Journal of Classroom Interaction, ISSN 0749-4025. © 2014, Vol 49.2, pages 4-10

Comparing Classroom Interactive Behaviors of Science and Non-Science Pre-Service Teachers

Daniel Bergman
Jason Morphew
Witchita State University, USA

ABSTRACT

This study compared classroom interactive behaviors of science pre-service teachers and pre-service teachers of other subjects. Participants included pre-service teachers enrolled in a general methods course for secondary educators and its school-based fieldwork counterpart. Statistical tests found that science pre-service teachers had fewer incidents of "teacher talk" (lecturing, giving directions), and more frequently asked closed-ended questions than their non-science counterparts. There was no significant difference in the frequency of asking open-ended questions or with types of responding behaviors. Implications include the important role of teacher preparation programs and faculty in exposing future teachers to pedagogical strategies necessary for effective instruction.

Keywords: Instructional Behaviors, Questioning, Responding, Inquiry Instruction, Science Teaching, Pre-Service

INTRODUCTION

The Science Teacher's Essential Role

Teachers' questioning behaviors can make a dramatic impact on student engagement and understanding (Herbel-Eisenmann & Breyfogle, 2005; Vogler, 2008; Wells, 2007). Likewise, how a teacher responds to students' questions and comments has considerable influence on student learning (Brophy, 1998; Deci, Koestner, & Ryan, 2001; Larrivee, 2002).

Purposeful, productive interactions with students are especially necessary for science teachers, who must provide "students with opportunities for a range of scientific activities and scientific thinking, including, but not limited to: inquiry and investigation, collection and analysis of evidence, logical reasoning, and communication and application of information" (National Research Council, 2010, p. 137). Colburn (2000) defines inquiry-based instruction as "the creation of a classroom where students are engaged in essentially open-ended, student-centered, hands-on activities" (p. 42). Effective science teachers go beyond demonstrations and hands-on experiences, and also engage students to actively review and discuss their ideas as they investigate phenomena and concepts.

Historically, science teachers have often struggled identifying their roles in inquiry-based lessons, which emphasize student-centered instruction and more intangible strategies on the part of the teacher (Colburn, 2000; Welch, Klopfer, Aikenhead, & Robinson, 1981). With regard to laboratory activities, Clark, Clough, and Berg (2000) note that science teachers often view a "false dichotomy," in that they think they either must give students a directed step-by-step procedure to follow with high control, or allow students to determine their own questions and procedures with little or no teacher intervention.

Research Focus

The focus of this study is to examine the patterns of interactive behaviors (questions, responses) exhibited by science pre-service teachers. In particular, two questions guide this research:

1. What classroom interaction patterns do science pre-service teachers show in their fieldwork (clinical) experiences?
2. How do these behaviors compare with pre-service teachers in other disciplines?

METHOD

Participants and the Program

Participants of this study included pre-service teachers enrolled in a one-semester general methods course (three credit hours) for secondary teachers at a large Midwestern university in the United States. Participants also enrolled in a co-requisite school-based field experience placement, during which they observed and interacted with the same classroom of students one hour each week. Pre-service teachers were chosen both as a sample of convenience and also due to their initial phase in the teachers' professional continuum (Feiman-Nemser, 2001). At this phase, teachers "develop new visions about teaching, and gain increasing understanding of learners and the learning process as they expand their teaching repertoires" (Fishman & Davis, 2006, p. 536).

The general methods course used in this study features an introduction to instructional strategies, teacher classroom behaviors, assessment methods, and classroom management. Candidates in these courses are typically at the junior or senior level, and are seeking initial licensure in one of the core subjects—English/language arts, mathematics, social studies, and science—for teaching grades 6-12. Most will student teach in schools full-time the following spring and graduate at the end of the same semester. Four years of data were collected from four subsequent years of pre-service teachers.

The total number of participants was 188. The number of pre-service teachers seeking science endorsements was 22, compared to 166 pre-service teachers seeking endorsements in other subjects (See Appendix A). The uneven distribution of the groups is due to using a sample of convenience and different numbers of individuals seeking licensure in different subjects.

Measures and Procedures

In the general methods course, all participants were taught by the same instructor and received instruction on teacher behaviors, questions, and interactions with students. They were trained to use the Schlitt Abraham Test of Interaction Coefficients (Abraham & Schlitt, 1973) as a guiding framework for reflecting on their teaching (See Appendix B). The SATIC instrument, as it is also known, is a non-subject specific coding tool used to monitor teachers' verbal interactions, and was chosen over other coding tools—such as Flanders' system of interaction (Amidon & Flanders, 1963)—because it is designed for any teacher to use, not just an evaluator or researcher. Teachers can use the SATIC instrument to code another teacher or themselves through review of a classroom recording. Furthermore, the SATIC tool features a more thorough and precise listing of possible teacher interactions, including responses and non-verbal behaviors.

Participants practiced using the SATIC tool by watching multiple video clips of classroom teachers and also coding transcripts of recorded classrooms. The methods course instructor also explicitly called attention to his own instructional behaviors and decisions. Participants were encouraged to use the SATIC tool to code the type of behaviors exhibited by the instructor. During one lesson, the class coded an entire ten-minute video-recorded lesson taught by the instructor in a previous classroom. Participants also spent class time in groups of three or four, in which they would take turns interviewing and coding each other's questions and responses.

Each participant taught a lesson lasting at least ten minutes in his or her field placement classroom. This "large group" lesson was an activity they planned and prepared with their cooperating teacher to teach with the whole class at their placement school. Nearly all schools were public middle or high schools and were located in suburban or urban settings within a large Midwest metropolitan area (U.S.A.). All participants recorded their teaching through either audio or video recording equipment. They then listened to the recording of their lesson and categorized their interactions with students using a SATIC coding sheet. Since the lessons used for the present study were taught early in the semester, the actual impact of the methods course is not the focus of this research.

Data Collection and Analysis

Data were collected from participants' completed SATIC sheets, along with transcriptions of at least ten classroom interactions (statements, questions, and/or responses) with students. Participants then labeled how they coded these interactions according to the SATIC coding sheet. Transcripts were used to check for accuracy of SATIC coding and comparison among groups.

A quantitative analysis of the data featured one-way between-groups ANOVA with planned comparisons (Keppel & Wickens, 2004), since the focus was singling out the science pre-service teachers to compare with non-science pre-service teachers. In all of the following analyses of variance, Levene's tests found that homogeneity could be assumed in every case (Levene, 1960). Due to the unequal distribution of participants, however, the non-parametric equivalent Kruskal-Wallis test was also conducted and confirmed initial parametric analyses (Hinkle, Wiersma, & Jurs, 2003). The results of the ANOVA tests are described in greater detail in the Results section.

Accuracy analysis. Accuracy of the participants' transcripts and self-coded questions/responses was determined by the percent of accurately coded behaviors divided by the total number of coded behaviors listed in the transcript. Inaccurately coded behaviors fell into two categories. The first was the participant incorrectly or wrongly coding a question or response according to the SATIC tool. The second inaccuracy in coding was scored to any question or response the participant overlooked and did not code while evaluating the transcript.

Both authors were trained in SATIC and practiced using this coding system for categorizing teacher behaviors. To avoid "coder drift" (Kugle, 1978; Marston, Zimmerer, & Vaughan, 1978), the two raters analyzed transcripts individually and in separate settings. Inter-rater agreement was high, with an average percent agreement of 95%, helping to establish empirically meaningful data (Kang, 1987).

Analysis of initiatory behaviors. Initiatory behaviors outlined by the SATIC tool (See Appendix B) include teacher talking and questioning. Each time one of these behaviors occurs, a mark is placed in the corresponding category on the SATIC sheet. Because of the potential differences in class time and context, incidents of initiatory behaviors were converted into percentages for each participant. For additional ease and clarity in analysis, initiatory behaviors were grouped into three categories:

- Teacher talking: Initiatory teacher talking that are categorized in the SATIC coding tool as SATIC 1 for lecturing or giving directions, or as SATIC 2 for making a statement or asking a rhetorical question.
- Closed-ended question: Initiatory teacher questions that do not require students to engage in considering their ideas, but rather give a brief or one-word answer. The SATIC coding tool has two categories of simple questions: yes/no/dichotomous (SATIC 3a) and short-answer (SATIC 3b).
- Open-ended question: Initiatory teacher questions that require students to think on their ideas and articulate their understandings: thought-provoking short-answer (SATIC 3c) and extended-answer (SATIC 4) questions.

Analysis of responding behaviors. As with initiatory behaviors, incidents of teacher responses to student comments/questions were grouped into categories and converted into percentages to create consistency for comparison and analysis. Teacher responses were categorized according to the following criteria

- Teacher-centered response: Responding behaviors used by teachers that limit student engagement and assessment: rejecting a student comment (SATIC 5), affirming or praising a student comment (SATIC 7), repeating a student comment (SATIC 8), clarifying or interpreting a student comment (SATIC 9, i.e. "putting words into the student's mouth"), and answering a student question (SATIC 10).
- Value-neutral response: A responding behavior by the teacher that acknowledges a student comment, coded as SATIC 6. This response has been separated from other teacher-centered responses (SATIC 5, 7-10) due to neither rejecting nor confirming the student comment.
- Student-centered responses: Responding behaviors by teachers that elucidate further engagement, assessment, and/or participation in learners: asking for elaboration or clarification (SATIC 11) or using a student idea or question (SATIC 12).

RESULTS

Accuracy of Coding

A one-way between-groups ANOVA with planned comparisons was conducted and no significant difference ($\alpha = .05$) was found between science and non-science pre-service teachers with respect to the accuracy of self-coding

Table 1
Self-Coding Accuracies of All Participants

Group	N	Percent Accuracy (Mean)	Standard Deviation
Science	22	80.1	17.8
Social Studies	63	80.7	16.8
English	59	81.6	12.6
Mathematics	41	83.1	13.7
Total	185	81.4	13.7

Table 2
Types and Mean Percentages of Pre-Service Teachers' Initiatory Behaviors

Group	N	Teacher Talking (lecture, giving directions) Mean Percent (Std Dev)	Closed Questions (yes/no, fill-in-the blank) Mean Percent (Std Dev)	Open Questions (thought-provoking, extended answer) Mean Percent (Std Dev)
Science	22	26.7 (13.9)	53.7 (14.2)	19.6 (11.6)
Social Studies	62	37.5 (19.8)	44.2 (18.4)	18.4 (13.8)
English	61	37.5 (20.1)	43.9 (17.4)	18.5 (13.8)
Mathematics	42	38.8 (20.0)	47.2 (17.4)	14.0 (15.5)
Total	187	36.5 (19.5)	45.9 (18.4)	17.6 (14.0)
ANOVA with planned comparisons		F(1,183) = 6.49 P=.012*	F(1,183)=4.33 P=.039*	F(1,183)=.666 p=.416

**Significant at the α = .05 level*

[F(1, 181) = .260, p = .611]. Among all participants, the mean accuracy in self-coding was 81.4% (see Table 1).

Initiatory Behaviors

Table 2 displays the types and average percentages of different initiatory behaviors used by participants in different subjects, along with results from the statistical tests. The most frequent behavior of science pre-service teachers was using close-ended questions, which accounted for more than one half of their initiatory behaviors. The least frequently exhibited behavior was open-ended questioning, used only one fifth of the time by the science pre-service teachers (see Table 2).

There were statistically significant differences between science and non-science pre-service teachers with respect to teacher talk and closed-ended questions. The average percent of teacher talk used by science pre-service teachers was 26.7%, compared with over 37%, and science pre-service teachers used closed-ended questions 53.7% of the time, as compared to 43.9-47.2% by each of the other groups. Even though there were statistically significant differences, the effect size was small to moderate in both cases (Cohen, 1988), with calculated eta squared values of .035 and .029 for teacher talk and closed questions, respectively. No statistically significant difference was found between science and non-science participants' use of open-ended questions.

Table 3
Types and Mean Percentages of Pre-Service Teachers' Responding Behaviors

Group	N	Teacher-Centered (rejection, praise, give answer) Mean Percent (Std Dev)	Neutral (e.g., "okay," thank you") Mean Percent (Std Dev)	Student-Centered (ask to elaborate, use student's idea) Mean Percent (Std Dev)
Science	21	65.3 (20.7)	18.0 (20.0)	16.7 (16.1)
Social Studies	61	67.5 (17.9)	18.1 (14.6)	14.4 (14.0)
English	61	37.5 (20.1)	21.2 (15.1)	14.1 (12.7)
Mathematics	42	38.8 (20.0)	17.4 (14.4)	14.6 (11.8)
Total	185	36.5 (19.5)	18.9 (15.4)	14.6 (13.3)
ANOVA with planned comparisons		F(1,181) = .124 P=.725	F(1,181)=.058 P=.810	F(1,181)=.557 p=.457

**Significant at the α = .05 level*

Responding Behaviors

Table 3 displays the average percentages of responding behaviors used by participants in different subjects, along with results from the one-way between-groups ANOVA with planned comparisons. On average, almost two-thirds of all responses used by the science pre-service teachers were teacher-centered. Student-centered responding was the category with lowest frequency during participants' lessons. With regard to the different ways participants responded to students, no significant differences were found between the science and non-science pre-service teachers.

DISCUSSION

The purpose of this study was to examine the patterns of classroom interactive behaviors (questions, responses) exhibited by science pre-service teachers and compare these behaviors with non-science pre-service teachers. The following paragraphs review results and discuss applications to both research and teaching.

Despite the emphasis in science education literature on using purposeful, open-ended questions to guide and model inquiry (Bybee, 2002; Penick, Crow, & Bonnstetter, 1996), science pre-service teachers generally show no prior dispositions toward this behavior in the classroom. The predominance of simple, closed questions by the science participants (73.3% of all questions asked) is consistent with past research on teacher questioning, which estimates an 80% rate of teacher questions requiring rote recitation (Gall, 1984; Watson & Young, 1986).

Almost two-thirds of all responses used by science pre-service teachers were teacher-centered (65.3%), which limits student engagement and decreases the teacher's ability to gauge student learning. The scarcity of student-centered responses can result in pedantic classrooms focusing on trivia and teacher appeasement, as opposed to students actively thinking, exchanging, and reflecting on ideas. This relates to findings of previous studies, in which productive teacher feedback was rare and contributed to passive and intellectually isolated students (Goodlad, 1984; Weiss, Pasley, Smith, Banilower, & Heck, 2003).

Significant difference ($\alpha = .05$) did occur between science and non-science participants in the other two categories of initiatory behaviors. Compared to their non-science counterparts' initiatory behaviors, science pre-service teachers had ten percent less teacher talk (giving directions, lecture). In place of teacher talk, science pre-service teachers' use of questions accounted for about ten percent more of their initiatory behaviors than non-science pre-service teachers. These additional questions, however, were mostly closed-ended (recall, yes/no).

Limitations and Delimitations

The lack of a large effect size in those cases of significant difference reveals the complexity of researching teacher behaviors (Schempp, 1986). Limitations occur due to the multifaceted classroom settings in which participants taught and recorded their lessons. Grade levels taught ranged from sixth to twelfth, with some classrooms featuring mixed ages. Students in these classrooms had different cultural backgrounds, previous learning experiences, future goals, and more. Participants themselves—although all being pre-service teachers in the same level of preparation at the same institution—came from equally diverse backgrounds, including varied work and school experiences. "Host" teachers who mentored the pre-service teachers during the field experience provided mixed levels of assistance and structure in the time before, during, and after participants taught their lessons. Additionally, participants were not equally distributed among various disciplines, with science pre-service teachers being the smallest group. Such issues are common with a sample of convenience and can limit generalizations of findings, though measures were enacted to promote systematic similarities among the participants—the same general methods preparation, SATIC coding training and practice, the same methods course instructor, recorded lesson parameters—as much as possible.

The context of the classroom also assists in determining the appropriateness of some interactive behaviors, such as giving directions or providing information when needed. Nevertheless, teachers can still insert questions and prompts during these moments to engage students in thinking and assess for understanding. Some may point to the difference of subjects and claim the field of study could warrant different methods of instruction. While this may have some merit, especially with regard to particular content-related strategies or activities, the use of questions and responses to engage and assess students is integral to effective pedagogy in any case. This is true also regardless of the lesson topic, length, format, and age of students, where developmentally appropriate.

Another issue that may arise is participants' self-coding. Due to various restrictions common to a study of teacher preparation—course and program expectations, field placements—participants coded their own teacher behaviors. However, participants were well prepared through study and practice of the SATIC tool. In addition, participants' transcripts and coding samples were evaluated for accuracy with a high (95%) inter-rater reliability. The mean accuracy of all participants was 81.4%, and no significant difference was found between science and non-science pre-service teachers. Would the inaccuracies in self-coding be corrected, the overall percentages of interactive behaviors would have skewed in favor of additional closed-ended questions and teacher-centered responses.

Implications for Future Research

Controlling as many variables as possible could address the additional issues that may impact pre-service teachers' teaching behaviors and coding accuracy. A random sample of participants—an equal number for each subject—would provide more uniformity in the data sources. Parity would also increase through establishing a common context and scope of the featured lessons—as much as possible in the field of teacher preparation research.

A similar study of full-time in-service teachers would provide for an interesting comparison with the featured pre-service participants. Years of teaching experience could be a noteworthy variable in analysis of teachers' classroom behavior patterns. Longitudinal studies of teachers progressing through different phases in a professional continuum (Feiman-Nemser, 2001), would be beneficial in examining various long-term effects on their interactions with students.

Implications for Science Teaching and Teacher Education

Inquiry-based science instruction creates more opportunities—and challenges—for teachers to interact with students on a meaningful level of learning. Many educators are familiar with the need to shift the teacher's role from "a sage on the stage" to "a guide on the side." However, the actual role of a teacher guiding his or her students (i.e. "facilitating") is complex and demanding. Effective pedagogical behaviors do not occur overnight, nor do they spontaneously come to mind (or the tongue) in the midst of a dynamic classroom. Science educators must be especially conscientious of preparing and using their interactions with students to shape a successful learning experience in an inquiry-based setting. This includes what questions, prompts, challenges, problems, examples, and responses a teacher might use to engage students' thinking, guide discussion, draw out ideas, and probe for deeper understanding.

Although science pre-service teachers typically have extensive laboratory and inquiry experiences, science teacher educators must not assume their protégées are predisposed to asking questions or responding to students in ways that encourage, engage and assess learning. Like all pre-service teachers, those seeking science licensure must study, practice, and reflect on the behaviors necessary to ensure successful student learning—especially so in an inquiry-based setting. A complete teacher preparation experience includes explicit teaching of interactive behaviors (including questioning and responding) and multiple opportunities for application and self-evaluation. In regard to developing elementary science teachers, Oliveira (2010) argues that science teacher educators must avoid ambiguous terminology such as "guide" and "facilitate" and instead focus on particular strategies and behaviors teachers can use to promote inquiry-based learning. The same transparent, fine-tuned approach is necessary for preparing teachers in middle and high schools.

Participants in this study were pre-service teachers, but recording and reflecting on one's classroom interactive behaviors should not be limited to preparation only. Educators who clamor for lifelong learning in students must also exhibit the same habits themselves—studying, practicing, monitoring, evaluating—in a collegial professional community. Teacher educators must be premier models for future teachers, living examples that self-improvement is not relegated to the pre-service experience, but rather occurs throughout an entire career. Such an endeavor is beneficial in both teacher preparation and science education contexts, for teachers and students alike.

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Correspondence regarding this article should be addressed to Daniel Bergman from Wichita State University, USA. Email may be sent to daniel.bergman@wichita.edu