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Learning Teamwork: Studies of Training in Software Development

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Introduction

Coordinating the activities of software system development teams is an important practical problem. Software system development is also an interesting domain to test theories of collaborative work and is paradigmatic of the type of work found in many organizations: the ad hoc project group (Kiesler, 1992). Ad hoc project groups are temporary groups set up to do a particular project. Ad hoc project groups may be composed of two to several hundred members. Membership is typically heterogeneous with members drawn from multiple other standing groups. Software development projects, e.g., require the participation of programmers, software engineers, application experts, researchers, requirements analysts, software testers, document writers, project managers, and customer support personnel, among others. Members may join and leave the project at different times, or move to different jobs on the same project. Despite the anarchy of participation and the unpredictability of the technical environment (Brooks, 1987; Curtis, Krasner, & Iscoe, 1988; Fox, 1982), projects have predictable stages (Davis, 1987).

We examine how different aspects of coordination and collaboration affect the performance of software development teams. We are particularly interesting in the role of training, and the relation among skill, learning, and performance. Our examination will take place in two contexts—undergraduate software development teams and corporate project groups. The students are Information and Decision Systems Majors at Carnegie Mellon University. Corporate teams are being solicited from various software development companies. The remainder of this paper discusses the data collection and preliminary results associated with the student teams.

The Information and Decision System Program

The student groups consist of college Juniors and Seniors majoring in Information and Decision Systems (IDS) at Carnegie Mellon University. This major combines social science courses with quantitative and professionally oriented courses in information and decision support systems (Wholey and Potash, 1993; Wholey, Potash and Carley, 1993). The course of study is more applied than computer science and more technical than business management. Students take a formal course in database design and another in decision support systems. Students also take two project courses, one as Juniors and another as Seniors. In these project courses they are required to build a working software system for a client. For the Juniors, this client is their TA (typically a student chosen from the Senior IDS majors). For the Seniors, this client is typically in the business community (or in the business office of the university). The students work in teams of 4 to 8 members; the teams' grades are determined by client and instructor evaluations (different team members may receive different grades). The Junior level course is the introductory course in the tools, methods, and theory of system analysis and design. This course is highly structured. The Senior level course is the capstone course in the major, in which students are expected to integrate all information systems, statistical, and organizational knowledge. This course is highly unstructured.

Throughout this major students are trained in the technical, people, and professional skills needed to design and build information systems. After their junior year many students get jobs in industry in the system development area for the summer. Senior project teams act quite professional, and clients often comment on the professionalism of the students. The teams being studied resemble the types of groups found in firms. We control for group size, resources available (such as a computer-network and the variety of powerful computers), and timing (starting date, milestone dates, and deadline for project completion).

Preliminary Results

We have been collecting data on these students for three years. Data collection methods include questionnaires, observation, grades, and time sheets. Questions are asked on commitment, conflict, communication, satisfaction, social network (dependencies and worked with), job, and fraction of time performing various tasks. We report preliminary results based on the first two years worth of data.

In setting up the groups we attempted to control group size and individual ability (see Table 1). In addition, all students are expected to put in a ceratin level of effort. Nevertheless, effort does vary across students and yet we see no relationship between effort and performance (see Table 1) (Wholey, Carley and Kiesler, 1991). We turned to the examination of the role of group structure in affecting performance. We examined the relationships worked with, depends on, and is depended on. The preliminary results suggest that group structure may affect performance. However, this affect may vary by the degree of training that the students receive.

Figures 1 (Juniors) and 2 (Seniors) contain composite views of the worked on and dependency relationships. A line with no arrows indicates a worked with relation. A line with one or more arrows indicates a dependency relation with the arrows indicating the direction of the dependency. As can be seen in Figure 1, Junior groups appear to fail because they fall apart. In low performing junior groups there are a large number of isolates who simply do not work with other group members. In contrast, Figure 2, Senior groups appear to fail because they get over coordinated.

Table 1: The Relationship of Group Size, Ability, and Effort to Training and Performance

Group	Size	Ability Mean-GPA	Effort (in Hours) Total	Mean	Min.	Max.
Training: Juniors						
Rank 1	5	2.08	662	132	71	220
Rank 2	5	2.75	783	157	96	222
Rank 3	5	2.81	446	89	69	109
Rank 4	4	3.07	525	131	93	169
Rank 5*	5	3.19	369	74	14	102
Rank 6*	4	2.80	463	116	54	208
Rank 7*	5	2.57	851	170	124	193
Rank 8*	5	2.45	776	155	134	189
Training: Seniors						
Rank 1	7	2.77	2373	339	103	638
Rank 2	7	2.69	1427	204	132	269
Rank 3	4	2.76	732	184	137	273
Rank 4	4	3.00	609	152	129	196
Rank 5	7	2.76	817	117	64	194
Rank 6*	5	2.53	1161	232	120	324
Rank 7*	7	2.86	1170	167	135	228

* - Unsuccessful Projects

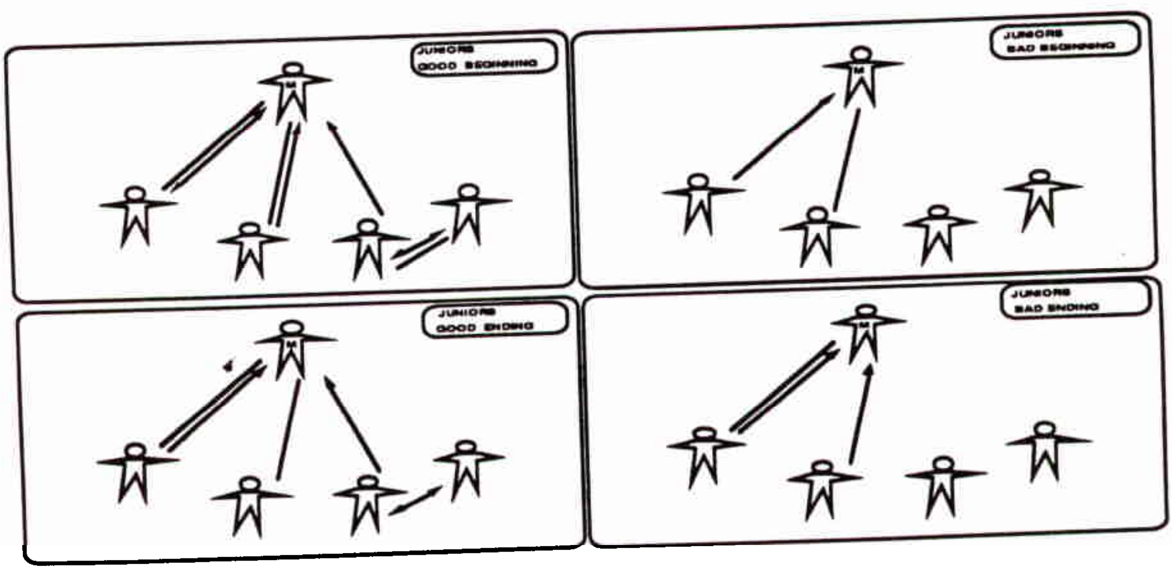

Figure 1. Social Networks for Juniors.

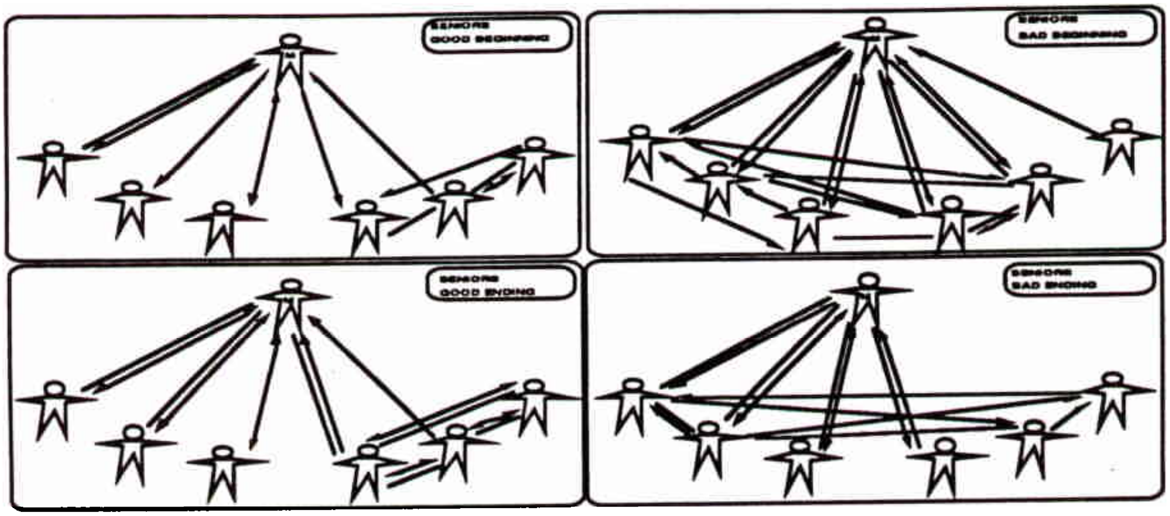

Figure 2. Social Networks for Seniors.

Between the time the students start their Junior year and end their senior year a great deal of learning is (hopefully) going on. Students learn, among other things, how to work with others in teams and how to design, analyze, and build information systems. We capture part of this learning by asking them two questions at various points in these years — "What is an information system?" and "What leads to information system success and failure?" The answers to these questions are coded using textual analysis tools for coding mental models (Carley and Palmquist, 1992; Carley, forthcoming). The coded models can be displayed as networks of concepts (see Figures 3 and 4).

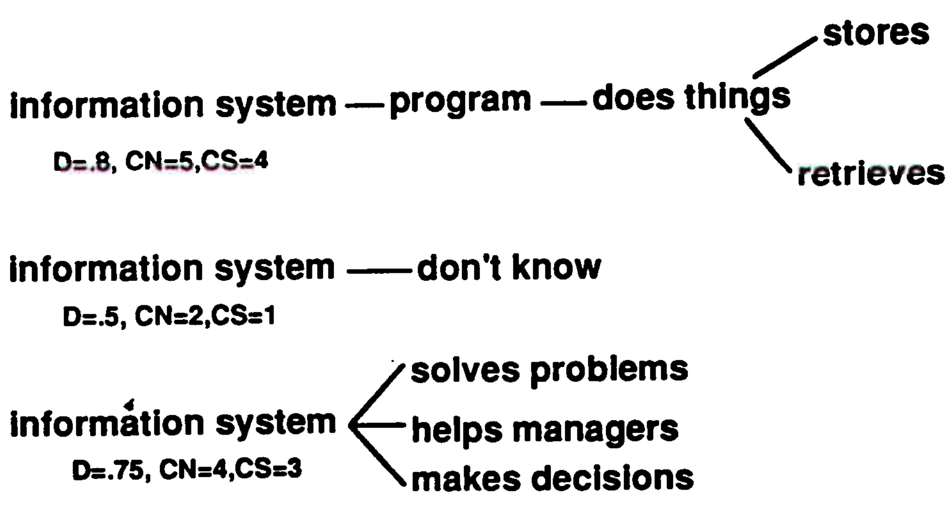

Figure 3. Illustrative Maps for Juniors.

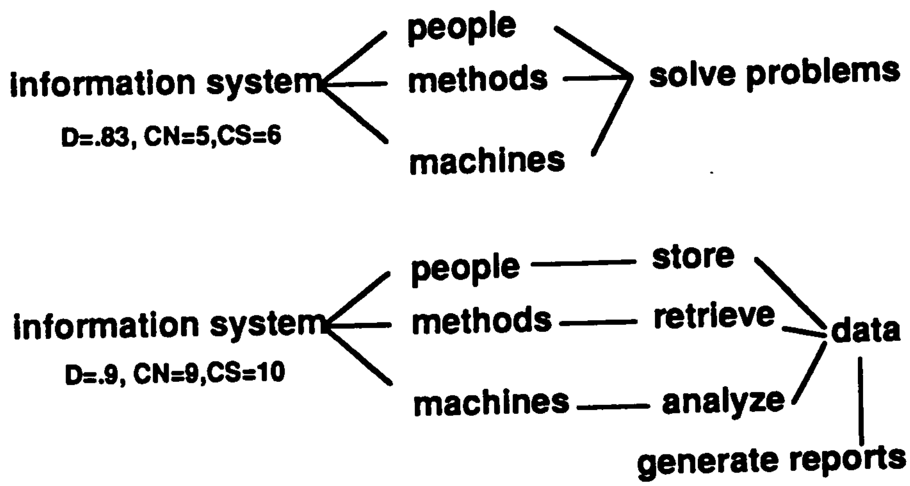

Figure 4. Illustrative Maps for Seniors.

Preliminary analysis indicates that there are differences in the Junior's and Senior's mental models with respect to these questions. We find that the Seniors maps are typically more elaborate (more concepts and more links between concepts). In addition, Juniors maps tend to focus more on rote book learning. This is particularly true in the question askinf for a definition of an information system. In this case, Seniors' answers tend to be similar to the "official definition" given in class. Seniors maps incorporate experience as well as book learning. We will be examining the relationship between the individual's position in the social network and their mental models. We will also be examining the relationship between group project performance and the content of the group member's mental models.

Various factors may account for the difference between Juniors and Seniors. The factor we examine most closely is experience and learning. Clearly there are learning differences as evinced by their mental models. Another, and very related factor, is self-selection. Both Juniors and Seniors are asked whom they wish to work with. Juniors, however, have not worked in an intensive group before and rarely know each other. Consequently, Juniors may be selecting into groups only on the basis of friendship; whereas Seniors may be selecting into groups on the basis of work experience. We will continue research on the relationship between self-selection and groupthink. We will also be examining questions such as: Are groups consisting of individuals who choose others on the basis of friendship more likely to end up with groupthink occurring only if the individuals are trained? Are groups consisting of individuals who choose others on the basis of each individual's ability to contribute to group performance less likely to exhibit groupthink?

In summary, we do not find that effort and skill per se are the primary determinants of project success. Rather we find that the structure of the group affects its performance. We also find that the effect of group structure depends on the level of training and what individuals have learned. Our goal is to develop a better understanding of organizational learning and the relationship between group structure and shared mental models. We intend to carry out this work both with further classroom studies and in the corporate environment.

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Project Publications

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