What Makes Inquiry Stick? The Quality of Preservice Teachers’ Understanding of Inquiry

Mark W. Aulls¹, Diana Tabatabai¹, and Bruce M. Shore¹

Abstract

This nonexperimental, exploratory, mixed-design study used questionnaires with 167 preservice secondary teachers to identify prior educational experiences associated with student-teachers’ inquiry understanding. Understanding was determined through content analysis then open coding of definitions of inquiry and descriptions of best-experienced inquiry instruction, in terms of 23 potential learner-inquiry outcomes. Only two of seven educational-context variables related to understanding: prior experience doing a thesis or research—especially to definition quality and having taken a research-methods course—especially to description quality. How definitions and descriptions of inquiry are different and similar was analyzed qualitatively and quantitatively. Implications for methodology, theory, and practice were presented, for example, research opportunities and research-methods training during teacher education.

Keywords

inquiry instruction, understanding inquiry, evaluating inquiry understanding, preservice teachers, teacher education, student-teacher background

The main purpose of this study was to assess secondary pre-service teachers’ understanding of inquiry and inquiry instruction. The secondary purpose was to discover what educational-background variables reported in educational research are significantly associated with this understanding. In the course of this exploration, we determined that the literature did not contain an adequate measure of or coding system for inquiry understanding. We, therefore, adapted a published instrument for this purpose, focused on inquiry-learning outcomes.

Inquiry and inquiry instruction have been part of substantial teacher-education curriculum revision, especially but not exclusively in the sciences (e.g., European Commission, Directorate-General for Research, Directorate L—Science, Economy and Society, 2007; National Council for the Social Studies, 2010; National Council of Teachers of Mathematics, 2000; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010; National Research Council, 1996, 2012). No empirical study has qualitatively and quantitatively explored secondary pre-service teachers’ understanding of inquiry and inquiry instruction from a constructivist learning view. Prospective secondary teachers should acquire conceptual, situational, and procedural knowledge of inquiry instruction in school subjects. Such knowledge cannot only be conceptual to transform it into strategies for learning how to inquire independently.

We inferred inquiry understanding separately from preservice teachers’ definitions of inquiry and descriptions of their best, self-selected, prior experience with inquiry instruction as students. Definitions represented conceptual knowledge of key conceptual elements of inquiry. Descriptions represented tacit knowledge and awareness of the experience-grounded concepts, situations, and procedures that might help generate or elaborate inquiry-based instruction.

Our central information source was the student-teachers themselves who, in their own words, defined inquiry and described what they had listed as the best example of inquiry instruction they recalled from their formal education.

Literature Review

We found only one existing but unpublished instrument (Curry-Sumrall, 2010) intended to directly measure teachers’ knowledge of inquiry and implementation of inquiry instruction, but its focus was on elementary schools, replies were

¹McGill University, Montreal, Québec, Canada

Corresponding Author:
Bruce M. Shore, McGill University, Educational and Counselling Psychology, 3700 McTavish, Montreal, Québec, Canada H3A 1Y2. Email: bruce.m.shore@mcgill.ca
grouped and categorized into internally diverse categories, and data generated were focused on science and unrelated to other variables. The inquiry literature about secondary teachers has especially addressed science, even though secondary teacher education includes specialists in many other subjects. Therefore, creating a versatile, qualitative, and quantitative indicator of preservice teachers’ inquiry understanding emerged as one of our goals, together with understanding how student-teachers might gain insight into educational inquiry.

Inquiry teaching and learning have a long history that, according to Kilbane and Milman (2013), dates from Ibn al-Haytham’s 11th-century Book of Optics. Inquiry instruction refers to how to establish conditions that enable learners to weave together disciplinary and interdisciplinary knowledge and the processes of inquiry to construct relevant knowledge (Aulls & Shore, 2008; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010; United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2008). Inquiry necessarily actively engages learners in acquiring and self-regulating inquiry-relevant conceptual and procedural knowledge (Llewellyn, 2005). Typically, it also builds on links to individual interests and knowledge. Although an inquiry approach to instruction should contain these elements, it does not always do so with consistent success (see multiple examples in Shore, Aulls, & Delcourt, 2008) and it requires considerable planning and deliberate effort on the part of both novice and expert teachers (Reiff, 2002) at all levels of formal education.

Inquiry-based education is an important instructional approach because it improves student-learning outcomes and is valued by students. Furtak, Seidel, Iverson, and Briggs (2012) conducted a meta-analysis of 37 experimental and quasi-experimental science-education studies. Students from inquiry-based classrooms outperformed students from traditional classrooms on measures of conceptual understanding. Field, Reis, and Sedam (2006) interviewed graduates of secondary gifted-education programs that included at least one original, inquiry-based project. Their most valued memories were about participation in these projects. If inquiry experiences form strong memories, then university students should be able to recall and describe the most memorable ones. Concepts are part of the declarative knowledge stored in memory and used to define complex schema such as inquiry as a process or as an instructional approach. Hence, we anticipated that describing preservice teachers’ understanding would entail addressing both conceptual and experiential inquiry representations.

Teaching through inquiry is challenging because enactment of inquiry curriculum is complex, can be done in a variety of ways, and can be used for different lengths of time in a classroom or course (Aulls, Kaur Magon, & Shore, 2015; Boyer Commission on Educating Undergraduates in the Research University, 1998; Davidson & Bruce, 1993; National Research Council, 2012; Reiff, 2002; Strum Kenny et al., 2001; Windschitl, 2002, 2008). A related challenge is understanding and setting learning goals of inquiry instruction, given the many operational definitions of inquiry. This, in part, prompted the U.S. National Research Council (2012) to rethink and limit its use of the term in the sciences and engineering.

Inquiry competence is built gradually and not always smoothly (Aulls & Shore, 2008; Shore et al., 2008). Levy and Petrusil (2012) asked 30 first-year, secondary education students about their experience and understanding of inquiry and research in relation to their overall university experience. Despite excitement about content that interested them, they experienced challenges in searching for information, adapting personal learning beliefs, the capabilities to carry out inquiry assignments, and coping with peer-collaboration dynamics. Such learners’ challenges likely also affect student-teachers.

**Possible Correlates of Inquiry Understanding**

We selected our educational-context or background variables through an extensive cross-disciplinary search of the research literature, including student-teachers’ or teachers’ understanding or classroom use of inquiry. We conducted a second search limited to education undergraduates. We identified the following two conditions in student-teachers’ learning histories that might especially correlate with the quality of their inquiry understanding.

**Taking a research-methods course.** Formally teaching research methods is common in some disciplines. We could not locate research linking them to student-teachers’ inquiry understanding, but we located a somewhat related dissertation. Meijer (2007) compared 257 psychology undergraduates regarding whether they had taken a research-methods course and asked two questions about basic, nontechnical concepts in psychological research methodology. Students who completed a research-methods course did significantly better, but still made more than 50% errors.

**Completing a thesis or a major or honors project.** Research on honors programs highlighted the importance of self-directed and self-generated learning. Pruitt (2013) observed seven first- and second-year honors students completing an independent, open-ended literature project with the teacher as a facilitator rather than authority figure. The experience encouraged students to recognize knowledge gaps and construct their own personally relevant knowledge. Crawford’s (1999, 2007) mentorship studies revealed the impact of student-teachers’ prior research experience on planning and enacting instruction.

**Preservice Teachers’ Understanding of Inquiry**

Crawford (1999); Eick and Dias (2005); Eick and Reed (2002); Grove, Dixon, and Pop (2009); and Windschitl (2002, 2004) studied implementation of inquiry during student-teaching in secondary school or college. These studies collectively suggested gaps in empirically derived knowledge about preservice teachers’ understand of inquiry and inquiry instruction,
educational experiences associated with their understanding, and how to design research for these purposes.

Aulls and Ibrahim (2010) randomly selected 21 of 175 preservice teachers’ essays about what makes an effective teacher, to explore whether effective instruction and effective inquiry instruction were understood as basically the same or different. Although mostly not previously taught through inquiry, they could distinguish between effective general and effective inquiry instruction. In effective inquiry instruction, student and teacher roles vary (Walker, Shore, & Tabatabai, 2013), activities promote understanding, and knowledge is co-constructed in group discussions. Thus, student-teachers should be able to articulate important inquiry qualities in conceptual definitions of the nature of inquiry and in descriptive writing indicating what they have experienced as inquiry instruction.

Demir and Abell (2010) used classroom observations and semistructured interviews to study four beginning science teachers’ and two faculty members’ inquiry understanding. During their third interview, they asked, “In what ways if any do you think your lesson used inquiry? Why?—or Why not?” (p. 721). They confirmed earlier findings that teachers’ understanding of inquiry-based teaching is poorly aligned with National Research Council (1996, 2000) definitions. Again, this suggested a discrepancy between what professional educators and practicing teachers think inquiry is. In addition, a multiple-case study of five secondary-science teachers demonstrated that “teachers’ conceptions of science” and presumably, by extension, inquiry, “do not necessarily influence classroom practice” (Lederman, 1999, p. 916). Most preservice teachers found it difficult to bridge subject-matter knowledge with pedagogy and to use content knowledge in ways that help all students as inquirers.

Hayes (2002) analyzed 22 preservice teachers’ writings and reflective journals from one of his elementary science-methods courses. Student-teachers’ words illustrated struggles defining three categories of meaning around which an inquiry approach to teaching could be articulated: letting go, going with students’ interests, and asking the right questions. Hayes addressed new teachers’ emerging identities and roles as they began their teaching practices; this differed from our focus but it invoked an interesting methodology with great attention paid to detailed descriptions, which we emulated.

Finally, prior research on preservice teachers’ experience-based understanding of inquiry instruction has mostly addressed secondary-science instruction and largely ignored other subjects. We included secondary preservice teachers preparing to teach several subjects.

Measuring the Quality of Student-Teacher’s Understanding of Inquiry

Curry-Sumrall’s (2010) eight-item Inquiry Definition Checklist was the only existing instrument we found that quantitatively evaluated inquiry definitions. Curry-Sumrall directly questioned how 18 elementary school teachers defined inquiry and why those who could define inquiry did not necessarily teach with inquiry. The checklist addressed making observations, asking questions, examining information sources, investigation, reviewing what is known, data manipulation (gather, analyze, interpret), offering answers, and communicating results. If one to three items were present, Curry-Sumrall evaluated the definition as “Does not define inquiry,” four to six as “Somewhat defines inquiry,” and seven or eight as “Thoroughly defines inquiry.” Multiple regression revealed no significant relations with subject-matter knowledge, education level, years of teaching, school, socioeconomic level, or extent of inquiry implementation. The scale was likely insufficiently sensitive to finer level differences in definitions, and the sample was small. Martin-Hansen (2002) also examined inquiry definitions in practicing teachers’ secondary-science classrooms. She described five essential features of an inquiry classroom: learner engagement with questions, importance of evidence responding to questions, formulating explanations from evidence, connecting explanations to scientific knowledge, and communication and explanations. These five qualities could be among the criteria sought in any good definition of inquiry. Therefore, we included developing a suitable evaluation tool for student-teachers’ inquiry understanding within this study.

Method

We conducted a nonexperimental, exploratory, mixed-design study (Creswell & Plano Clark, 2007, 2011). In this design, qualitative and quantitative data were collected concurrently. A survey solicited quantitative inquiry-background data and included two open-ended questions to be qualitatively analyzed. One question elicited definitions of what inquiry meant to participants, and the second elicited a description of the best inquiry instruction they reported having experienced during their formal education from the descriptions provided.

Participants

The 167 preservice student-teacher volunteers were in two sections of introductory educational psychology, within their teacher-education program at a large, Canadian, research-oriented university. They included 113 women (68%) and 54 men (32%) preparing to be secondary school teachers across several teaching disciplines. Almost half (81, 49%) were in English language arts or second language education as their program concentration and 48 (29%) specialized in physical education. Only 17 (10%) specialized in science, mathematics, or technology; 13 (8%) in social-science teaching; and eight (5%) in the arts. All had high-school diplomas, 102 (61%) graduated from Quebec pre-university college programs, and 104 (62%) had less than 3 months of teaching experience.
Procedures

The university research ethics board approved the study. After a research assistant described the study to the class, seeking volunteers, the questionnaire was distributed to 175 preservice secondary teachers in two course sections taught by one of the authors. Students started the questionnaire in class where they could obtain clarification about the directions. They had 2 weeks to complete the survey outside class time and were given course-participation credit for completing it on time. Eight questionnaires (5%) were incomplete, and 167 completed questionnaires were analyzed.

Section A asked about their background, including having done research or a thesis and having taken a research-methods course. In Section B, we operationalized understanding inquiry by requesting, “Please explain what ‘inquiry’ means to you from a student’s point of view.” In Section C, we asked participants to separately describe in detail all occasions of inquiry they could recall in their elementary, secondary, community college, and university education. Student-teachers had space to name the grade level and subject and briefly describe what happened in every example. Later they were asked to “Go back (to the inquiry experiences listed) and place an asterisk (*) in front of the example you consider the best inquiry experience you had as a student.”

Data Coding and Analyses

We first applied a deductive qualitative-analysis procedure by Mayring (2000). Twenty-three conceptions of inquiry-learning outcomes in the McGill Inventory of Student Inquiry Outcomes–Students (MISIO-S; Saunders-Stewart, Gyles, & Shore, 2012), that had been criterion-referenced in the literature, were used to categorize noun and verb phrases in each sentence of each definition and description. The items had been selected from a literature review of research reporting evidence of learning outcomes of inquiry instruction and of existing measures of inquiry-learning outcomes. Operationally, the term outcome was used to describe any change that is a result of engagement in inquiry, for example, not limited to, learning content and skills, or changes in attitudes and motivation. Some outcomes, for example, asking questions, are part of the inquiry process, but outcomes such as heightened curiosity and asking more or better questions also may be evident. (Saunders-Stewart et al., 2012, p. 8)

Three items (4, 5, 6) addressing understanding were combined. Two new items were added, for mentioning data collection or doing research. The two left columns of Table 1 list the 23 coding categories. We identified the modified MISIO-S as MISIO-Sm.

The MISIO-Sm discriminated strong and weak inquiry definitions and descriptions of approximately equal length that had been selected by a panel from our research team (Table 2). More MISIO-Sm categories were coded in the stronger responses. Such discrimination was not observed when we coded responses with instruments having fewer inquiry-pedagogy items (12 in Llewellyn, 2004) or many more representing specific, learner tasks in inquiry (79 in Shore, Chichekian, Syer, Aulls, & Frederiksen, 2012).

Inductive open coding followed, of sentences in students’ replies defining inquiry and describing inquiry instruction (Corbin & Strauss, 2015). The coder compared every sentence in each definition or description with the next to determine if they were semantically alike or different. Those that were alike were initially grouped by the noun-phrase or verb-phrase in the responders’ own written words to prevent the coder from using too high a level of inference to represent how they were alike. Continuing through all the passages, the procedure resulted in groups of sentences or phrases elaborating each theme. Themes might have occurred in the definition, the description, or both. Some sentences could not be categorized and did not contribute to a theme.

We assumed that the combination of (a) the conceptual representation of inquiry—the definition—and (b) the situational representation of inquiry instruction they actually experienced and valued—the description—were evidence of their understanding of inquiry. Definitions could likely be used to represent goals for inquiry instruction. Descriptions could likely represent declarative and procedural knowledge for accomplishing inquiry instruction, articulating knowledge they might be able to use as a basis for deciding what to teach and how to enact inquiry instruction as a secondary teacher.

Coding reliability. From the literature, we anticipated that responses to defining inquiry and describing best inquiry experiences might differ in terms of cognitive demands. To link prior inquiry experiences and current inquiry knowledge, we needed a way to systematically and reliably code both kinds of inquiry understanding.

Miles and Huberman (1994) suggested independently coding 25% of statements to assure interrater reliability. A random-generator program identified 47 (28%) of the 167 statements for coding by a graduate student unfamiliar with the research. This rater was given the MISIO-Sm code guide (Table 1, two left columns) and told the purpose of the exercise. Initial agreement between the two coders on all categories was 74% for the definitions. After discussing differences with the third author, agreement rose to 90%. For the remaining 10%, consensus was achieved between the second and third authors. Initial agreement for the descriptions was 47%, perhaps reflecting the difficulty of coding such descriptive data. After discussing differences and asking the third author to recode some difficult statements, agreement rose to 78%. The source of greatest disagreement was “interest” that was not among the MISIO-Sm codes; we coded it “motivation.” Remaining final codes achieved consensus between the second and third authors.

Response length. This potential quantitative index of response quality was inspired by two studies in other domains. Kobrin,
Deng, and Shaw (2007) counted words and paragraphs in 2,820 SAT essays; word-counts explained 39% of overall grade variance ($r = .62$). Tan (2010) tested 175 community college students attending a developmental-writing course. Participants scoring higher in reading ability and vocabulary wrote longer text summaries containing significantly more ideas. Widely used creativity measures also use word-counts (Torrance, 2008).

### Results

#### Descriptive Information

Fifty-two participants (31%) previously took a research-methods course and 54 (32%) reported completing a thesis or a major project. Twelve (1%) had both experiences. Eighty-one (49%) were enrolled in English language arts or second language concentrations; 48 (29%) in physical education; 17 (10%) in mathematics, science, and technology; 13 (8%) in social sciences; and eight (5%) in arts. These enrolments were artifacts of scheduling; students in other programs (e.g., elementary education) were enrolled in different sections of compulsory educational psychology.

Participants remembered 925 inquiry situations over their years in school (see Table 1), with 386 (42%)—the highest—at the secondary level, then 230 at university (25%), 185 (20%) at elementary school, and 124 (13%) at college. Total numbers of elementary and secondary inquiry-instruction experiences were moderately correlated ($r = .41, n = 154, p = .00$), as were secondary and university-level inquiry instances ($r = .28, n = 151, p = .001$). However, the numbers of reported inquiry experiences between the college and university levels were not significantly correlated ($r = .09, n = 151, p = .25$). Student-teachers recalled and described their best inquiry experience mostly at the secondary level (58, 35%) followed by university (44, 26%), pre-university college (33, 20%), and least at the elementary level (15, 9%). Seventeen participants (10%) did not respond.

#### Qualitative Analysis Results

The right six columns of Table 1 present the frequencies of occurrence of the 23 categories of inquiry-learning outcomes in student-teachers’ inquiry definitions of inquiry and descriptions of best-experienced inquiry instruction.

### Table 1. Modified MISIO-S Coding Categories and Their Frequency of Occurrence in Definitions and Descriptions.

| Code | Category                                                                 | In definitions | In descriptions | Total |
|------|--------------------------------------------------------------------------|----------------|----------------|-------|
|      |                                                                          | $f$     | $f$   | $f$     | $f$   | $f$   | $f$   | $f$   |
| 1    | Acquisition of facts or knowledge by using different sources             | 66     | 17  | 20     | 122   | 18  |
| 2    | Improved achievement, effective learning                                 | 2     | 1   | 3      | 10    | 2   |
| 3    | Learning the process—the “how to” [procedural knowledge]                | 7     | 2   | 8      | 3     | 15   | 2     |
| 4    | Understanding (nature or value of the content area, inquiry, or concepts) | 26    | 7   | 12     | 4     | 38   | 6     |
| 5    | Construction of knowledge                                               | 1     | 0   | 3      | 1     | 4    |
| 6    | Ability to see concepts as related                                      | 2     | 1   | 0      | 0     | 2    |
| 7    | Application of knowledge or skill                                       | 4     | 1   | 10     | 4     | 14   |
| 8    | Development of intellectual or thinking skills, reflection               | 12    | 3   | 17     | 6     | 29   | 4     |
| 9    | Problem-solving skills, inquiry or research skills                       | 55    | 14  | 3      | 1     | 58   |
| 10   | Learn how to learn or lifelong learning, personal projects              | 0     | 0   | 10     | 0     | 10   |
| 11   | Development of personal skills (e.g., planning, organization), habits of mind | 3     | 1   | 4      | 1     | 4    |
| 12   | Positive attitude toward the subject or learning                         | 4     | 1   | 14     | 5     | 18   |
| 13   | Self-esteem, self-confidence, self-efficacy                              | 1     | 0   | 2      | 1     | 3    |
| 14   | Generation of questions, curiosity, seeking answers                     | 86    | 22  | 41     | 14    | 127  |
| 15   | Motivation, task commitment, generating interest                         | 52    | 14  | 2      | 1     | 54   |
| 16   | Emulate professionals, create authentic products, real-world examples, experiments, and science fair | 1     | 0   | 5      | 2     | 6    |
| 17   | Development of expertise                                                 | 0     | 0   | 1      | 0     | 1    |
| 18   | Social nature of learning, group work                                    | 9     | 2   | 10     | 4     | 19   |
| 19   | Enhanced creativity                                                      | 2     | 1   | 1      | 0     | 3    |
| 20   | Increased social awareness and action, motivation to be informed citizens | 4     | 1   | 10     | 4     | 14   |
| 21   | Teacher, student role changes, student ownership, interests guide choices | 47    | 12  | 0      | 0     | 47   |
| 22   | Data collection                                                          | 0     | 0   | 31     | 11    | 31   |
| 23   | Doing research                                                           | 0     | 0   | 33     | 12    | 33   |
| Total|                                                                       | 384   | 100 | 278    | 100   | 662  |

Note. MISIO-S = McGill Inventory of Student Inquiry Outcomes—Students.

*Code 4 was three “understanding” items in MISIO-S; 22 and 23 were added.*

*Difference from 100% is due to decimal rounding.*
Table 2. Sample Coding of Strong and Weak Inquiry Definitions and Descriptions.

| Inquiry definitions | MISIO-Sm categories | Best-experienced inquiry descriptions | MISIO-S categories |
|---------------------|---------------------|---------------------------------------|-------------------|
| Strong (ID = 79; word-count = 91): | 5 items (10-14-8-15-5) | Strong (ID = 104; word-count = 68): | 6 items (14-10-16-4-8-15) |
| “Inquiry” does not mean just get a formal or pre-fixed answer to certain pre-made questions. “Inquiry” is stimulating searching attitude and desire to learn and improve oneself rather than just getting simple information or knowledge only. Therefore, it involves the teachers’ personal integrity, personality, and attitude to involve the student’s well-being because it will initiate student’s motivation to inquire and search for real important things in life. Then students will put their willing and voluntary effort to discover deeper knowledge instead of stopping at getting the second-hand information only. | The teacher always lectured. However, we had to do a big assignment in his class that required us to form our own questions. I went to the Ottawa archives in order to accumulate and study primary sources. I had to make sense of the material on my own. I felt like a discoverer, or a historian, because I had to ask questions and make sense of the past. |
| Weak (ID = 54; word-count = 88): | 2 items (14-15) | Weak (ID = 65; word-count = 63): | 1 item (21) |
| To me, inquiry refers to an investigation. I would use this word only to refer to official investigations, such as the police are conducting an inquiry into (someone’s) death. However, as it is used in the paper I assume it means question asking. Do the teachers/professors encourage/discourage question asking? Do they allow it? Are students free to ask questions whenever they have them or only at the end of class? To me, this concept is fairly straightforward, but it hardly sticks out of mind. | The first 15 minutes of every day were devoted to “calm down” time. Teacher would ask us to think out a “word” name, an event or concept for the next day. In effect this was a pre-teaching activity as this inquiry was used as a basis for introducing a subject, or concept which the teacher introduced in the next day’s class. |

Note. MISIO-Sm = modified MISIO; MISIO-S = McGill Inventory of Student Inquiry Outcomes–Students.

Definitions. The 160 student-teachers who wrote definitions of inquiry assigned the 23 MISIO-Sm codes 384 times with a range of one to seven and a mean of 2.4 codes. Only two outlier definitions generated six and seven codes; they were aggregated and the minimum-maximum range of MISIO-Sm codes was reduced to one to five. To define inquiry, participants used 6,039 total words, ranging from eight to 124, with a mean word-count of 37.7. Four fifths of the responses (306, 80%) were accounted for by the five codes that each contributed 10% or more of the total: #14, acquisition of facts or knowledge by using different sources (66, 17%); #9, problem-solving skills (55, 14%); #15, motivation (52, 14%); and #21, student and teacher role changes (47, 12%).

Descriptions. One hundred forty-eight participants assigned 278 MISIO-Sm codes to their descriptions. The minimum was one, maximum four, and mean 1.9. Just four codes each contributed more than 10% of the responses and together, 161 (58%) of the best-experienced inquiry descriptions: #1, acquisition of facts and knowledge from different sources (56, 22%), followed by #14, generating questions (41, 14%), and #23, research papers completed (33, 12%), and #22, data collection (31, 12%). Descriptions used 4,815 words, ranging from one to 118 with a mean of 30.7. Twenty-five words sufficed for 78 (53%) participants to describe their best inquiry-instructional experience, and only two participants (1%) wrote more than 100 words.

Comparing inquiry definitions and descriptions as indicators of student-teachers’ knowledge of inquiry. In Table 1, the total frequencies of occurrence for nine categories, codes 2, 5, 6, 10, 11, 13, 16, 17, and 19, ranged between one and 10 occurrences (each below 2% of the total). These were seldom used to define inquiry or describe enactment of inquiry instruction that they recalled as their best inquiry-learning experience.

The remaining 14 categories occurred 14 to 127 times. The two most frequent categories (#14, question generation and #1, acquisition of knowledge from different sources) were found in both definitions and descriptions (127 and 122, respectively). Category 1 had similar frequencies for definitions (66) and descriptions (56), but #14 occurred twice as often in definitions (86) versus descriptions (41).

Categories #9, problem solving, #15, motivation, and #21, role changes were also among the most frequently occurring categories overall, with frequencies of 58, 54, and 47, respectively. However, these appeared more in definitions and seldom in descriptions. Category 4, understanding, occurred 38 times, twice as often in definitions (26) as descriptions (12).

Categories 23, research, and 22, data collection, the next most frequent, occurred 33 and 31 times, respectively. These
occurred solely in inquiry-instruction descriptions. The remaining four categories ranged between 14 and 29 occurrences in both definition and description: #3, procedural learning, #7, knowledge or skill application, #8, developing intellectual or thinking skills, and #11, positive attitude toward the subject or learning.

These 14 more frequently used category frequencies revealed interesting patterns when compared between and within definitions and descriptions. Question generation (#14) and acquisition of facts and knowledge from different sources (#1) were the most common categories, shared by the majority of secondary student-teachers as core elements in their understanding of inquiry as central concepts in their definitions of inquiry and also in their descriptions of good inquiry-instructional practices that they experienced as students.

Other shared categories followed similar patterns but occurred less often. Categories #8, thinking skills, and #9, problem solving focused on the development and the application of skills. Category 3 (learning “how to” inquire) was related to these because it encompasses enabling the learner to self-regulate their application. These three categories focus on cognitive strategies and their self-regulation used to actively engage in inquiry alone or under teacher guidance. University teachers often do not appear to consider these as part of their instructional responsibility, perhaps because they usually assume them to be already developed and make few attempts to teach students how to do these strategies. Instead they concentrate on constructing knowledge of the subject-matter content rather showing students how to learn how to acquire it.

A second pattern involved categories occurring exclusively within inquiry definitions or descriptions. When a category occurred only within definitions, but seldom or never in descriptions, this could imply insufficient opportunity to observe inquiry enacted or learn to do it, or having tried to do it unsupervised. When the category occurred only within a description, perhaps it had not attained the level of abstraction of a concept or cluster of concepts. Descriptions are evidence of student awareness of a category, but their meaning is assumed to be tacit rather than explicit. Tacit knowledge is less easily accessed from memory to be used to acquire new knowledge without assistance or outside the context in which it was experienced. When a category represents a concept used in a definition, it might have associated strategies that are not evident in the description of best-experienced inquiry instruction. Alternatively, it could be a token for a word used as a concept. It can be repeated, but its meanings are not necessarily clear. The pattern differences obtained through qualitative analysis were also examined quantitatively.

Quantitative Analysis Results

We compared all 23 category frequencies for participants who had done research, taken a research-methods course, or both (see Table 3). Categories #14, question generation, and #1, acquiring facts from multiple sources, were most frequently cited by all three groups. Categories 6, relate concepts, and 21, role changes, were in the definitions but not the descriptions; Categories 10, learning to learn, 17, develop expertise, 22, data collection, and 23, having done research were present in the descriptions but not the definitions. At least one student-teacher in each group cited Category 4, understanding.

The frequency of cited inquiry-learning outcomes (MISIO-Sm codes) in inquiry definitions and the number of words used were significantly and positively correlated (r = .60, n = 160, p < .001, large effect size $R^2 = .36$). A similar result emerged for inquiry descriptions (r = .41, n = 148, p < .001, moderate effect size $R^2 = .17$). However, there was a low positive correlation between the numbers of words used to define inquiry and words used to describe the best inquiry experience recalled (r = .18, N = 151, p = .025, small effect size $R^2 = .03$). This finding reaffirmed our assumption that the definition and description tasks tapped different cognitive processes underlying inquiry understanding. Only one significant $\chi^2$ was obtained between having completed a thesis or major project and definitions of inquiry coded for student outcomes, $\chi^2(4, 106) = 10.61, p = .03$; medium effect size $\eta = .32$.

One-way ANOVA revealed no significant difference in the number of MISIO-Sm student-inquiry outcomes in the descriptions related to theses or major projects completed. A significant $\chi^2$ was obtained, between having taken a research-methods course and the number of MISIO-Sm outcomes found in descriptions of the best inquiry-instruction participants recalled, $\chi^2(2, N = 146) = 6.51, p = .04$; the effect size ($\eta = .21$) was medium.

To follow-up potential differences in the patterns of codes between inquiry definitions and descriptions, we conducted three other statistical analyses. First, we conducted a $\chi^2$ on the frequency columns of Table 1 for definitions and descriptions. The patterns were significantly different, $\chi^2(22, N = 146) = 248.86, p = .00$ (extremely large effect size = 1.30).

Second, given that these distributions might be associated with prior research experiences or having studied research-methods, we divided our sample into three: student-teachers who had done a thesis or research project, who had taken a research-methods course, and who did neither (we omitted those who had done both). First, we repeated the $\chi^2$ calculation of the three groups by the 23 code categories, separately for the definitions and descriptions. The $\chi^2$ statistics were nonsignificant; therefore, differences between, not within, the groups warranted most attention.

We then compared the proportions of the two most frequent response codes for definitions and descriptions in turn, for the thesis and research-methods groups combined versus those who had neither prior experience. These two most frequent codes in both cases were #14 (generating questions)
For the descriptions, of 49 coded instances, 34 (69%) of the research-experienced group defined inquiry instruction as acquiring facts from different sources (code #1), versus 15 (31%) of those who had neither experience. The significant sign test probability was \( p = .009 \). The same numbers defined inquiry instruction as generating questions (code #14), \( p = .009 \), also significant. In contrast, neither comparison was significant for the definitions. In articulating descriptions of inquiry instruction, respondents having either thesis or research-methods course experience versus neither, despite similar patterns of frequencies across the 23 codes, used more categories and differed uniquely and significantly in their proportions of the two most frequently assigned codes.

We also checked five other background variables suggested in the literature (numbers of inquiry experiences across schooling levels; grade and subject in which best inquiry experiences occurred; having completed a creative project such as writing a play or song; having designed a curriculum, software, or other product; and months of preservice teaching experience), but none was related to the quality of inquiry understanding reflected in either definitions or descriptions.

**Discussion and Conclusion**

Our first purpose was to examine the words used by secondary preservice teachers to reveal their conceptual and experiential understanding of inquiry and inquiry instruction. A secondary but prerequisite purpose was to develop an instrument and coding system that could reflect their inquiry understanding.

**Measuring the Quality of Inquiry Understanding**

Secondary preservice teachers’ understanding of inquiry and inquiry instruction can be usefully evaluated by coding questionnaire replies in terms of learners’ inquiry-related outcomes. All codes were assigned at least once, but there was wide variation in the frequency with which each was found in secondary student-teachers’ responses to requests to define inquiry or describe inquiry instruction. We concluded that the MISIO-Sm codes in Table 1 can be used effectively to describe the concepts and instructional situations that secondary preservice teachers associate with inquiry.

The MISIO-Sm is built around student inquiry-learning outcomes with which preservice teachers are likely familiar and engaged, and it has a sufficiently wide range of items to enable detection of subtle inquiry-category differences such as detecting changes in teachers’ and students’ roles or collecting data from multiple sources. It might usefully be further explored as a measure of learning about inquiry over the course of teacher education and early-career experiences. The MISIO-Sm codes were sensitive to differences between preservice teachers’ responses considered strong or weak. Each was moderately correlated with the total word-count of the replies. However, correlations were low between categories underlying the definitions versus the descriptions. This result suggests that secondary preservice teachers’ understanding of inquiry occurs separately at conceptual and experiential levels. These two kinds of inquiry understanding include some common and some unique inquiry categories and therefore are not measuring the same thing: Providing a definition of inquiry or providing a description of an inquiry event are not equivalent tasks, at least for a student-teacher.

**Table 3. Learner-Inquiry Code Frequencies for Each Category According to Research-Training History.**

| Codes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Definitions | Did thesis | 14 | 1 | 3 | 2 | 0 | 0 | 1 | 7 | 4 | 14 | 0 | 1 | 0 | 38 | 6 | 0 | 0 | 3 | 1 | 13 | 1 | 0 |
| Took research-methods course | 13 | 1 | 1 | 5 | 0 | 0 | 1 | 9 | 2 | 14 | 0 | 3 | 0 | 26 | 5 | 0 | 0 | 1 | 0 | 2 | 2 | 2 | 0 |
| Neither | 32 | 0 | 2 | 4 | 2 | 1 | 4 | 9 | 7 | 11 | 0 | 2 | 0 | 43 | 1 | 0 | 0 | 0 | 1 | 1 | 5 | 5 | 0 |
| Descriptions | Did Thesis | 14 | 1 | 4 | 4 | 1 | 0 | 3 | 6 | 0 | 6 | 1 | 4 | 1 | 15 | 1 | 3 | 0 | 2 | 0 | 3 | 7 | 6 | 9 |
| Took research-methods course | 20 | 1 | 3 | 1 | 0 | 6 | 3 | 0 | 7 | 0 | 3 | 0 | 19 | 0 | 1 | 1 | 5 | 0 | 5 | 10 | 10 | 7 |
| Neither | 15 | 4 | 1 | 8 | 2 | 0 | 8 | 11 | 0 | 5 | 0 | 7 | 1 | 15 | 1 | 0 | 0 | 5 | 0 | 4 | 19 | 14 | 15 |

*See Table 1.*
sophisticated learning outcomes such as developing expertise, emulating professionals, learning how to learn, and enhancing self-efficacy were rarely coded. The recognition of role changes was, however, insightful and reflected knowledge that research has deemed critical to successful enactment of inquiry instruction (Aulls et al., 2015).

Second, having done a thesis or other research project and having taken a research-methods course were related to secondary student-teachers’ understanding of inquiry and inquiry instruction. The relatively low frequencies of individual students whose replies invoked three or more of the 23 codes is not encouraging; however, it is consistent with Windschitl’s (2002, 2004) observation that extended research experience was associated with inquiry use in just one of his secondary preservice teachers’ first year teaching secondary-science classes. Crawford (1999) also reported a case study that came to the same conclusion.

Hands-on, direct experience with inquiry as teaching and learning might help student-teachers recall salient and more sophisticated elements of inquiry instruction. This is consistent with Meijer’s (2007) observation that a research-methods course improved but did not guarantee inquiry understanding. It is also compatible with the comparison by Syer, Chichekian, Shore, and Aulls (2012) in which student-teachers who had inquiry experiences as teachers were directly comparable with psychology undergraduates who had done a major research project in recognition and valuing of major elements of doing inquiry. However, the education students were better able to articulate the inquiry as a pedagogical approach.

Categories of learner outcomes associated with inquiry as pedagogy are expressed more explicitly in descriptions than in definitions. Taking a research-methods course was a better predictor than past research experience of a quality inquiry-instruction description. However, the quality of abstract or conceptual definitions of inquiry is related to having had prior direct instruction in how to do research.

Research-methods courses benefit from being recent in students’ recollections. Such courses build vocabulary to talk with others about inquiry and help cast student-teachers, perhaps vicariously, into authentic roles that emulate the work of teachers or their professors. Having learned about research methods in a course might enhance the ability to recognize inquiry in one’s own learning history. Skills and dispositions learned, such as choosing a topic based on personal interest, acting as a professional creator of new knowledge, and evaluating evidence, could become connected to the outcomes they remembered from past inquiry experiences. If the course is in education, the links could be even stronger.

Third, generating definitions and descriptions are not only different cognitive tasks, but they also constitute different student resources for preservice teachers to build an understanding of inquiry useful to growth in teaching.

Three types of student-inquiry outcomes are most frequent when preservice teachers define or describe inquiry, namely, acquisition of facts or knowledge using different sources, problem-solving skills, and question-generation. All three were common to both definitions and descriptions of inquiry. Question generation was the most frequent outcome cited in the definitions and third in the descriptions. Problem solving was third in definitions, fourth in descriptions. The fact that they all occur in students’ current knowledge as well as descriptions of past instructional experiences in school affords evidence of their face validity. Our interpretation is that preservice teachers respond at a very concrete level when challenged by the request to conceptually define inquiry, but they are able to articulate broader generalizations about inquiry when they can draw on vivid, well-remembered, personal experiences.

Finally, total word-counts do not indicate the content or quality of an individual’s understanding of inquiry, so they should not be used for individual evaluations, to track learning, or to compare definitions or descriptions.

**Limitations and Opportunities for Further Study**

This study was ex-post-facto and a snap-shot of student-teachers in their last year of coursework toward secondary-teaching certification. Richer data could be available from a longitudinal design more like Crawford’s (1999) or Windschitl’s (2002), but with a purposeful sample that includes student-teachers with a range of experiences in terms of research and research-related courses. We did not follow their progress from acceptance into university to graduation as a teacher and into professional practice, as done by Chichekian, Shore, and Tabatabai (2016), who also triangulated other data, such as interviews and focus groups.

Using the coding categories identified in this study, researchers could use a larger and random rather than a purposeful sample to determine how generalizable the results of the study might be. The use of open coding might also generate additional distinguishing categories among the definitions and descriptions.

**Implications for Theory and Research**

A future model or theory of inquiry instruction should focus on the knowledge bases of preservice teachers and on just two background variables, research-methods training and research experiences. Social-constructivist learning theory (Vygotsky, 1978) seems barely articulated in preservice teachers’ inquiry understanding. Focusing on student-teachers’ understanding and instructional use of their own inquiry experiences might be an important early step toward being able to conceptualize rich inquiry experiences for their own future students.

That student-teachers’ understanding of the nature of inquiry is revealed differently in the quality of general definitions versus the quality of descriptions of well-recalled prior inquiry experiences does not mean that the same distinction characterizes experienced teachers. Rather, the
distinction might especially help describe the trajectory from novice to expert inquiry teacher. Chichekian et al. (2016) specifically addressed this progression, but with regard to self-efficacy for inquiry instruction rather than understanding of inquiry.

**Implications for Practice**

It is feasible in the selection and education of secondary teachers to provide both research experiences and research-methods courses in close proximity to the rest of the teacher-education program. This idea is well established in undergraduate education generally (Boyer Commission on Educating Undergraduates in the Research University, 1998). The conceptually based research-methods course is the easier of the two to arrange and require. It has the most salient links to more sophisticated inquiry understanding and practices. It can also engage students in inquiry projects.

How student-teachers conceptualize inquiry instruction is likely connected to what they actually do during their formal education. Dewey recommended that teacher-education programs have a laboratory school (Tanner, 1997) to facilitate immersing preservice teachers in a culture of simultaneous inquiry learning, teaching, and research. Student-teachers often (but not always) regard practicum experiences as the most valuable part of teacher education (Melynchuk, 2001). Notably, none of our participants reported his or her best inquiry-instructional experiences to have occurred during student-teaching. Instead, they were associated with their experiences in elementary and secondary education.

Teaching student-teachers about inquiry conceptually is probably better done, at least initially, through reference to the design and enactment of their own inquiry instruction. Thesis-like work and research-methods courses can be designed to further build these opportunities into teacher-education programs. It seems unnecessary to worry about what earlier inquiry experiences student-teachers had, in what subjects, or at what level of education, nor to be primarily concerned about the nature of inquiry experiences in “content” courses at the university level.

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**Author Biographies**

**Mark W. Aulls** obtained his BS in education from Ball State University, MA in Reading Education from Indiana University in reading education, and EdD in reading and educational psychology from the University of Georgia. He is emeritus professor of educational psychology at McGill University in Montreal. His research foci are the effects of student-teacher interaction on the development of students’ intellectual skills and on the development and cultivation of inquiry learning and instruction in students, teachers, and preservice teachers.

**Diana Tabatabai** received her MA in educational planning from the University of Toronto, and PhD in educational psychology from McGill University. She has worked as a research associate with the Toronto Board of Education, in private industry on planning and project development, as well as in medical education, psychiatry, and educational psychology at McGill University in Montreal.

**Bruce M. Shore** holds a BSc specialized in mathematics and chemistry, a teaching diploma, and an MA in education from McGill University, and a PhD in educational psychology from The University of Calgary. He is emeritus professor of educational psychology at McGill University in Montreal, Fellow of the American Educational Research Association, and a licensed psychologist. His research is on intellectual and social qualities of giftedness and on inquiry-based teaching.