When Do Small Groups Work during Inquiry-Based Science Laboratory Activities?

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This qualitative study examines affective and micro-social dynamics of small group work that foster or hinder science learning in a ninth grade environmental science class (N=15).
Pros of Collaborative Small Group Learning in Inquiry-Based Science

- Reduce teacher-centeredness and reliance on prepackaged material (NRC, 1996)
- Maximize student autonomy (NRC, 1996)
- Collaboration within a group
  - leads to shared goals, values, and student understanding
  - develops collective and individual responsibility, stronger engagement, interest and motivation (Bennett, Hogarth, Lubben, Campbell, & Robinson, 2010)
- Well-structured and managed group work allows students
  - to develop communication skills by defending their work based on evidence,
  - to learn from other groups,
  - to engage in problem solving that mirrors future work and life experiences.
Challenges of Collaborative Small Group Learning in Inquiry-Based Science

- Teachers lack
  - skills designing inquiry projects properly (Quintana, Reiser, Davis, et al., 2004)
  - experience implementing inquiry activities (Smerdon, Burkam, & Lee, 1999; Luft, 2001)
  - confidence in monitoring small group discussions (Bennett, Hogarth, Lubben, Campbell, & Robinson, 2010)
  - of motivation and peer and administrative support for the implementation (Wee, Shepardson, Fast, & Harbor, 2007)

- Intellectually challenging for students (Blumenfeld, Soloway, Marx, et al., 1991; Krajcik, Blumenfeld, Marx, et al., 1998) including difficulties in designing and learning from authentic inquiry investigations (Fortus, Dershimer, Krajcik, et al., 2004)
If science teachers understood and could monitor small group dynamics that are central to most inquiry-based activities, we believe that inquiry would be much more consistently used in U.S. science teaching than is currently the case (Roehrig & Luft, 2004).
Challenges of small groups addressed by focusing on what group members must do:

• Groups need to construct “joint problem-solving space” (Teasley & Roschelle, 1993) involves coming to a collective cognitive understanding of the task.

• Barron (2003) proposes a “dual-space” model of collaboration in which groups must attend to and develop
  • the “content space” - the problem to be solved and
  • the “relational space” - challenges based on social interactions within the group.
We posit that the affective domain constitutes a significant theoretical “missing piece” in small group research.

Our research investigates how the demands of inquiry necessitate collective construction of a “triple problem-solving space” in which content, social/relational, and affective components are developed on a moment-by-moment basis.
Research Questions

Students bring various kinds of individual resources to the demands of collaborative inquiry work, such as prior knowledge and skills, social competencies, and situational interest. Present study focuses on examining the collective construction of the group’s triple problem-solving space addressing the following research question:

How does the group as a social unit construct the triple problem-solving space when faced with an inquiry task?
Hypothesis

The three aspects of the collectively constructed problem solving space – the content, social/relational and affective – overlap and influence the development of each other. If groups fail to manage any of the three collective spaces, group collaboration will be unsuccessful and learning is likely to be minimal.
Methodology

Participants:
15 ninth graders and their science teacher

Context:
Environmental science class in a rural high school in Western Massachusetts during a unit on enzymes
Data collection

• Videotaped group observations (GO) during series of four inquiry-based small group tasks
  • Two randomly chosen groups videotaped - hand-held camera
  • All other groups (n=4) videotaped - i-Pads on lab table
• Focus group interviews (FGI; after last observation) with three randomly selected student groups focusing on how students’ individual affective, social and cognitive resources factored into their collective work as a group.
• Follow-up interview with teacher (TI) focusing on group learning behavior exhibited during the task.
• Field notes and artifacts
Data Analysis

- Classroom observations and interviews fully transcribed
- Three dimensions of triple problem-solving space assessed separately
- Two of the authors coded independently for data evincing different categories including frequency of occurrence, then compared their coding and resolved any discrepancies through discussion with first author.
- Coding based on predetermined categories modified from previous studies
Data Analysis - Affective space

- **Psychological Safety** (Edmondson, 1999) shared beliefs about how safe group is for interpersonal risk taking (e.g., “making mistakes is allowed”, “safe to take a risk”, or “asking group members for help”).
- **Perceptions of Competence** (Deci & Ryan, 1985, 1991, 2000) – master challenges with the task as a group;
- **Interest** inferred based on various indicators (Renninger & Su, 2011):
  - depth of activity
  - frequency of activity
  - voluntary activity or forced by e.g., question within task, teacher, or peers
  - ability doing activity independently
  - actively seeking feedback, e.g., asking 'why' and 'how' questions
Data Analysis

Relational space:
• **Social Cohesion categories** (Sargent & Sue-Chang, 2001), e.g., being friends with group members, getting along with group members
• **Social Loafing and Positive Group Interaction categories** (Linnenbrink-Garcia et al., 2011), e.g., distribution of work; solving questions or task challenges; group enjoys working together, group members listen to each other

Cognitive Space:
• **Group Interaction categories** (Visschers-Pleijers et al., 2005), e.g., exploratory questions, cumulative reasoning, and handling conflict
Results

**Group 1: Alexis, Kayla and Emma** – self selected group of three girls who point out that they are close friends

**Group 2: Dennis, Sam and Jason** – self selected group of three boys who also stress that they are close friends
Alexis, Kayla, and Emma

**Relational**

Report being “friends” during interview, yet show low social cohesion during small group work

**Content**

Alexis and Kayla struggle with content more than Emma, yet Emma does not put forth her knowledge
Alexis, Kayla, and Emma

Affective

• Low perceptions of abilities to do science and about their intelligence in general ("I am not smart") (perceptions of competence)

• Group not a safe place to put forward ideas or take the lead (psychological safety)
Alexis, Kayla, and Emma

Low interest in inquiry tasks – interest not triggered:

• do not ask how/why questions
• are stuck in procedures (how to follow the guidelines)
• work only with support from teacher (forced by and dependent of teacher)
• don't take initiative
Alexis, Kayla, and Emma
Alexis, Kayla, and Emma
Dennis, Sam, and Jason

Relational
- Show that they enjoy working together
- Listen to each other
- Cue each other to stay on task
- Members play different roles in the group
- Little social loafing.

Content
- Plenty of cumulative reasoning where all group members contribute to solve a problem
- Explain things to each other, but don’t always take up the initial ideas
- Dennis seen as the intellectual leader.
Dennis, Sam, and Jason

**High interest** – triggered and maintained during inquiry tasks:

- Group starts tasks and stays on-tasks with very little input from teacher.
- Demonstrate endurance to struggle through challenging portions of lab without seeking outside help.
- Small percentage of off-task behavior (social plans, playing video games together); only during procedural work; short-lived with someone in the group redirecting to get back on task.
- Task directions or procedures drive work; participants saying things like, “let’s follow the procedure first” or “Ok, next question”; pause to think.
Dennis, Sam, and Jason

Affective

• Safe space to ask questions, to think aloud, or to ask for help (psychological safety).

• Group gets started and stays on-task with very little input from the teacher. Dennis or task itself cues.

• Group seems to believe they can complete the tasks and is willing to struggle through on their own (perception of competence).

• Members don’t perceive themselves or each other all to be intellectually equal, but seem comfortable with their roles and support each other through explanation (perception of competence).
Dennis, Sam, and Jason
Conclusion

Results suggest:

• Three spaces of collectively constructed problem solving space – content, social/relational, and affective – overlap and influence development of each other

• When spaces are positively developed and maintained – as in the case of Dennis, Sam and Jason – group work successful and learning likely to take place within group

• If these spaces are not developed and maintained – as in the case of Alexis, Kayla and Emma – then group work is not successful and if learning takes place than outside of the group
Thank You!

QUESTIONS - COMMENTS?