Group and Individual Factors that Influence Middle School Students' Sense-Making Discussions of Force/Motion

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This study investigated small-group discussions in an inquiry-based middle school science classroom. The purpose of the study was to determine the group and individual factors that provide support (or not) for students' sense-making discussions. To do this, two groups were videotaped during the Interactions and Motion unit from the Constructing Ideas in Physical Science curriculum. A six-component framework was used to identify and categorize instances of sense-making: predicting; clarifying facts; describing and explaining a phenomenon or experimental result; defining, describing, clarifying, and connecting scientific concepts, procedures, processes, and representations; testing knowledge compatibility; and making requests for any of the above. Analysis revealed that there were differences in sense-making discussion across both groups and individual students. Differences across groups are explained in terms of group obligations and expectations, collaboration, and leadership. Differences across students are explained in terms of learning and social goals, science interest, work preferences, and ability.

Rationale and Purpose

The National Research Council [1] recommends that science education should be grounded in collaborative, inquiry-based activity. Inherently, sense-making discussions are an important aspect of this activity.

While educators would love for group sense-making discussions to be commonplace and of high quality, this may not occur without support from the teacher and the school curriculum [2]. Ultimately, the idea is that educators will be able to create learning environments that are conducive to high quality sense-making discussions once they become more aware of the many factors affecting this special brand of discourse.

With this in mind, the goal of the present study is to answer the following question: Which individual and group factors have the most influence on middle school students' small-group sense-making discussions?

Participants and Data

I videotaped two four-person groups for five weeks as they went through the Force and Motion unit of the Constructing Ideas in Physical Science (CIPS) middle school curriculum. Group 1 consisted of Darla, Lacey, Grace, and Porter; Group 2 consisted of Arthur, Roxanne, Sabrina, and Jasper. (These names are pseudonyms.) As supplemental data, I collected each participant's worksheets, homework, and exams. I also recorded whole-class video and fieldnotes for each class period.

Theoretical Framework for Sense-Making Discussion

In their research on nonverbal comprehension activity, Hatano [3] and Hatano and Inagaki [4] have identified four components of nonverbal sense-making: seeking new information, generating inferences, searching for knowledge compatibility, and retrieving prior knowledge.

After careful analysis of the small-group discussions in this study, I modified Hatano and

Inagaki's four components and formulated my own six-component framework for sense-making discussion (SMD). The six components of my framework are as follows.

1. Predicting a phenomenon or experimental outcome. An instance of this component of SMD contains a predicted phenomenon or experimental outcome, and may also include supportive reasoning.

2. Clarifying the facts of a phenomenon or experimental result. This component involves those instances of SMD where students clarify the facts of a phenomenon or experimental result as they remember or reconstruct the phenomenon/result.

3. Describing and explaining a phenomenon or experimental result. This component of SMD involves describing physical phenomena or experimental results in new terms (in terms of scientific concepts or small scale phenomena, for example), and determining the underlying explanation for phenomena or experimental results.

4. Defining, describing, clarifying, and connecting scientific concepts, procedures, processes, and representations. An instance of this component of SMD contains a subject (that which is being explained) and an idea statement, and may also include supportive reasoning. The idea statement is an inference or piece of retrieved knowledge.

5. Testing knowledge compatibility. Tests for knowledge compatibility are instances of SMD where students explore the validity of scientific ideas and explanations or explore the consistency of scientific results and phenomena.

6. Making a request for any of the above. This component is similar to Hatano's nonverbal "searching for additional information", the only difference being that nonverbal searches draw upon one's own prior knowledge and experience, whereas verbal searches draw upon the knowledge and experience of other people.

Procedure

Quantitative. After documenting instances of sense-making according to the six-component scheme listed above, I determined the numerical distribution of these instances for each group and for each individual student. I also calculated the average percentage of time dedicated to sense-making discussion for each group.

Qualitative. Once I identified differences in SMD between groups and individual students, I identified a set of factors that helped to explain these differences. This identification of factors resulted from four analytical passes through the data.

Results: Sense-Making Discussion

Overall, combining the results for both groups, there were 47 instances of predicting, 173 instances of clarifying facts, 122 instances of describing and explaining a phenomenon/result, 113 instances of defining, describing, clarifying, and connecting scientific concepts, procedures, processes, and representations, 71 instances of testing for knowledge compatibility, and 141 requests for any of the above.

The distribution of actual instances of sense-making (actual clarifications, underlying explanations, etc.) did not differ across groups, $\chi^2(4) = 7.4$, $\mathbf{p} > .05$; also, the total distribution of requests for sense-making (requests for predictions, clarifications, etc.) did not differ across groups, $\chi^2(4) = 7.9$, $\mathbf{p} > .05$. However, an important result is that one group spent 26% of their time on SMD, while the other group spent only 16% of their time on SMD, $\chi^2(1) = 6.4$, $\mathbf{p} < .05$.

Comparing the sense-making instances of individual students, the amount and type of sense-making statements per student varied quite a bit in both groups.

Table 1. Instances of verbal sense-making, by student.

	Student	CL	P	UE	DDC	TC	R	Total
Group 1	Darla	21	6	16	25	14	27	109
	Grace	22	8	12	10	4	15	71
	Lacey	23	12	12	15	14	26	102
	Porter	1	1	7	3	1	1	14
Group 2	Arthur	48	8	29	27	13	16	141
	Roxanne	26	5	28	17	17	14	107
	Jasper	0	0	0	0	0	0	0
	Sabrina	32	7	18	16	8	42	123

Abbreviations: **CL** = **Cl**arifying, **P** = **P**redicting, **UE** = **U**nderlying **E**xplanation, **DDC** = **D**efining, **D**escribing, **C**onnecting; **TC** = **T**esting **C**ompatibility; **R** = **R**equests.

Results: Factors Influencing Sense-Making Discussion

Group factors.

Factors that contributed to the differences between Groups 1 and 2 in the percentage of time spent on SMD were that:

Group 1 felt obligated to stay on-task, complete the activities as intended, and fill in all of the appropriate worksheet blanks. In general, Group 2 did not feel these same obligations.

Group 1 was more concerned than Group 2 about understanding the underlying concepts of the CIPS curriculum.

The leaders of Group 1 (Darla and Lacey) encouraged the group to cooperate, complete the activities as intended, and evaluate and understand the concepts underlying the CIPS curriculum. The leader of Group 2 (Roxanne) was almost always looking for an excuse to go off-task, and frequently succeeded in drawing other group members off-task.

In Group 2, one of the main contributors to sense-making discussion (Sabrina) maintained an expectation that verbal and written explanations should be simple and brief. The main contributors in Group 1 did not share this same expectation.

In Group 2, there was friction between the two main contributors of sense-making statements. There was no friction observed between the main contributors in Group 1.

Individual factors.

The factors that explained differences between the students' sense-making distributions are as follows:

Darla, one of the leaders of Group 1, had a strong learning goal, and wouldn't settle for an idea that was problematic or confusing. Also, Darla appeared to have a general interest in science. Darla's constant demand for clarification and explanation -- coupled with her propensity for peer tutoring -- is reflected in the large number of clarifications, explanations, and descriptions in her distribution of sense-making instances.

Lacey was the other leader of Group 1. Lacey was fairly conscientious about staying on-task and learning the CIPS content. However, Darla usually served as the ultimate authority and provider of guidance for Group 1's SMD, which is why Lacey had fewer instances of defining, describing, and connecting than Darla.

Grace's participation in Group 1's sense-making discussions is not accurately reflected in her distribution of sense-making instances, in which Grace's instances are nearly equal in number and

type to Darla's and Lacey's instances. In fact, either Darla or Lacey typically drove the group's sense-making discussions, while Grace's sense-making statements were limited to brief side comments. Grace seemed not to be at a sufficient intellectual level and speed to contribute substantially to Group 1's SMD.

Porter's extremely small number of sense-making instances was due to the fact that he preferred to work alone. When he tried to engage in SMD with his group, his past history of working alone, coupled with his lack of communication and interpersonal skills, interfered with his attempts at SMD.

Roxanne was the leader of Group 2. Roxanne's sense-making statements were less frequent and less elaborate than the sense-making statements made by either Arthur or Sabrina. The reason that Roxanne had as many sense-making instances as she did is that there were a few isolated incidents where Roxanne engaged in extraordinary amounts of sense-making. Although she engaged in SMD, Roxanne would, in general, constantly look for an excuse to go off-task, and often succeeded in drawing other group members off-task.

Sabrina made more requests for sense-making than any other student. This was because she was the member of Group 2 who felt most obligated to complete each activity's worksheets, keep the group on-task, and understand the activities' underlying concepts. Sabrina and Arthur were the two main contributors to Group 2's SMD.

Like Darla, Arthur was a student with a fairly high interest in science. Generally, Arthur's role in Group 2's SMD was not the initiator or director of sense-making, so much as a source of knowledge. Arthur's role is reflected in his distribution of sense-making instances; he had more instances of verbal sense-making than any other member of his group.

During the short time that Jasper participated in the study (he was removed from Group 2 on the request of the author), Jasper didn't engage in a single instance of verbal sense-making. Jasper appeared to have little interest in understanding the principles of science or completing each day's activity; most of his time was spent disruptively off-task with Roxanne.

Conclusion

Many individual and group factors influenced the SMD in this study: group leadership, degree of group collaboration, student beliefs about the nature of scientific explanations, learning and social goals, work preference, the obligation to complete the activities as intended, and cognitive ability.

Although there is not sufficient space here to describe the instructional implications of these factors, a few things are clear. To support SMD in middle school classrooms to the greatest extent possible, the instructor cannot ignore such issues as motivation, curricular and teacher support for group collaboration, students' perceptions of the nature of scientific explanations, and the placement of low-ability students in groups.

References

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