Passive non-cooperation with authority” (DB) and “ejection of established procedures, rejection of conformity” (NB).

Country	SYMLOG Rating
England	UPF
France	UPF
Russia	PF
Turkey	DB, NB

Table 2: Austro-Hungry SYMLOG

5 participants, out of a maximum of 7, took part in the experiment which ran for 3 hours on a Thursday evening. The subject group consisted of 3 males and

2 females, with 2 subjects of Arabic descent and the rest of a White British background. 3 participants were undertaking PhDs in Computer Science, 1 had completed their PhD in Computer Science, and the final had just started a BSc in Mathematics. Due to the number of participants, the 5 player variant of Diplomacy was selected, meaning that Austro-Hungry, England, France, Russia, and Turkey would be taken by participants while Italy and Germany would remain neutral. Each country was randomly assigned a number between 1 and 5, then participants selected numbers from 1 to 5 from a hat to randomly assign a country to each person with minimal bias.

The participants, in conjunction with playing the game, filled out a negotiation log at the end of each negotiation phase, recording current and established agreements between participants and using the SYMLOG adjective rating system to score interactions they had with other participants.

3.1 Mod-SYMLOG Experimental Set Up

With the original SYMLOG experiment establishing Diplomacy as being a suitable analogue for cooperative and non-cooperative group interaction, we began a second phase of experimentation to test adjustments to the SYMLOG framework data collection and member position methodology. The Mod-SYMLOG experiments took place on two different evenings in January with two games played on each day. On the first day 5 participants took part in game 1, and 4 for game 2. The second day there were 7 players for game 3 and 6 for game 4. These were run with the same methodology as the pilot, with the only amendment being the new rating system. As with the pilot experiment, most of the participants were STEM PhD or MSc students. However the participants were significantly less diverse than the pilot. All the group were male and originated from the European continent.

4 Results

4.1 SYMLOG Results

Year 1 phase of SYMLOG Diplomacy tends to be fairly cooperative as players tend to avoid early conflict and agree on the division of neutral territory, participants followed this pattern and started as a cooperative group. Out of 13 recorded interactions between participants in Turn 1, 6 of the ratings were "UPF," 1 "PF," and 1 "F," meaning that 8/13 (61%) of the interactions were rated as positive. In turn 3 (Year 2 spring), 17 interactions were recorded of which 9 (53%) were negative. The position of each participant was calculated for each turn, based on the average rating received from all participants that recorded an interaction rating.

Once the results had been plotted, the participants were interviewed and asked if they felt that the SFDs accurately represented the group playing the game. Out of the 5 participants, 4 responded stating that the SFDs agreed with their own assessment of the group dynamics.

Figure 3 shows a sample of 2 SFDs from Turns 1 and 3. While all participants were in or near the effective teamwork sphere in Turn 1, the group is moving away from close cooperation by Turn 3, with Russia moving towards the disruptive area.

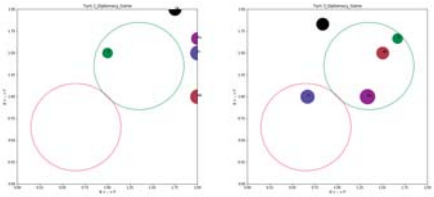

Figure 3: Human Diplomacy SYMLOG Turns 1 3

More detail for the interaction between group members was captured and represented via node graphs. Interactions between participants were broadly defined as "Teamwork" and "Opposition" based on the location of these ratings when plotted within the classic SFD (Figure 2). Teamwork rating fell within the "PF," "UPF," "UF," "P," "UNF," "UP," and "F" ranges, while Opposition ratings where "BD," "DB," "DN," "DNB," "DPB," "N," and "NB". The direction of opinion is noted by an arrow, for example the blue arrow in Turn 1 pointing from Turkey (T) to France (F) (Figure 4) signifies that Turkey believes that France is being cooperative. These diagrams provide additional incite into how the group were interacting. We can see that Russia is viewed, by Austria, as moving from working cooperatively to working against. This shift explains why Russia moves towards the disruptive area on the SDF.

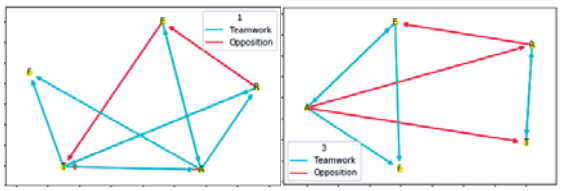

Figure 4: Human Node Graphs Turns 1 3

4.2 Mod SYMLOG

In all four games, Mod-SYMLOG recorded groups forming in cooperative and non-cooperative states. Similar patterns of behaviour were captured - the movement of the group from initial cooperation between all players to non-cooperation and/or formation of subgroups (see fig 5 for an example from game 3).

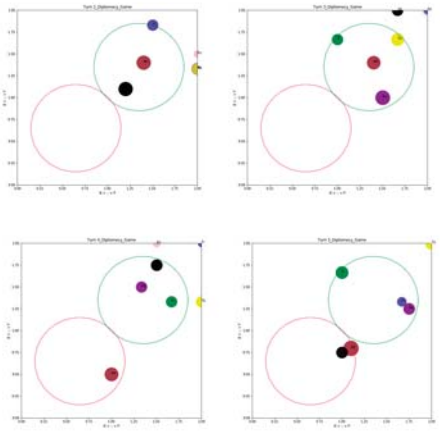

Figure 5: Human Diplomacy Game 3 Mod-SYMLOG Turns 2 - 5

The results from Game 3 can provide indicators for sub-group formation. The node diagram in Fig 6 shows negative interactions existing between Austria and Germany for turns 2 and 3. On turn 4, France moves from a cooperative state with Austria in turn 3, to a non-cooperative state, while maintaining a cooperative position with Germany. France has also been in a non-cooperative state with Italy, which maintained a cooperative state with Austria. This is the Potential forming of two sub-groups, where players seek cooperation against common non-cooperative players (France and Germany against Austria and Italy). The creation of these sub-groups transpires in turn 5 France and Germany are joined by England, while Austria and Italy and aligned with Russia. Turkey remains in a cooperative state with two to three members of each sub-group. Similar indicators of sub-group formation were seen in Games 1, 2, and 4. More detail how individual participants viewed other group members in Turn 5 can be seen in Table 3

Player/Target	Turn	Ah	En	Fr	Ge	It	Ru	Tu
Ah	5					P	PF	PF
En	5			D,F,P	P,D			
Fr	5	UNB	DF		F	NF		
Ge	5	UB	DP	DPF			B	
IT	5	PB	B	B	B		P	
Ru	5	UPF	NB		NB			PF
Tu	5	F, UNF				F	DPF	

Table 3: Game 3 Mod-SYMLOG ratings Turns 4 and 5

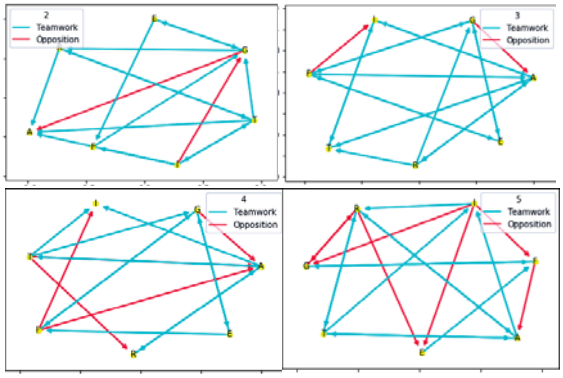

Figure 6: Human Diplomacy Game 3 Mod-SYMLOG Turns 2 - 5

5 Conclusion and Discussion

Both sets of experiments have shown the ability to capture the dynamics of group behaviour and how these interactions can be modelled.

Participants identified that categorisations of types of interaction as the most difficult part of the pilot experiment. For example, players found it difficult to distinguish between "UPF," "UF," and "UNF" during the negotiation phase. Mod-SYMLOG provided an easy to use alternative, with players asking fewer questions about how to encode ratings than in the pilot. Additionally, one of the experiment participants is an AI Games Lecturer, who expressed interest in using the Mod-SYMLOG system for a cooperative gaming AI, which aligns with the original intention that a simple triple axis would be easier for an AI to learn and model human behaviour from. This redesigned metric was intended for AI monitoring system, so feedback was beneficial over it's potential usefulness.

There is some indication that it is also possible to extract some group hierarchy from the data. In turns 4 and 5 Austria and Germany either viewed their respective cooperative partners as equal or submissive, or their partners saw them as dominate and positive (see Table 3). For example, in Turn 5 France viewed Germany as "F", while Germany viewed France as "DPF," suggesting some hierarchy. This concurs with observations from the game, where Austria and Germany were in clear leadership positions. Further experimental work would be required to establish the validity of detecting these hierarchies.

Active monitoring of students within the classroom, analysed through Mod-SYMLOG, could provide teachers with the ability to intervene and prevent negative groups from establishing a permanence through lessons or the school year.

6 Future Work

With experimental evidence that Mod-SYMLOG can capture group dynamics, it will be used to further the development of the ICTS. Our current intention

is to apply the Mod-SYMLOG model of recording group interactions to a real classroom scenario and have the information fed back to a teacher.

AI agents for a digital version of Diplomacy, are to be created with a Mod-SYMLOG module to assist with decision making and AI-Human interaction. This could have potential applications in the creation of an AI monitoring system as part of the ICTS.

The next phase of research and development of the ICTS framework is the Group Pedagogy Module. Here the intent is to investigate various methods for selection for intervention methods within a classroom environment. Investigations towards modelling an N-Player Prisoner's Dilemma game. Results of intervention shall be measured not only by academic results of group work, but also the cooperative levels within the group as interpreted by Mod-SYMLOG data.

This will be followed by investigations of representing feedback gathered from the monitoring system to a teacher. Other methods under investigation Are 3 Dimensional SFD, heat maps of positive/negative interactions and assessing levels of detail the teacher requires.

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