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Understanding how social and epistemic scripts perpetuate intersubjectivity through patterns of interactions

Jay W. Mahardale⁴* and Chwee B. Lee⁵

⁴Admiralty Primary School, Ministry of Education, Singapore; ⁵Learning Sciences and Technology, Nanyang Technological University, Singapore

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Supporting the interactions of participants in an online learning environment is important to achieve a successful learning experience. The lack of support may cause collaborating learners to fail to complete their joint task or require too much time and effort (Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem-solving in computer-mediated settings. Journal of the Learning Sciences, 14, 201–241). It is often necessary to provide some form of scaffolding to facilitate the elaboration of collaborative learners through means of structuring their interactions. For this reason, it is important to find out what kind of support effectively perpetuates intersubjectivity and promotes richer learning by collaboration. The objective of this study was to examine how two different types of scripts influence intersubjectivity in an online problem-solving environment. The specific roles played by the participants using the social scripts helped them to develop richer iterative patterns of interaction, solve problems better, and motivate joint elaboration of learning. This finding is of great importance to educators in designing group interactions which are highly participative.

Keywords: intersubjectivity; interactions; problem solving

1. Introduction

The world we live in is changing, with our society transforming into one that is making greater demands on the development of skills for its citizens and this has caused the work space to continually become more challenging and complex. As such, there is a need for the development of key skills such as teamwork, problem solving, ability to take initiative, independent learning, oral communication, and flexibility in applying knowledge (National University of Singapore [NUS], 2000; United Nations Educational, Scientific & Cultural Organisation [UNESCO], 2005).

Two of the important characteristics of workplace expectancies that this article investigates are how learners develop problem-solving skills as part of a team. Problem solving is a personally satisfying process, which encourages independent learning and enhances success in school (Reich, 1993; Tan, 2007). Stasz (2000) believes that problem solving is one of the key intrapersonal skills that are part of the

*Corresponding author. Email: jay_mahardale@moe.edu.sg; jaynita@singnet.com.sg

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workplace competencies to survive in the knowledge economy of the future. The ill-structured nature of problems in our daily lives is the one our learners will likely encounter in the workplace and the types that will engage learners in contextualized meaningful activities (Scardamalia & Bereiter, 2003). In addition to solving ill-structured problems, there is also a need for learners in schools to work collaboratively so that the future transition from school to working environments is less daunting (Mahardale, 2009). The discourse through collaboration enables learners to develop skills such as interdependence, shared responsibility, and leadership, and emphasizes the process of problem-solving activities (Dillenbourg, 2002; Tan, 2007).

However, the limitation of collaboration, when collaborating partners often fail to complete their joint task or require too much time and effort in the absence of systemic support (Rourke, 2000; Rummel & Spada, 2005), has spurred the design of learning environments where support such as collaboration scripts are created (Kollar, Fischer & Hesse, 2003; O'Donnell, 1999; Rummel & Spada, 2005) to facilitate collaborative learning activities.

The conceptualization of epistemic and social scripts by Weinberger, Ertl, Fischer, & Mandl (2005) sought to specify how learners collaborate with each other. Epistemic scripts specify how learners work on a given task while social scripts structure how learners interact with each other. The study showed that groups using epistemic scripts were hindered in acquiring knowledge as the script did not motivate joint elaboration of the learning material (Weinberger et al., 2005).

Our study builds on the results obtained by Weinberger et al. (2005) but further investigates how the interactions in groups assigned with different scripts differ and influence their ability to solve problems collaboratively. These interactions between group members take the form of processes and dynamics such as patterns of influence and conflict management, which influence the effectiveness and efficiency of groups in a learning activity (Jonassen & Kwon, 2001) and has been the new focus of understanding students’ collaborative learning or problem-solving activities (Suthers, Dwyer, Medine & Vatrapu, 2007).

The purpose of this article is to investigate intersubjectivity between learners through the study of the influence of script types on: (1) patterns of group problem solving and (2) group problem-solving performance.

2. What is intersubjectivity?

Much of the research on Computer Supported Collaborative Learning (CSCL) has tended to focus on how individuals perform in a group but in recent years, there has been an increasing interest in how groups as a whole has performed. The social and largely linguistic sequences of events where a group or groups of people produce utterances that constitute a cognitive act is what we call intersubjectivity (Mahardale, 2009; Vygotsky, 1978) and this can be viewed as either a movement from a state of disagreement to one of agreement or shared understanding (Stahl, 2006; Wertsch, 1979).

These interactions may lead to emerging ideas that have multiple perspectives and cannot be credited to any one individual in a group but rather arose from the discourse between individuals. The group has become the unit in which analysis is conducted on and the focus has shifted to a more emergent, socially constructed property of the interaction (Dillenbourg, 1996).
Co-construction of knowledge and meaning is built on through the collaboration among members in a group tasked to perform a common goal. This shared group processes among the members is a form of intersubjectivity among collaborators, where the shared interactions and tools used for discourse play a part in what outcome is reached or resolved among the collaborators (Hutchins, 1996; Norman, 1993; Stahl, 2003). Without discourse taking place, we can say that the cognitive ability of the group vanishes because it is dependent on the interactions that take place (Stahl, 2005). One of the issues in understanding and validating intersubjectivity though has been the difficulty in measuring it (Stahl, 2006; Suthers, 2006). To understand how collaborative problem solving is accomplished among participants, it is important to examine how they engage in their activity that leads to the act of problem solving.

Principal to studying intersubjectivity between learners has been analyses of interactions and how these interactions have created a joint learning space. In Barron’s (2003) work in analyzing problem-solving performances, group work led to better problem solving and learning outcomes compared to problems being solved individually. Groups that performed successfully were also found to have greater quality of interactions among members (Barron, 2003). This suggests that how group members’ ideas or postings are interpreted by others determines the level of intersubjectivity and is key to the success of a group (Suthers, Vatrapu, Medina & Dwyer, 2007).

3. Patterns of interactions as an analytical tool to measure intersubjectivity

It is essential to understand how groups solve problems through examining communication patterns involved in group decision making (Hirokawa, 1992; Jonassen & Kwon, 2001), as it is key in collaborative problem solving. Decision making among members in a group will affect the interpersonal communication processes, as the effectiveness of completing a task is reflective of how well groups communicate with each other (Poole, 1992). The impact different factors have in influencing decisions made by individuals and agreed on as a group would provide insights on how groups solve problems. This makes analyses of interaction patterns a plausible way of measuring group intersubjectivity.

Coding the interactions between members in a group would be the initial step in studying communication patterns of interactions. The functional category system, developed by Poole and Holmes (1995) used to code interactions between participants, in this study is a coding system that helps to classify communication acts between people. The acts were classified as problem definition, orientation, solution development, non-task, simple agreement or simple disagreement. Coding the communication acts allows quantification of the role each utterance plays in a communication setting. In this study, coding the functions of learners’ transcriptions will provide insights into the role a collaborative script plays in fuelling the interactions between learners of a group. It also allows these acts to be organized so that a pattern of communication during the problem-solving process could be identified.

Studies in communication patterns of interactions have been applied by Jonassen and Kwon (2001) in their research on types of communication modes, and Roberts and Nason (2003) found that teams which are more balanced in social roles demonstrated better knowledge-building activity and produced better knowledge artifacts than nonbalanced teams.
4. Providing support for learning

CSCL environments are often equipped with support systems that help to avoid dysfunctional group phenomena, improve the learning process, and foster knowledge acquisition (O’Donnell & King, 1999). One such support is the use of collaboration scripts which improve the process of collaborative knowledge construction (Fischer, Bruhn, Gräsel, & Mandl, 2002; Rummel, Ertl, Harder, & Spada, 2003).

Collaboration scripts are considered a powerful means to improve processes and outcomes of collaborative learning (Kollar et al., 2003; O’Donnell, 1996, 1999). Studies have shown that collaboration scripts were able to improve learners’ ability to apply theory-based knowledge to transfer problems as well as their recall rates of learned information (Kollar & Fischer, 2006), decrease uncertainty, increase the amount of discourse and promote learning. O’Donnell (1996) found that the greatest advantage of collaboration scripts is that they can be tailored to support a variety of activities such as problem solving, learning from text, or learning concrete procedures and this may well influence the intersubjectivity between participants tasked to solve a problem jointly (Mahardale, 2009).

Makitalo, Weinberger, Hakkinen, Jarvela and Fischer (2005) found that learners working in unscripted conditions had better learning outcomes, thus throwing into doubt the idea that greater amount of discourse would be closely connected to better learning outcomes. Makitalo et al.’s (2005) study suggests that some degree of uncertainty through the absence of scripts is necessary to facilitate some forms of interactions which have greater impact on the learning outcome but this is conflicting with studies where collaborating partners often fail to complete their joint task or require too much time and effort (Dillenbourg, Baker, Blaye & O’Malley, 1995; Rummel & Spada, 2005) in the absences of scripts. A greater look at the quality of the interactions is thus important in getting a better understanding at how scripts foster collaboration and ultimately the quality of the outcomes, whatever they may be.

CSCL research has most notably focused on the development of technology scaffolds within the CSCL tools, which are used to structure and facilitate collaborative interactions and construction of knowledge (Roberts & Nason, 2003). However, the power status between interlocutors in the given task also plays a part in the outcome of the task. The use of differentiated scripts, where there is regulations of social roles, could provide the difference in facilitating problem-solving tasks and may give us insights into the varying results on the use of scripts in this research area.

A study by Larson et al. (1985) compared two types of scripts with specific goal dimensions – elaborative and metacognitive script. The study found that differentiated effects of scripts can have different effects on collaborative learning – with the former facilitating individual knowledge acquisition and the latter detrimental for knowledge acquisition. The results were the basis of Weinberger’s (2003) study on the effects of differentiated scripts manifested as epistemic and social.

Epistemic scripts specify and sequence knowledge-construction activities. Epistemic scripts will facilitate activities that describe how learners work on the task in more detail and in a more systemic way. Such scripts guide learners toward specific aspects of the task and toward specific task-oriented activities. Epistemic scripts can assist a group of learners in structuring the contents to be discussed when doing a task such as solving a problem. The scripts can be in the form of questions
about the problem given and aimed to get learners to identify the problem, suggest possible solutions, and finally develop an agreed solution.

Social scripts foster learning through increased elaboration activities, through specifying and sequencing interactions of learners. These scripts provide learners with roles and encourage them to perform interactions only under the parameters of the role assigned (Weinberger et al., 2005). Such scripts though offer no guarantee that any type of social interaction may support learning. As pointed out by King (1999) and Weinberger et al. (2005), social scripts aim to help learners structure discourse based on successful interaction patterns of knowledge construction. This is done through providing learners with specific roles and encouraging them to perform particular interactions at specified times. A good example of such is the scientific review process where peers take on the role of a critic in weighing the merits of a proposal (Weinberger, 2003).

Weinberger et al. (2005) researched the effects of social and epistemic scripts on an individual’s acquisition of knowledge and found that the use of epistemic scripts hindered the individual acquisition of knowledge as the script did not motivate joint elaboration of the learning material. There should be further study on how to design scripts that can better motivate collaborative activities (Weinberger et al., 2005), but of greater need is an investigation on the quantity and quality of interactions between collaborative learners which is an integral part of successful problem solving (Cohen, 1994).

5. Design of the learning environment

Twelve participants from a Co-Curricular Club were randomly assigned to form four triads with each triad subjected to one problem each. Two triads were provided with epistemic scripts and two triads were provided with social scripts. The two sets of scripts were adapted from Weinberger et al. (2005) but a key difference in the use of social scripts is that considerations for the social infrastructure of the groups solving a problem will be taken into account. This social infrastructure is based on Roberts and Nason’s (2004) study on team preferences which found that a balanced group would put in more quality interaction than nonbalanced teams and addresses one of the gaps in the design of social scripts (Weinberger et al., 2005). A balanced team is one which takes into account the group members’ team role preference as defined by Margerison–McCann’s Team Management Wheel (1998). Team role preference is defined as the tendency of an individual to behave, contribute, and interrelate with others at work in certain distinctive ways (Belbin, 1996).

Most of the time, in lieu of the technology scaffold provided, social interactions in small groups are taken for granted and there is also a lack of attention to the social psychological dimensions of social interaction outside of the task context (Kreijns, Kirschner, & Jochems, 2002; Rourke, 2000), thus the roles assigned to the members take this ideology into account.

The roles assigned to the members are: adviser, organizer, and innovator. An adviser supports the solutions put forth by providing insights into its creativity and feasibility. An organizer organizes the way the interactions are taking place and helps to structure the ongoing discussion, making sure the participants are on track in their problem-solving activity. The innovator provides the solutions to the problems. The ideas put forth must be based on the problem scenarios given and will be confined to the perimeters set by the other members of the triad. Each role complements each
other and makes each triad a balanced team (Figure 1). The role of controller was not adapted to this study taking into account the need for status of power to be distributed equally among the members.

The two triads using epistemic scripts were not given specific roles but all of them perform the same role as problem solvers with scripts that aim to get them to expertly solve the problem posed. The epistemic triads are given scripts that point toward the actual tasks and the contents they have to deal with (Weinberger, 2003).

Students were given an opportunity to solve an authentic environmental problem through this activity and they were required to analyze extracted problem scenarios developed for an environmental competition for primary school students and had been checked for face validity by the Science Head of Department of the school:

Tom lives in Happy City, a developing city of a population of 4 million and works as a factory production worker for the company Sunshine Place which produces finished products for sale. The city’s development hinges on the economic prospect of the manufacturing industries and foreign investments. The massive industrialization led to many factories being built with exhaust chimneys towering over buildings and factories located near rivers and canals.

He travels to work on a daily basis with his petrol-driven car that is 5 years old jostling with many others in the jam-packed urban roads. An air quality reader always registers an unhealthy level. Tom complains to the city council but there are no significant actions taken by the council so he keeps a mask with him wherever he travels.

You are a member of the Environmental Agency tasked to tackle the problems in the preceding scenario. With your Agency members, suggest solutions to the issues in the text.

Students used the online Knowledge Forum™ as the platform to solve the problems given. The type of script was in-built to the group the students were assigned to in the KF environment. This was done through the scaffold technology that is prevalent in KF.

![Figure 1. Margerison–McCann Team Management Wheel (1998).](image-url)
KF has the tools necessary in providing scaffolding in the form of scripts and can easily capture learners' discourse which is essential in coding their interactions (Scardamalia & Bereiter, 2003) and among the many tools available, KF has been proven to be a very reliable program in use among many researchers (Scardamalia & Bereiter, 1996, 1999, 2003). These two criteria are essential in the choice of KF as the CSCL tool.

The scaffolds in this study were customized to ensure that two groups – epistemic and social – were given the right type of support to allow for meaningful discourse. Figure 2 shows how phrases or questions used for providing support through the use of collaboration scripts are viewed by the participants. Table 1 shows the flow of the design of the learning environment in this study.

6. Evaluating intersubjectivity in the learning environment

Transcripts of interactions were segmented and coded through the use of Quantitative Content Analysis (QCA) devised by Chi (1997). The unit of analysis is defined as the function that an intentional utterance served in the problem-solving process. Utterances were segmented into one or more interaction units and coded into categories using the Functional Category System (FCS) developed by Poole and Holmes (1995).

Two coders classified each communication act for all four triads and a consensus reached on each act. Both coders are postgraduate students from the educational field and were trained in using the Poole and Holmes’ FCS (1995) through coding exercises, where the coders were given sample utterances to analyze and reach agreement on standards. Each coder categorized each triad’s transcripts from KF and achieved a Cohen’s kappa coefficient of 0.82 indicating that there is a strong inter-rater reliability.

Figure 2. Posting of a new note with script support.
The total number of communication acts in each FCS category (Table 2) was summed up for each triad for each problem they solved, indicating the script type used for each.

The communication acts must be analyzed to find out if there are any coherent patterns of communication between the participants. According to Jonassen and Kwon’s (2001) study, the communication acts during the problem-solving process can be further analyzed through the following sequence of activities developed by Poole and Holmes (1995):

1. **Transform communication acts into eight distinct phases.** Each utterance was transformed into one of the eight problem-solving phases based on the matrix in Table 3. Each triad’s problem-solving process was represented by distinct phases.

2. **Identify phase sequence.** The sequence of phases was identified and divided into separate segments or stretch of phases. A segment is identified when three distinct phases in a row are observed. This is short enough to identify interaction shifts in a triad but also long enough to show coherence in a triad’s problem-solving activity (Jonassen and Kwon, 2001).

For example, if the interaction phases are coded as PA, PA, CD, CD, CD, OO, PA, SD, SD, SD, SC, NT, NT, NT, the first segment of coherent phases starts with the third CD as it has three consecutive phases with the same coded value. The second segment begins with OO, followed by one phase of similar coded value, SD. The interaction phases are represented as PA, PA, CD, CD, CD/OO, PA, SD, SD, SD/SC, NT, NT, NT. This means that there are three interaction sequences of criteria development, solution development, and non-task. The frequency and sequence of interaction phases were investigated and related to the effects of script type in each problem-solving triad.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction of problem-solving environment in Knowledge Forum™</td>
</tr>
<tr>
<td>2</td>
<td>Construction of problem-solving scenario</td>
</tr>
<tr>
<td>3</td>
<td>Construction of scripts</td>
</tr>
<tr>
<td>4</td>
<td>Scripts assigned to students in epistemic and social script groups through scaffold support in Knowledge Forum™</td>
</tr>
<tr>
<td>5</td>
<td>Posting of problem scenario in triads’ view in Knowledge Forum™</td>
</tr>
</tbody>
</table>

Table 1. Flow of design of learning environment.
Table 2. Functional category system (Poole & Holmes, 1995).

1. **Problem definition**  
   1a. Problem analysis: Statements that define or state the causes behind a problem  
   E.g. ‘From what I understand, we are supposed to propose solutions to the environmental problems’  
   1b. Problem critique: Statements that evaluate problem analysis statements (may be assigned a positive [+] or negative [−] valence)  
   E.g. ‘I think your ideas can be used to help us with coming up a skeleton of the solutions’

2. **Orientation**  
   2a. Orientation: Statements that attempt to orient or guide the group’s process  
   2b. Process reflection: Statements that reflect on or evaluate the group’s process or progress  
   E.g. ‘I think we are on track with this idea’

3. **Solution development**  
   3a. Solution analysis: Statements that concern criteria for decision-making or general parameters for solutions  
   3b. Solution suggestions: Suggestions of alternatives  
   3c. Solution elaboration: Statements that provide detail or elaborate on a previously stated alternative. They are neutral in character and provide ideas or further information about alternatives  
   3d. Solution evaluation: Statements that evaluate alternatives and give reasons, explicit or implicit, for the evaluations. They may be assigned a positive [+] or negative [−] valence  
   3e. Solution confirmation: Statements that state the decision in its final form or ask for final group confirmation of the decision. They may be assigned a positive [+] valence if they argue for confirmation, or neutral (/) valance if they merely ask for confirmation. Negative responses to 3e are coded 3d−  
   E.g. ‘I think we should put up headings for our solution so that it addresses the different parts we are supposed to prepare’

4. **Non-task**: Statements that do not have anything to do with the decision task. They include off-topic jokes and tangents  
   E.g. ‘Ok then we are done. Have a great weekend.’

5. **Simple agreement**  
   E.g. ‘The idea sounds good for me’

6. **Simple disagreement**  
   E.g. ‘I think what you are suggesting is not a good idea’

Table 3. Eight phases and their indicators (Poole and Holmes, 1995).

<table>
<thead>
<tr>
<th>Symbol (phase)</th>
<th>Definition</th>
<th>Phasic indicators (from FCS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>Problem analysis</td>
<td>1a, 1b+</td>
</tr>
<tr>
<td>PC</td>
<td>Problem critique</td>
<td>1b−</td>
</tr>
<tr>
<td>OD</td>
<td>Orientation</td>
<td>2a, 2b</td>
</tr>
<tr>
<td>CD</td>
<td>Criteria development</td>
<td>3a</td>
</tr>
<tr>
<td>SD</td>
<td>Solution development</td>
<td>3b, 3c</td>
</tr>
<tr>
<td>SA</td>
<td>Solution approval</td>
<td>3d+, 3d, 3e+, 3e, 5</td>
</tr>
<tr>
<td>SC</td>
<td>Solution critique</td>
<td>3d−, 6</td>
</tr>
<tr>
<td>NT</td>
<td>Non-task</td>
<td>4</td>
</tr>
</tbody>
</table>

The problem-solving performance of each triad was operationalized as the quality of the solutions produced by the group. Four aspects of the triads’ problem-solving activity were taken into consideration, namely problem identification,
developing a plan(s) to solve the problem, evaluating the solution, and communicating results. Part of the holistic rubric is developed by John Hopkins University and based on the four problem-solving steps in ill-structured problems described by Jonassen (1997) – identifying problems, discussing problems, identifying solutions, and discussing solutions.

The accomplishment for each aspect was rated on a scale of 1–4 using a holistic rubric designed for this study. Two postgraduate students marked the solutions presented in the transcripts and achieved an inter-rater Cohen’s kappa coefficient of 0.78. A maximum of 16 points can be scored on the solutions proposed.

An open-ended questionnaire was also administered to find out how participants felt about the learning environment based on the conditions provided for each script type and also to elicit perceptions about the efficacy of the scripts provided in helping them solve the problem given.

7. Evaluation results
7.1. Patterns of interactions

The understanding of the processes of problem solving found in the social and epistemic groups will provide the underpinnings on the resulting patterns of interactions between members. The categories of problem-solving processes are Problem Definition (PD), Orientation (OO), Solution Development (SOLD), Non-task (NT), Simple Agreement (SA), and Simple Disagreement (SD) (Table 2).

The total messages logged in KF for the social groups ($M = 77$, $SD = 2.74$) exceeded the total number of messages for both epistemic groups ($M = 39$, $SD = 6.24$). The total messages in social group 2 were slightly higher than the total messages in social group 1 as shown in Table 4.

As shown in Table 5, participants from the social groups ($M = 59.5$, $SD = 0.71$) had more interactions on solution development (SOLD) compared to Epistemic

<table>
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<th>Table 4. Total messages of triads.</th>
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<tr>
<td></td>
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<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Social group 1</td>
</tr>
<tr>
<td>Social group 2</td>
</tr>
<tr>
<td>Epistemic group 1</td>
</tr>
<tr>
<td>Epistemic group 2</td>
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</tbody>
</table>

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<tr>
<th>Table 5. Participants’ problem-solving interactions.</th>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Social scripts</strong></td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>PD</td>
</tr>
<tr>
<td>OO</td>
</tr>
<tr>
<td>SOLD</td>
</tr>
<tr>
<td>NT</td>
</tr>
<tr>
<td>SA</td>
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<tr>
<td>SD</td>
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groups ($M = 18.5$, $SD = 3.53$) and there was a very large effect size ($ES = 16.10$) based on the calculation of Cohen’s $d$ (Cohen, 1998). Participants from the social groups ($M = 9.5$, $SD = 0.71$) also tended to agree (SA) more with their members’ ideas and solutions than epistemic groups ($M = 3.5$, $SD = 0.71$) generating a large effect size ($ES = 8.45$). Barron (2003) found that groups were more successful when they were more receptive to ideas discussed or accepted them while less successful groups tended to ignore or rejected proposals.

From Table 5, in terms of the amount of interactions in other categories – Orientation (OO), Problem Development (PD), Non-Task (NT), and Simple Disagreement (SD) – both groups did not differ much.

The results indicate that social groups ($M = 26.83$) had more interactions in typical problem-solving processes of problem development (PD), orientation (OO), and solution development (SOLD) (Jonassen & Kwon, 2001) than epistemic groups ($M = 12$).

The communication acts exhibited by the participants shown in Table 5 were coded further into eight distinct phases based on Pooles and Holmes’ system (1995). A problem-solving sequence is defined as a series of phasic periods of problem definition (problem analysis and problem critique), orientation, and solution development (including solution critique) (Jonassen & Kwon, 2001).

Phasic periods, defined as at least three phases in a row, are far less common in epistemic groups than in social groups. Epistemic group 1 went through a problem-solving sequence once during the interactions but each phase in this sequence lasted only two interactions in a row. Epistemic group 2 rarely had two interaction problem solving runs yet alone go through three problem-solving sequence runs as observed in Table 4. Phasic periods in Table 6 are underlined while problem-solving sequences occur when interactions follow the PA-PC-DD-SD-SA-SC sequence, thus depicting a cycle of problem solving.

However, the interactions between subjects showed that the interactions followed a problem-solving process of problem definition, orientation, and solution development at least twice, if we ignore the earlier convention of having three consecutive runs as a phasic period.

Social groups had more interactions with three consecutive runs and were found to have a reiterative problem-solving sequence where the groups’ interactions repeated the group problem-solving processes repeatedly (Table 7). There were a lot of repetitions of solution development and solution critique in the two social groups as opposed to the interactions in the epistemic groups (phasic periods are underlined).

Table 6. Epistemic group problem-solving sequences.

<table>
<thead>
<tr>
<th>Problem-solving sequences</th>
<th>EG 1</th>
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Interactions in epistemic and social groups went through the problem-solving sequence at least twice but the duration spent on one phase was longer in the social groups leading to the belief that social scripts enabled participants to contribute in a sustained and joint effort.

Another important finding was that despite the greater number of interactions in social groups, the orientation phase (OO) accounted for a larger percentage of interactions in epistemic (23%) than social groups (14.3%). This suggests that the use of social scripts enabled participants to focus more on essential problem-solving stages than trying to orientate ideas or tasks to achieve a common understanding that is more prominent in epistemic groups.

The iterative problem-solving process observed in social groups suggests that the group members checked their group processes and their own thinking (Jonassen & Kwon, 2001). The social scripts appear to support a more focused, on task, and purposive communication (Jonassen & Kwon, 2001). This suggests that the scripts may have enhanced students' reflection and helped them focus on the communication process.

### 7.2. Episodic illustrations

This section is used to form a reasonable explanation on the patterns of communications between the groups that emerged from the problem-solving activity. A few episodes are provided as illustrations to gain insight into the patterns of interactions observed. The utterances shown are actual notes taken from students' postings from the Knowledge Forum™.

There were very few critiques made on the problem. Episode 1 (Figure 3) shows one member of EG2 critiquing the problem. The problem critique made by EG2 was important but not built on by the other members of the group. The group seemed to have missed a point of coordination on an important issue but why this happened was not clear.

Epistemic groups were given a set of guidelines on how to construct knowledge and based on the transcript in Episode 1 (Figure 3), it appears to the group that the

<table>
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<tr>
<th>Problem-solving sequences</th>
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<tr>
<td><strong>SG 1</strong></td>
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</table>

Note: PA, problem analysis; PC, problem critique; OO, orientation; CD, criteria development; SD, solution development; SA, solution approval; SC, solution critique; NT, non-task.
The critique made by EE2 does not constitute important knowledge. The reason why this occurred could be due to the nature of the scripts where structuring interactions takes a back seat and the knowledge put forth might not meet the knowledge goals of the other members.

The interactions as evidenced in Episode 1 differed considerably from those among members in SG1. As shown in Episode 2 (Figure 4), the result of a problem critique started a chain of discussions on the topic “buses should be used instead of taxis.”

Further discussions allowed explanations to be made on their comments and led to them looking at not only which transport should be used but also how to attract parents into using them – by reducing public transport fares.

The results from Table 3 showed that EG groups spent a greater proportion of their interactions on the orientation phase (OO) than the SG groups. One emergent behavior among SG groups is that they spent less time trying to converge because each member had a specific role and were given scripts specially tagged to their roles.

An examination of their interactions showed that the specific role they played allowed them to converge their ideas better and prevented their discussions from going off track. Episode 3 (Figure 5) shows how S1 from SG1 helped to organize her group members’ ideas. Playing the role of an organizer, her members were clear in how the discussions should progress.

From Episode 3 (Figure 5), it is clear that at that juncture, the organizer has decided after their previous discussions that they should now discuss about the issue of public transport. This allows the group to focus on one issue at a time, judging from the other members’ compliance by the idea put forth by S1. What is interesting here is that from the orientation phase by S1 at the beginning of the excerpt, there was no more attempt at orientation as the group was right on track. The last entry in
Figure 4. (Episode 2). Problem critique leads to analysis and developments to solutions.

Figure 5. (Episode 3). Organizer orientates the ideas.
this episode showed how S3 attempted to bring the group back into focus on a critical issue – reducing car usage and volume of cars on the road. The member’s role as an adviser in the triad made it crucial for her to look at the solutions put forth and offer constructive criticism.

Episode 4 (Figure 6) shows how members in EG1 try to orientate their discussions. There is greater effort in trying to get members to converge. From the transcripts, it is clear that the lack of convergence had led to some frustration by E3 toward the end of this episode. A clarification by E3 led not to further development in the next comment by E1 but to another act of orientation in trying to get members to discuss ways of preventing pollution. These ways had in fact been discussed by E3 in the first entry of the episode.

Episode 5 (Figure 7) details how criteria development is sustained by members of SG2. In their transcripts, criteria development occurred after many interactions between the group members. Members returned to criteria development after a few discussions on solutions. There was an attempt to sustain this phase of their interactions, and the act of returning to developing criteria again showed that in SG groups, their problem-solving sequence was more phasic where interactions on a similar stage of problem solving were more sustained. When interactions are more sustained, each member will be able to contribute more in terms of quality and quantity to the group ideas and allow time for changes in epistemic beliefs (Scardamalia, 2002; Wilson, Timmel, & Miller, 2004). The first criteria development contribution was about the need to make public transport more accessible. As the group progressed, the next criterion discussed is the use of labels. SS3 wanted the group to choose between using metallic or sicker type labels. This got the group to discuss the environmental impact the labels used might have. Of the four phases
coded as criteria development in this episode, the adviser, SS3, contributed to half of the notes.

In terms of patterns of interactions, phasic periods were far more common in social than epistemic groups. There were also far more frequent problem-solving sequences in social than epistemic groups.

One more important finding is that epistemic groups spent more effort in orienting interactions between participants indicating that social groups were far more focused on essential problem-solving stages than epistemic groups.

7.3. Group problem-solving performance
Social groups scored a mean of 13.5 out of a total of 16 points for the solutions they proposed in KF (Table 8) which equates to a percentage score of 84.38%. Epistemic
groups scored a mean of 12 which equates to a percentage score of 75% in their problem-solving proficiency. Social groups outperformed the epistemic groups by 12.5%. The areas these students scored more in were Problem Identification and Evaluating the Solution.

Social group discussions were far more phasic than epistemic groups, where students underwent periods of problem definition and solution development. Social groups had a more iterative problem-solving sequence, and solution development and critiquing problem-solving stages were repeated more widely. The duration spent on one phase was longer in social groups than epistemic groups as well.

The findings are similar to Roberts and Nason (2003) that a more balanced team produces better knowledge building. This balance was achieved due to assigned social roles in which scripts were provided to scaffold discussions. There was perceptibly less quality to the interactions being discussed in epistemic groups due to the ill-defined roles, which though diverse did not help to produce quality of interactions that contributed to the problem-solving activity as a group (Roberts and Nason, 2004).

### 8. Conclusions

The time spent on reorientating discussions was detrimental to the problem-solving performance of the teams (Barron, 2000), while the manner in which the collaboration scripts have built in social roles have enabled participants to orientate their discussions appropriately as evidenced from the episodes presented.

Social group participants also had more elaborated discussions and higher levels of intersubjectivity. This echoed Barron’s (2003) finding when the researcher found that successful groups had higher quality of interactions.

As social group participants jointly progress through the problem space, there is greater interdependency and this resulted in more collaboration which influences students’ joint problem solving. This suggests that the structures in place in the social groups are better than in epistemic groups and enable students’ group problem-solving performance (Wilson et al., 2004).

Social groups reiterated the problem-solving process of problem definition, orientation, and solution development, while there is a more linear sequence of interactions in the epistemic groups and this result is consistent with what Jonassen and Kwon (2001) found when groups communicated with computer-mediated communication. There is some evidence of iteration in epistemic groups but this type of pattern is not as sustained as those in social groups especially in the cyclical sequences in criteria development. Participants’ pattern of communications better reflected the problem-solving nature of the task. The type of scripts given played a role in encouraging the process of solving problems.

Table 8. Problem-solving performance of groups.

<table>
<thead>
<tr>
<th></th>
<th>Social scripts</th>
<th>Epistemic scripts</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Groups’ mean</td>
</tr>
<tr>
<td>Group 1</td>
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<td>13.5</td>
</tr>
<tr>
<td>Group 2</td>
<td>13</td>
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Based on an open-ended questionnaire administered at the end of the study, participants in epistemic groups found that the scripts helped them focus better on structuring their thinking and that not being given a specific role did not affect their problem-solving activity as they had already been given scripts to facilitate their discussions. Social groups felt that it was easier to communicate among their members as they performed specific roles with predefined scaffolds to communicate. However, they also felt restricted in the problem-solving process as they had to stick to one way of contributing. The results do show, however, that when the members perform a role they are accustomed or suited to, they perform much better as a group in solving problems.

One of the limitations of this study is its sample size. The sample consisted of 12 higher ability students. Hence, results cannot be generalized to a larger population or to students with different abilities and grade levels. Efforts to ensure each group had similarly matched students in terms of their ability were made but no pretesting of students’ ability in solving ill-structured problems was made.

The lack of a control group exposes the design of this study to threats of internal validity such as maturity and instrumentation. Randomization was done to remove biases when it comes to selection of comparison groups but because the sample size was small, a statistical phenomenon called Simpson Paradox might occur.

Regardless of its limitations, our results show that the use of scripts and especially the use of social scripts is an effective form of help for students to develop as better problem solvers. The use of social scripts had naturally shaped the interaction patterns toward the ideal problem-solving processes without further intervention from the facilitator. This finding is of great importance to teachers who may have difficulty in getting students to be participative in group interactions. The use of social scripts can be applied through face-to-face interactions in group work as well and not just restricted to CSCL environments.

Social scripting can be successfully incorporated into the design of interactive learning environments such as Knowledge Forum™ or other programs designed for computer-mediated communication (CMC). As shown from the study, equipping participants with social roles and scripts will lead to greater intersubjectivity and ultimately improve upon the individual knowledge and skills of a participant.

9. Recommendations for future research

Some of the recommendations could include giving more problems and monitoring students’ problem-solving behavior over a longer period of time. A test that measures students’ individual problem-solving ability could be administered and this can then be compared to their performance as a group. This would help to substantiate the idea of intersubjectivity. To be able to increase the generalizability of the results obtained, a greater number of subjects should be included. This would also help in performing inferential statistical analyses that can improve the validation of the results in this study.

Although the use of patterns of interactions was not extensive in current research, this study has shown the possibility of understanding how the use of this tool to study interactions between participants could provide us with richer understanding on the intersubjectivity. Future research on intersubjectivity should study how such similar tools are used so as to provide a greater and richer understanding on how individuals perform as a group unit.
Notes on contributors

Jay Mahardale is the Head of the Department of Science, Research and Curriculum Innovation at Admiralty Primary School. He has been championing research in schools especially in the field of problem-based learning, reflective thinking, and support structures for collaborative learning. He welcomes international collaborative learning opportunities for his students and teachers.

Dr. Chwee Beng Lee is an Assistant Professor at the National Institute of Education, Nanyang Technological University. Her research interests include using technologies for problem solving, studying learners’ conceptual change, and building powerful technology-rich environments for teaching and learning. She has published in a number of reputable journals and she is currently co-editing an academic book titled *Fostering conceptual change with technologies* which will be released in early 2012.

References


