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Science Student Role: Evidence of Social Structural Norms Specific to School Science

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Abstract: Sociocultural studies of science education have consistently recognized the dialectic nature of students' agency to create and author positions for themselves and the structural constraints that may influence them. This mixed-methods study explores one particular aspect of these potential constraints: the possibility of a social structure specific to school science, using the concept of a science student role as an indicator. The first phase of the study was qualitative and exploratory, using open-ended questionnaires and interviews to understand students' views of the expectations placed on them as science students ($n = 95$). The second phase was quantitative (using items developed from the qualitative analysis), with both exploratory and confirmatory elements ($n = 157$). Results suggest clear and explicit role understandings among these students, characterized by references to expectations of intelligence, experimental skill, scientific mindedness, and appropriate classroom behavior. The consistency of these expectations across genders, science teachers and schools provides evidence that there is an element of social structure specific to school science that needs to be considered in studies of student agency and identity. © 2010 Wiley Periodicals, Inc. J Res Sci Teach 48: 367–395, 2011

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Researchers examining the concept of identity as it relates to science learning have consistently worked from the assumption that social and cultural constraints and influences are an inextricable element of identity processes. In a seminal illustration of the value of identity as a frame for understanding engagement in science, Calabrese Barton (1998) argued that ''perceptions of and choices about self and science are influenced by the various and complex power arrangements active within the science and educational communities, within families, and within society in general'' (p. 382). Tan and Calabrese Barton (2008) probe students identities-in-practice, recognizing the repertoire of identities in play for students within science contexts and that ''these identities are often hierarchically valued or positioned by others through power relationships and societal structures'' (p. 49). Taking a discursive approach to identity, Rahm (2007) framed her analysis with the following reference to social and cultural influences, ''Utterances are never neutral but were spoken by others previously, and hence, are associated with certain social groups and positions. Accordingly, meanings of science that are situationally defined also need to be understood in terms of the kinds of social groups and positions such ways of talking are associated with'' (p. 520). Within this literature there is a consistent recognition that students are not free to be whomever they want to be in science, that in authoring identities they must also negotiate established meanings, expectations, and power relationships.

The exact meaning and definition of the social groups involved and the specific nature of the constraints or resources has, however, varied in these conceptualizations. For example, Malone and Barabino (2009) examine the reproduction of racial meanings in self-definitions of science graduate students, emphasizing the impact of society-wide social structures. Similar analyses have addressed (re)production and influence of

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gendered and class-referenced structures (e.g., Brickhouse & Potter, 2001). Others have emphasized the importance of the structural impact of the culture of schools. Gilbert and Yerrick (2001) narrowed their focus to the school specific structures of tracked classrooms and Olitsky (2006) illustrated the constraining role that school-level discourse can have on the options that students see for themselves in science.

Still others (e.g., Carlone, 2004; Lee, 1998, 2002) have highlighted the impact of the social meanings typically associated with science and scientists. Lee in particular emphasizes the meanings and requirements associated with wanting to become a scientist. In considering social-structural influences at play for students in science, it is important to recognize, however, that classrooms are not the same as scientific communities. Students may be expected to act in ways related to the practice of scientists, and their views and perceptions of the nature of science will certainly impact their views and perceptions of themselves in school science but they do all of this within a classroom context, which carries with it particular school-related expectations and versions of scientific behavior. For example, atheoretical inquiries can dominate in classroom situations (Windschitl, 2004) and practical experiences are often used to illustrate known ideas rather than to generate new understandings (Bowen, 2005). Archer et al. (2010) illustrate that even young children make a distinction between doing school science and the science of scientists. In this study, we therefore turn the consideration of structural influences directly on the culture of school science, asking whether there is evidence of specific structural elements (that may act as identity resources and constraints) emergent from students' position within science classrooms. These elements are most certainly intertwined with larger structures related to race, gender and class, and to the culture of science, but we ask whether there is also an element that is particular to school science.

Social Structure and School Science

Structure, as we take it, refers to underlying patterns, expectations, and norms that influence relationships and behavior within social groups (Sewell, 1992). Stryker (2008) emphasizes the durability of these patterns of interaction and their strong capacity to be reproduced. It is a concept that has been invoked in the social sciences both to explain and predict actions and interactions in communities and other social groups. The original metaphor was one of a building where the framework of the structure itself influences the behavior of all within it (Sewell, 1992). This view, however, wrongly suggests that social structure is something separate from the people and communities who move through it. Social structure is created by individuals in their interactions with each other. While it is most often already existent from the point of view of a new individual (e.g., a new baby born into a family or a novice entering a community of practice), it would be misleading to suggest that it something external to people and their communities. Sewell argues, therefore, for a less rigid understanding of structure, proposing instead that it be viewed as ''the tendency of patterns of relations to be reproduced even when actors engaging in the relations are unaware of the patterns or do not desire their reproduction'' (p. 3). This change in focus shifts our conceptualization from one of objective external pressures (i.e., immovable walls, beams, and doors) to one of a socially constructed (and continuously produced and reproduced) system that is at the same time both robust and dynamic.

Social structure here is taken broadly—not referring necessarily only to the embedded inequalities assumed in analyses related to race, gender, and class, but instead recognizing that any social group or social space may have a social structure (a typical pattern of interactions including expectations and norms required for participation). This approach (while it may name the processes and results differently) actually has some degree of common ground with the idea of figured worlds (Holland, Skinner, William, & Cain, 2001), defined as a ''realm of interpretation in which a particular set of characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others. Each is a simplified world populated by a set of agents . . . who engage in a limited range of meaningful acts or changes of state'' (p. 52). Here school science is the proposed figured world—much like Basu, Calabrese Barton, Claimont, and Locke (2009) approach physics as a figured world offering agency and identity development possibilities to students—but the level of analysis is moved from the figured world of individual students to a place where patterns in the features and characters of these figured worlds can be examined. Patterns in the permissible actors and characters and the valued outcomes and acts across different contexts (e.g., across classrooms) is understood here as evidence of a social structure of school science. This requires a different theoretical view than Holland et al., as it proposes a structure beyond the figured world and emphasizes connections that may be external to it.

In looking to address one element of the complex and interconnected systems that influence students' identities, we position this paper within the *Personality and Social Structure Perspective* (PSSP) (Côté & Levine, 2002). Côté and Levine propose the PSSP as a way to bring together diverse perspectives on the study of identity. One of its primary theoretical commitments is that identity as a construct cannot be understood through any single theoretical or methodological perspective. They suggest instead a meta-theoretical recognition of three possible levels of analysis in the study of identity (Personality, Interaction, and Social Structure). As above, *social structure* describes the patterns that characterize, facilitate and constrain groups and societies, including social norms, social roles, and the conformity pressures that individuals may experience within these groups. The level of *interaction* describes the day-to-day actions and discourse exchanged between individuals. It is at the level of interaction that individuals form and present their unique selves to those around them and where they learn from the reactions and beliefs of those around them about the expectations of a social group (including the degree of their success in meeting these expectations). The level of *personality* refers to the individual self. It is here that Mead's conceptions of *I* and *me*—one subject (where individuals create, present and author versions of themselves and conceive of their agency in a social group) and one object (where self-concepts and self-perceptions are constructed and learned in the responses and expectations of others)—reside. It is also the level of personality that acknowledges the sameness and continuity that individuals feel moving through time and from one social context to another. It is in the articulation between these levels that the processes related to identity reside, as illustrated in Figure 1.

In proposing the PSSP as a meta-theoretical framework, Côté and Levine argue that it allows researchers to step back and see broader connections between their work. Côté (2006) emphasizes the links that it allows between approaches founded in different theoretical convictions, suggesting that studies that might be considered subjectivist, objectivist, critical, status quo, and those with an individual focus or a social focus may all be considered to fall somewhere within this framework. They may examine these processes with conflicting methodologies and understand the latent processes that guide identity processes differently but a complete understanding can only be achieved through their integration. This is much like Polanyi's (1969) assertions that continuous movements through different levels of analysis is necessary in analyzing any complex system: each time we foreground a different level, we obscure information evident in another but at the same time we uncover patterns and details not previously evident. Working within the PSSP allows us to foreground one particular (and small) piece of the science identity puzzle (a social structure specific to school science) without rejecting or necessarily implying contradiction with important understandings developed by

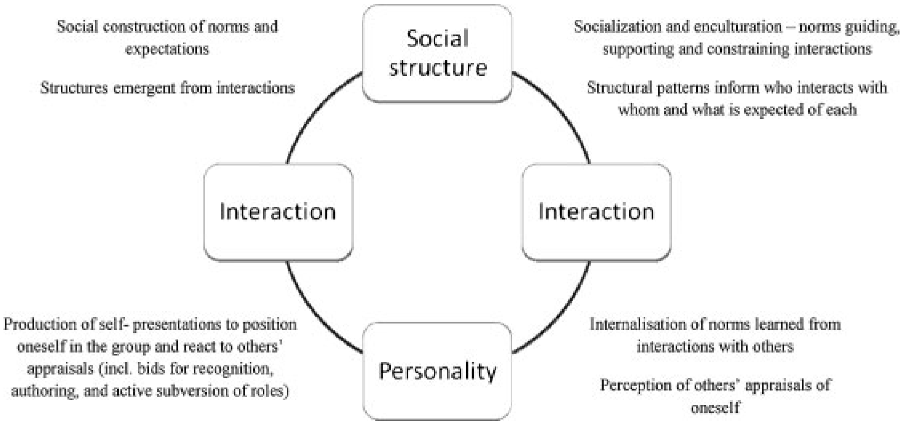

Figure 1. The location of identity processes in the articulations between levels of social analysis. (Figure based on those proposed by Côté and Levine (2002) in their discussions of the Personality and Social Structure Perspective and on those presented in Shanahan, 2009.)

others in their examination of other levels and from other theoretical positions, for example, Aschbacher, Li, and Roth's (2010) examination of the community and interaction influences on individual students' science identities and their persistence in science, located primarily between the levels of the interaction and personality, or Calabrese Barton and Tan's (2010) exploration of students appropriating and challenging typical definitions and authoring new positions for themselves as science experts, a study taking a critical and subjectivist view of the articulation from personality to interaction.

Studying and Understanding Social Structure

Our particular approach to understanding social structure draws on the theoretical position of structural symbolic interactionism (Burke & Stets, 2009; Stryker, 1980[2002], 2008). From this perspective, interactions between people lead to the creation and understanding of shared symbols that help individuals define social situations and the actors they encounter in them. Labeling others and oneself in relation to those symbols invokes expectations that can influence behavior through ongoing (and often subtle) negotiations. Within structural symbolic interactionism (as opposed to other versions, sometimes called traditional symbolic interactionism, such as Denzin, 1992) there is an ''emphasis on the expectations of others as constraining actors' definitions of situations—their definitions of self, of others, and of remaining objects in the situation; the view of social structure as in part facilitating and in part constraining the choices made by human actors'' (Stryker, 1980[2002], p. 86). Seeing social structure in this way, it is a very abstract idea. Our individual senses are not well adapted to seeing beyond our local interactions (Burke & Stets, 2009). To the individual, social structure is evident in the expectations and reactions of others, which constrain and facilitate individual behavior. To the analyst, social structure is evident in patterns. But how to gain access to these patterns?

Among the symbols that are learned, created and invoked in interaction are those marking *positions*—social categories that an individual may occupy. They are ''symbols for the kinds of person it is possible to be'' in society or a social group (Stryker, 1980[2002], p. 57). Positions can be normative and institutionally assigned (e.g., science teacher, emergency room physician, municipal politician) or more open and based on interests and activities (e.g., basketball player, hockey fan). These various types of positions mirror in some ways Gee's (2000–2001) description of different types of identities based on in-born attributes, institutional assignments, affinity groups, and discursive patterns. Regardless of the source of the positional definition, the position label leads to behaviors that are expected from the individual residing in the position and expected towards that individual. Taken together, these expectations constitute a *role*: ''the set of expectations tied to a social position that guide people's attitudes and behaviour'' (Burke & Stets, 2009, p. 114).

The expectations that constitute roles are considered robust but not necessarily rigid. Depending on the social context and nature of the position, the expectations can vary from group to group. Roles also vary in the degree of adherence required. Some roles can carry little influential normative power while others may require strict observance. Different positions and groups can impose varying degrees of sanctions for failing to meeting role expectations or to interact with others in role appropriate ways, and the expectations themselves may range from broad and general to specific and detailed:

> They can require precise performance of specific behaviours or can simply exist in the form of an outline within which a great deal of improvisation can take place; they can be very clear in their demands or vague and uncertain; they can apply to a minimal segment of one's range of interactions or across the whole of that range; they may attach to positions in formally organized social structures or relate to informal social relationships (Stryker, 1980[2002], p. 58)

In invoking the concept of a role, symbolic interactionism does not insist on a totally deterministic relationship between perceptions of role expectations and role behavior (unlike traditional role theory). Roles are better understood in relation to Linton's (1936) idea of ''ideal patterns,'' held up as models for behavior and standards that shape interactions. And while these ideal patterns are never fully replicated in behavior, social behavior is influenced by them. Additionally, role making, role taking, identity trying, and identity authoring all provide opportunities to accept, challenge, or subvert role expectations, further lessoning their deterministic power. Callero (1992) and Collier and Callero (2005) also make the important argument that there is no single role definition that exists outside of the group participants. Each individual understands a role in unique ways based on the interactions through which he or she has learned about it. In any true social group, however, while the exact form of the role may differ from person to person, it is the patterns of common expectations understandings across people that are more rightly called ''role.'' Understanding a role can best be understood to give an individual a strong probabilistic (rather than deterministic) sense of the behaviors, expectations, and reactions of others within a particular group or context (Kuhn, 1968, as cited in Stryker, 1980[2002]). Similarly role gives the analyst a probabilistic sense of the likely expectations influencing the behavior and interactions of these individuals.

It is this probabilistic nature that supports the connection between role and social structure. As described above, from the interactionist perspective, it is stable and repeated interindividual and intergroup patterns of interaction that constitute social structure (Burke & Stets, 2009), and the relevance of larger social structures is in affecting the probabilities that interaction will take on particular forms and content—that particular people will interact with each other in particular ways. ''Indeed one way of defining (or ascertaining the existence of) social structures is precisely in terms of the degree to which such probabilities are affected'' (Stryker, 1980[2002], p. 69). One of the most salient guides of interaction within social groups, is role. Roles suggest the model patterns for how individuals should be expected to behave and react to one another. Seeing patterns in role understanding is therefore taken as evidence and instantiation of social structure. For example, finding patterns in role understandings among female basketball players across the country would suggest that there is a larger social structure of women's basketball beyond the social groups of individual teams or clubs. Finding these role expectations to be different from those of female athletes or athletes in general suggests a social structure specific to women' basketball. Role is in a sense a technic—it is a proxy that depends on our theoretical understanding. Like an assay test for viral infection where our understanding of viral mechanisms leads us to a test that takes the presence of certain antibodies as an indicator of the presence of the virus (Corbett, 2010), our understanding of social structure leads us to believe that evidence of predictable role patterns across individuals and across groups is taken as an indicator of the presence of a social structure.

In the context of the science classroom, approaching social structure through the study of role provides a framework for examining the enduring and historically constructed meanings associated with science and school science. So far, one of the only applications of role concepts to science students has been Lee's (1998, 2002) explorations of the gender differences in students' relationship to a ''future scientist'' role. For example, Lee (1998), asked teenagers participating in a summer science program to compare themselves to peers who want to be scientists. School science was not part of his framework. There is also a well-developed literature surrounding students' understanding of scientists and science professions (e.g., Chambers, 1983; Finson, Pederson, & Thomas, 2006; Scherz & Oren, 2006) but do these expectation translate directly to the expectations students perceive for themselves? Examining role as evidence of a social structure of school science allows us to begin to piece apart this relationship.

Figure 2 illustrates this approach in further detail. We are interested in questions of a social structure specific to school science. This is, of course, only one aspect of the structures that would be salient for students in a science classroom. First, any school science-related structure is no doubt related to and overlapping with structural elements related to science as a larger enterprise, perhaps related to students' and teachers' understanding of the nature of science. Similarly there is overlap with the structures inherent to the nature of schooling. School science takes place within the context of school more generally—students read textbooks, take notes, study for tests, listen to their teachers and receive report cards just as they do in all other subject areas. We suggest, however, that there is more to science education than just a place where the social structures of science and of schooling overlap. We suggest that there may be structural elements specific to school science and differing from both the general structures of schooling and of science. Note also that we recognize, for example, that school structures not confined to science education (such as diplomas and overall grades) can act as gatekeepers into the world of science. There is also therefore overlap between the social structures of schooling and science, beyond that taken into account by school science (although these elements are not our focus here). In seeking to explore the idea of a social structure of school science, it is also important that we recognize that all of these structures are also embedded in larger societal structures (such as

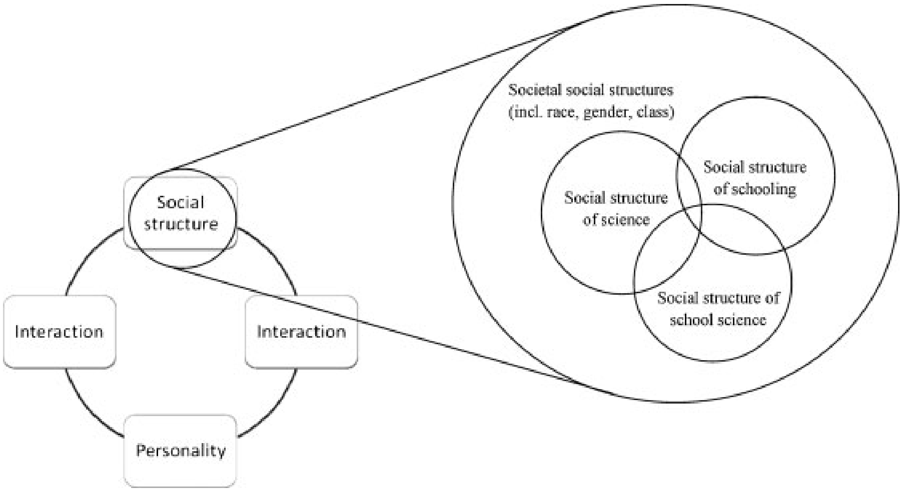

Figure 2. Locating this study within the PSSP and the various social structures relevant to the science classroom.

those related to race, class, and gender) and that any school science social structure cannot be understood to be isolated from them.

In approaching social structure and role in this way, we are cognizant that this requires certain theoretical commitments. This study asks, in an exploratory way, whether there is evidence (in the form of patterns in role understanding) of social structural elements that are specific school science. This positions the study as taking a status quo approach rather than a critical one (Côté, 2006), not in the sense that status quo is necessarily considered acceptable, but instead meaning that the focus of our analysis is on what *is* rather than what might or should be. We maintain a dual perspective in this regard, as we hope that our status quo approach may be a resource for the further work of those with more critical perspectives. Furthermore, we are also social in our perspective rather than individual. While our data collection emphasizes individuals and their perceptions, the unit of analysis is neither the individual nor his or her version of the science student role (developed through the sum of individual interactions related to school science), it is instead each of the expectations expressed in the individual reported versions of the science student role. These expectations are then examined for patterns—with these patterns understood to be an embodiment or reflection of social structure. We also propose a dual objectivist/subjectivist position based on the above understanding of our analysis. Our perspective on the individual student is a subjectivist one—in asking for their understanding of the science student role, we view each student to have a subjective understanding of what is expected in school science, each student having experienced and created different interactions and subjectively interpreted those interactions to build their understanding of school science. As we move from the level of the individual student to the level of the structure of school science, we move to an objectivist perspective—making the assumption that from the subjective interpretations of individual students, meaningful objective patterns may be found in their interpretations. In understanding social structure as consisting of patterns, this objectivist position (characterized by the assumption of an outside observer or analyst) is embedded.

Methods

In our study, we employ a sequential mixed-methods design (Tashakkori & Teddlie, 1998) for understanding students' perceptions of the school science role, using exploratory qualitative approaches that lead to more confirmatory quantitative approaches. We should make clear that our intent is not to move towards an overall quantification of identity and related constructs, a task that would be both undesirable and impossible.

Instead, we propose that quantitative methods offer the opportunity to study an aspect of the identity process (the patterns of social structure) that can help to inform and complement the deep qualitative study necessary for probing other aspects.

Data Collection and Participants

This study was undertaken in two parts: (i) an initial exploratory qualitative phase aimed at eliciting students' perceptions of the role (Phase 1), and (ii) a more confirmatory quantitative phase aimed at verifying the relationships between the expectations found in Phase 1 and examining whether these expectations are associated with the science student role rather than a more generalized student role (Phase 2).

In both phases, the samples included students enrolled in Grade 10 Academic science courses in Canadian high schools within the Southern and Eastern parts of the province of Ontario ($n_1 = 95, n_2 = 157$). Grade 10 classes were chosen because this is the final mandatory science course in the Ontario high school program and therefore this grade level provided access to: (a) students with widely varying degrees of identification in science—including those who will choose courses aimed at a career in science and those who will take only the required courses and no more, and (b) students who have a well-developed sense of what it means to study science—younger students in mandatory science courses would not have had as much opportunity to develop their perceptions of the science student role. Also in both phases, efforts were made to gather responses from a wide and diverse group of students. Both urban and rural schools were included in different regions of Ontario, and within these settings schools with differing socio-economic and ethnic populations were sought. In both phases, the individual schools selected from the different regions and types were selected on a convenience basis, drawing upon the researchers' connections in the teaching community and on invitations sent to district level consultants and officials. Interested principals and department heads contacted the researchers based on these invitations. Within each school, all teachers with Grade 10 teaching responsibilities were asked for permission to enter their classes to invite student participants and to conduct the study. All eligible teachers in the selected schools agreed.

In Ontario, the content of the all science courses is highly prescribed in the mandated curriculum, which specifies outcomes in three categories: Relating Science and Technology to Society and the Environment; Developing Investigation and Communication Skills; and Understanding Basic Concepts (Ministry of Education and Training, Ontario, 1999). Teachers, however, choose the activities that are part of the day-to-day teaching and learning to meet these expectations. Individual classrooms can therefore be very different in the way that the curriculum is enacted—some teachers and schools may emphasize open inquiry while others maintain structured, teacher-directed programs. Most classes use one of two common approved textbooks but again the way they are used is decided by the teacher and the school or department. Some may remain in strict lockstep with the text while others may refer to the text only in passing and provide it more as an additional resource for students to access. There are therefore many ways in which the interactional contexts may vary for the students in this study and the search for intergroup patterns across these contexts is an important element of the analysis. And while we do examine potential teacher-related differences, the connections between role understanding and these possible day-to-day teaching practice differences are not examined here.

One aspect of the experienced curriculum that will be common to all students is the organization of their course as a general science course. Like other subject areas, the science curriculum takes a parallel development approach. From Grade 1 to Grade 10, all Ontario schools offer a general science program, where each year includes content from four streams: biology, chemistry, physics, and Earth and space science. Their Grade 10 science program included units focusing on chemical processes, ecosystems, weather dynamics, and forces and motion. It is for this reason that the questions are posed with respect to a *science student* role—the institutional and practical definition for these students is as science students (rather than, e.g., as chemistry students).

Phase 1 involved 95 students from three publicly funded Ontario high schools (one inner-city, $n = 19$; one suburban, $n = 24$; one rural, $n = 22$) and one private school (urban, $n = 30$). These schools were chosen to create a maximum variation sample (Creswell, 2008). Table 1 summarizes some of the factors that were taken into consideration during the construction of this sample and the differences between the schools that

Table 1
Available demographic information for Phase 1 and Phase 2 schools

	Comparative Household Income Level[a]	Grade 9 Math Achievement[b,c]	Percentage English Language Learners[c]	Percentage With Special Learning Needs[c,d]
Phase 1				
Inner-city	Low	Above	10	15
Suburban	Medium	Equal	1	17
Rural	Low	Below	0	27
Urban private	High	N/A[d]	2	2
Phase 2				
Inner-city	Low	Equal	20	9
Rural	Low	Below	0	16
Suburban private	High	N/A	5	3

[a] Average household income category of the census region from which the school draws its primary population reported in comparison to provincial average (medium values indicates that it is approximately equal to the provincial average). Data from 2006 Canadian Census (Statistics Canada, 2008).

[b,c] Percentage of students meeting or exceeding provincial standards reported in comparison to all of the schools in the province.

[c,d] Data from Ontario Education Quality and Accountability Office (2010).

[d] Private schools in Ontario are not required to participate in EQAO testing. ELL and special needs percentages gathered from the school principals for these two schools.

were selected. The sample was roughly balanced between male ($n = 51$) and female ($n = 44$) participants. Racial and ethnic background information is not available for individual students or their schools due to district level privacy policies and ethical guidelines. Phase 2 included 157 students from three Ontario high schools. This sample was again selected for maximum variation and included students from one rural public school ($n = 45$), one inner-city public school ($n = 76$), and one suburban private school ($n = 36$) (different schools from Phase 1) (see Table 1 for a comparison of the schools). There were, however, more than twice as many female participants ($n = 106$) as male participants ($n = 51$) in the Phase 2 sample. The analysis presented here includes all of these participants, but to address the over-representation of female students, a follow-up analysis was conducted with a random sample of female participants equal in size to the number of male participants.

Phase 1—Qualitative Data Collection and Analysis

The study began with an exploratory phase asking students about their perceptions of the expectations associated with the science student role. This approach of asking openly for participant understandings of role expectations is consistent with established structural symbolic interactionist approaches to studying role (e.g., Burke, 1980; Callero, 1992, 1994; Collier & Callero, 2005). It is emblematically interactionist to emphasize the participants' perceptions rather than relying on the researcher to provide possible expectations for participants to respond to (Stryker, 1980[2002]).

In order to balance the need for in-depth discussion with that for eliciting responses from a wide variety of students, data were collected in two ways: open-ended questionnaires and individual interviews. In both instances the questions aimed to elicit responses highlighting the expectations specific to the science classroom. The open-ended questionnaires consisted of two items based on those developed and tested by Collier and Callero (2005) for the exploration of the expectations associated with other roles:

(1) Compared to all other students, a science student is *more* likely to . . . (Fill in with what you think a science student is more likely to be expected to do or be like.)
(2) Compared to all other students, a science student is *less* likely to . . . (Fill in with what you think a science student is less likely to be expected to do or be like.)

All 95 participating students completed this questionnaire. From these students, approximately one-third ($n_{\text{int}} = 33$) were randomly selected for individual interviews lasting approximately 20–30 minutes.

During the interviews, students responded to further open-ended questions addressing the science student role (e.g., How would describe someone that you think is an excellent science student? If a group of science teachers were in the staff room talking about the ideal science student, what might they say? What do you feel that your teacher expects of you during science class?). They were also asked clarifying and probing questions based on their survey responses (e.g., Which of your questionnaire responses do you think are most important in science class? Which ones do you think are different from being a good student in general?).

Qualitative data analysis proceeded through a coding-recoding study cycle identifying major themes (Miles & Huberman, 1994). The open-ended questionnaires were analyzed first and then the interviews were used to triangulate the findings and note any new themes not present in the questionnaire data. The interviews were also used to clarify and confirm the intention of students' written statements. We began the coding of the questionnaires by parsing the responses into text segments ranging in length from a single word to a paragraph where each segment addressed a single expectation. Overlapping sentences that connected more than one expectation were copied and included in both adjacent segments to provide context and note the connections that students expressed. These segments were then grouped with others explicitly representing the same behavior or attribute expectation. During the first round of analysis these groupings aimed to be as discriminating as possible, grouping text segments only when they expressed very similar ideas. These were called first-level themes. The interview transcripts were then analyzed similarly and these expectations were compared with and added to those identified in the surveys. Finally, these expectations were themselves analyzed and second-level codes were used to collapse groups of expectations together where appropriate (as determined by *interpretation* of students' meaning, especially where supported by their interview transcripts or evidence from the broader literature) and organize the types of expectations that students perceived into thematic groups (second-level themes). The process is recognized to be an interpretive one that no doubt relied on the researchers' understanding of the nature of science and of school science.

Phase 2—Quantitative Data Collection and Analysis

In Phase 2, an instrument was developed that included clusters of 3–14 questionnaire items that reflected the expectations identified by the students in Phase 1. Participants were asked to rate the importance of these expectations (such as inquisitiveness and mathematical ability) to science students and students in other classes. The goal was to gain a more precise understanding of students' views of a science student role by separating out those expectations that they might associate with a more general *student* role or with other students roles (e.g., history or literature) and to seek triangulating evidence for the relationships and groupings proposed during the qualitative analysis. Burke (1980, also Stryker & Burke, 2000) emphasizes the importance of understanding roles as they are defined in relation to counter-roles and oppositional roles. We take a position closer to Collero's (1992), however, and emphasize the comparison to non-holders of the role (i.e., others) rather than seeking an opposite student role. This is because in a high school, students are asked to be different types of students over the course of the day. They may be both history students and science students within minutes of each other. Additionally, defining a role that is the direct opposite of science would not be possible. School-related roles would presumably exist in parallel to each other, sharing many common elements.

Based on the expectation themes emerging in Phase 1, category response items were created for five proposed instrument subscales. Each subscale represented one of Phase 1 themes and consisted of 3–14 individual items (subscale construction procedures based on DeVellis, 2003). Consistent with Callero's (1992) guidelines for measuring role (see also Collier & Callero, 2005), all of the items were created to be part of a single question: "How likely are the following students to . . ." Each item then presented one expectation drawn from the Phase 1 analysis and was followed by five possible response categories ranging from "very likely" to "very unlikely." The exact wording used by participants was used wherever possible. For example,

How likely are the following students to…

1. …ask questions such as 'how does that happen'? Science students:
very likely ___ ___ ___ ___ ___ very unlikely
Other students:
very likely ___ ___ ___ ___ ___ very unlikely

For each of the subscales, differences between the students' scores for science students and other students were examined through multivariate analysis of variance (MANOVA) profile analysis in SPSS. Profile analysis is a special case of MANOVA where several dependent variables that are measured on the same scale can be compared for different groups (Tabachnick & Fidell, 2001). In this case, the dependent variables were the items in each of the subscales and the groups were the students' responses for science students and other students. This provides a more detailed analysis than a single comparison of mean scores. It allows the research to also examine patterns in individual item response that may different for each of the groups.

Profile analysis makes three basic comparisons between groups based on the profile of responses and our focus was on two of these tests: test of levels and test for parallelism (Tabachnick & Fidell, 2001). The test for *levels* examines the differences in the means for each of the groups across the combined dependent variables. In our study, it includes examining the differences in means between science students and other students for all of the items in each subscale. It is similar in effect to a *t*-test to compare the mean scores for each group, except that it is calculated based on the mean difference for each of the items rather than on a single subscale score. The test for *parallelism* examines the shape of the profiles and asks if the slope of each segment in the profile is the same for both groups. From this analysis (including both levels and parallelism), subscales that did not sufficiently differentiate science students and other students could be best identified. If combined subscale scores had only been used differences may have been missed. For example, consider the following rating possibilities for two hypothetical items: interest in math and interest in dance. Imagine that for some reason they were part of the same subscale (e.g., interest in school subjects). If the ratings for science students had been $math = 5$ and $dance = 1$ and for other students they had been $math = 1$ and $dance = 5$, a test for mean difference that only used combined subscale scores would find no significant difference between the ratings for the two types of students even though there is clearly a difference in the patterns of their responses. Using profile analysis allowed us to be more confident that we had fully examined possible similarities and differences between the groups of expectations identified for science students and other students.

The second goal of the Phase 2 analysis was to examine the support provided by the quantitative data for the Phase 1 thematic analysis. This was accomplished through confirmatory factor analysis (CFA). In CFA, the goal is to *test* the fit of a theoretically supported or created model—for example, testing whether proposed subscales load on a single factor. In contrast, exploratory factor analysis seeks to *find* a model of underlying factors that suits the data, and although it is sometimes used for confirmatory purposes (e.g., asking if the emergent models is the same as the proposed model) the underlying mechanisms are not confirmatory in nature (Schumaker & Lomax, 2004).

CFA was conducted using LISREL, which uses structural equation modeling (SEM) to test the fit of proposed models. The following model fit indices were used to assess the fit of each factor model: minimum fit function chi-square (good fit indicated by non-significant result at 0.05 level), root mean square error of approximation (RMSEA; values under 0.05 acceptable), and goodness of fit index (GFI; values >0.95 acceptable) (Schumaker & Lomax, 2004). For all goodness of fit indices used here, p values of >0.05 reflect good model fit. This non-significant result suggests good model fit because it indicates non-significant differences between the proposed model and the data.

Results and Discussion

Phase 1

Phase 1 was a qualitative exploration of students' understanding of the science student role. As role is understood to be comprised of expectations learned and created through interaction, the results are presented here in the form of expectations that students perceive to be associated with the role. In our analysis we actively sought both commonalities and differences in students' responses by gender, teacher, and school. There were, however, very few differences evident in the distribution of expectations associated with these themes. Therefore, the themes are presented as general student views. To support the consistency of these views across students, a table comparing percentage mentions by different student groups is presented after all of the overall qualitative analysis has been explained. Possible differences are examined further in Phase 2 through statistical group comparisons.

The themes presented here will be discussed in two categories. During the analysis it was evident that students were most often discussing two different types of expectations: (a) actions that students are expected to take (e.g., ‘‘They ask questions . . . they try and think about something else that might happen because of what you’ve been told or what you’ve been taught’’) and attributes that students possess (e.g., ‘‘They’ve got to be very observant’’). See Table 2 for a list of the first-level themes that were identified in the *Actions* category and in the *Attributes* category (note that it is a coincidence that there are a similar number in each category). Each theme will be presented here with representative quotes from students. We do not report frequencies, because the goal of Phase I was to explore the possible meanings that the science student role has for students, not to rank and compare these meanings.

Actions. The first-level themes collected under the Actions category all represent behaviors associated with being a science student. Students spoke of them mainly as expectations (e.g., ‘‘Science students are expected to . . .’’), but also used language such as ‘‘they/I could . . .,’’ suggesting that there was a degree of agency represented by the actions. Students could to a certain degree, choose to take on these behaviors if they wanted to be more like science students (e.g., ‘‘If they want to work hard, they could be better’’).

One identified action was ‘‘asking questions’’ which students expressed as: ‘‘Science students should ask questions like ‘why does that occur?’ or ‘how does that happen?’’’; ‘‘A science student tries to get the question of how and why to the very last bit of info they have.’’ These examples also demonstrate a complexity in the Phase 1 data analysis. Despite often clear language differentiating actions and attributes, in some cases student expressed both meanings simultaneously. The following response illustrates this type of response with action-related language shown with double underline and attribute-related language shown with single underline:

> Science students are more likely to be expected to be like questioners. To be a good science student you should have some sort of need as to know ‘‘why?’’ or ‘‘how?’’ They should want to know what happens when you mix two chemicals together and wonder what they’ll find when they slice open their frog. . . . Most importantly, when they show up, they should ask questions. A science student is more likely to question, doubt, create new ideas, listen and voice what they think.

This comment blends the idea of asking questions as an action with the idea that being a questioner is an attribute. In the first-level analysis, we approached this issue by recognizing both aspects of the students’ responses and creating similar thematic groups classified as actions and attributes (e.g., see Attribute theme ‘‘Inquisitive’’). We return to this tension later in the analysis.

In addition to questioning, students also identified three expectations that related to regular classroom behavior: follow the rules, work hard, and follow instructions. Students wrote and spoke of these in a very similar manner, describing them as being part of being a good student. They were therefore coded as three subthemes under the action, ‘‘Be Good’’ as in be a good student. With respect to following rules, they wrote and said, for example: ‘‘I am expected to be in class on time. I am also required to bring utensils to class and not to drink or eat food;’’ ‘‘A science student needs to respect others and everything in the science class.’’

Table 2
Summary of emergent first-level expectation themes grouped by action or attribute

Actions	Attributes
Ask questions	Serious and focused
Be good	Intelligent
Work hard	Able to understand scientific concepts
Follow the rules	Good at math
Follow instructions	Gets good marks
Be safe	Skilled with their hands
Rely on facts and logic	Skilled at conducting experiments
Memorize facts and formulas	Logical
Make detailed observations	Inquisitive
Thinking creatively	

In addressing working hard, students stated, for example: ‘‘A science student is expected to always try your hardest to understand what your teacher is saying. They are also expected to always complete your labs and homework assignments . . . You also have to thoroughly study your notes before a test or exam.’’ Working hard in class also included participating in labs, discussions, and other classroom activities: ‘‘Science students are less likely to be expected to not just sit there and not do anything in your class. The teacher would want you to come and answer your questions and be there all the time to do projects and stuff.’’ Finally, participants believed that science students are expected to follow instructions and pay attention: ‘‘Always paying attention to all lessons in class is an important value and follow the rules exactly when conducting an experiment.’’

A question could be raised at this point as to whether this overall theme, of being a good student, should be included here. Is it really part of the science student role or something more generally expected in any classroom—part of an overlapping general student role? We decided to include it at this point because students made it clear that it is especially important in science: Science students ‘‘do more work because science is the hardest course;’’ ‘‘I think the expectations are pretty strict and hard but I can see why because in science you can’t really screw up.’’ This question, regarding whether being a good student is part of the science student role, is further explored in the follow-up quantitative analysis of Phase 2.

In addition to the expectation of being a generally good student, participants expressed the need for science students to be good in another way: to be safe. Labs and chemicals figured prominently in students’ descriptions of science classes and especially in how science differs from other subjects. They articulated that the presence of certain materials and equipment added a further dimension to their teachers’ expectations that they ‘‘be good.’’ For example, ‘‘Be more responsible if you’re in a class because of all the equipment. Be safe around all the different chemicals. Don’t horse around because a science room is dangerous.’’ One student expressed this with exceptional clarity, writing:

> Due to the overall nature of science and the materials related to science, a student has the task of applying or acquiring a certain knowledge as to the different equipment used and its basic function. With science involving a number of experiments, science has the extra element of safety intertwined.

While this expectation appears very closely related to the previous one, because of its very specific science focus (as compared to ‘‘be good’’) it was kept separate for the first-level analysis.

Another theme very specific to the science classroom was that of relying on facts and logic to make decisions. According to the participants, science students are ‘‘expected to put logic before beliefs.’’ Students contrasted this expected behavior in science with the expectations of creative pursuits. According to the participants, science students are meant to rely on facts only and not opinions or beliefs: ‘‘A science student is more concerned with concrete evidence than opinions (unless they are supported through legitimate evidence).’’ This differed somewhat from the other expectations because it appeared to be tied specifically to students’ understanding of the nature of science rather than necessarily to classroom science. While an analysts perspective might suggest that several of the perceived expectations are related to students’ views of the nature of science, this was the only theme in which students themselves consistently made reference to scientists and science outside of school: ‘‘Scientists are more susceptible to . . . think ‘‘Oh, we have solid scientific facts saying this is how the world was created. It wasn’t God.’’ It is because of this, this and this and there’s all scientific reasons.’’ This was a connection that students made themselves, as the work and expectations of scientists was never explicitly asked about or brought up by the researchers. It interesting to note that finding that these students made few explicit connections to the practice of science outside of school is somewhat contrary to the findings of Archer et al. (2010) who report younger school children also distinguishing between attributes and actions, but expressing actions in terms of what they do in school science and attributes in terms of what it means to be a scientist. This distinction, while not actively probed, was not evident in these students’ responses.

Related to the reliance on facts were the actions of memorizing facts and formulas and making detailed factual observations. Science students were seen to be students who could and did memorize the facts presented in class. Students wrote that science students ‘‘memorize things (e.g., formulae, periodic table, etc.),’’ they ‘‘should memorize charges/symbols/classifications, etc.’’ As with questioning, it was difficult to discern if these codes were best grouped with the actions or the attributes. Again, the initial decision to code memorization of facts as an action was made based on the wording that students used.

Students also discussed creative thinking as a part of school science. There was some disagreement, however, about the use of the word creative. Most students agreed that the ability to think creatively is important to science but many argued that science students are not creative types of people in the same sense as art students. In discussing creative thinking, students reported creative actions that science students might take: "A science student thinks outside of the box;" "I think that a science student is expected to bring his/her creativity to the classroom and they can use it in various experiments and labs. . . . They should be able to think outside the box in terms of various methods and procedures." Most did not, however, describe science students as creative people: "Students who study science are less likely to be . . . good at speaking or performing or creative;" "[They are less expected to] be creative and design-aware. Creativity is unnecessary and artistic representations aren't necessary. Expressive work is uncommon and not the 'typical' criterion for a science student." Many students were unsure how to reconcile these two ideas, saying, for example:

> I guess they kind of have to be creative because they have to use their brain a lot so you have to think about a lot of different options that could be there. You probably have to have a good creative brain to get everything or figure something out. You've got to be creative. But then I don't really think it's that important because everything's so factual and just all—it's not like you have to have a super imagination but you kind of have to be creative to figure stuff out.

The degree of importance of this expectation to the science student role is explored further in Phase 2.

Attributes. The second major group of first-level expectation themes was the attributes. These are characteristics and abilities that participants described as necessary or valuable for science students. Their wording suggested that students do not have a choice in these expectations—they either can meet them or they cannot. The students suggested a static meaning in using words like "type of person."

One attribute that participants described was the need to be serious and focused: "I still think that science students would be . . . more focused on school." This is of course, closely related to the previously described action of working hard. The reason that being serious and focused was categorized differently was the language that students used. All sections of text placed in this category used words suggesting a particular type of person. For example, "I see science students as more serious and smarter people." This is different from the action of doing homework and assignments.

Participants also spoke and wrote about four different types of expectations generally related to intelligence. They spoke directly of science students being smart: "Smarter. I see science as the hardest course and if you can understand science you must be very smart. A 90% in science is better than a 90% in any other course." They also described science students as the type of students who received good marks in science and in other classes: "I still think that science students would . . . get higher grades and stuff like that . . . I think they should have at least an 85 or higher in their science courses at school." Moreover, our participants described science students as the type of students who could understand science concepts quickly and easily, the type who did not require repeated explanations: "[They] understand all concepts and go above and beyond knowledge expectations. [A science student] does not require much explanation (extra help is offered in math, discussions are common in English, art, and music leave room for interpretation but science is straightforward and moves quickly)." Finally, participants reported that science students need to have strong abilities and interest in math: "Compared to other students, a science student is more likely to be good at math as well;" "When somebody's interested in science . . . they're usually more math or number oriented and smart that way." These four subthemes were addressed frequently by the students, highlighting their impression that science is difficult and meant for highly intelligent students. Unlike other first-level themes which were kept separate, we decided that these could immediately be grouped together because of the common usage of the words "smart" and "intelligent" in conjunction with the other elements.

The next group of themes addressed the hands-on and practical work that students do in science. Two distinct themes emerged: (1) enjoying and being skilled with one's hands and (2) being skilled in creating and conducting experiments. In describing the first, participants addressed issues of being able to use equipment, and mix chemicals: ‘‘Well, some of the units tend be more like you’re actually up there mixing chemicals and doing experiments whereas in English and math usually it’s just all in your head. So if you’re the type of person that likes to do stuff with your hands then that can be more interesting for you.’’ Participants also acknowledged the importance of being able to, for example, conduct original experiments. One student wrote that they are expected ‘‘to be able to make up their own experiments.’’ While the idea of experimental skill was found across all student groups, this was one instance where the individual teachers’ influence was strong. Those who spoke of the need to conduct and create their own experiments, if they were selected for follow-up interview tended to make reference to very specific activities they had done (e.g., ‘‘Like in our class in October we had to come up with a way to test what happens when there is too much nitrogen in the water that plants get. We had to think up different procedures for testing it.’’) and talked about their teachers in particular (e.g., ‘‘Ya, our teacher usually likes us to come up with our own ideas for experiments. She doesn’t like us to just do what it says in the textbook’’). This was common in one class at the private school and two classes (with different teachers) at the suburban public school. We do not have sufficient evidence to make any sort of causal link between teaching and learning activities and students’ role perceptions but this expectation was notable in the explicit references made by students to their teachers and the activities that their teachers preferred. Differences according to science teacher are explored further in Phase 2.

In addition to skills in conducting experiments, participants identified logic and reasoning skills as important to science. They reported that science students need to be able to think things through and use logic to draw conclusions: ‘‘They should have good reasoning or good logic;’’ ‘‘[They are expected] to be organized in their thinking and with a sense of critical reasoning.’’

Finally, participants acknowledged the importance of being an inquisitive person. This is very closely related to the Action category of asking questions. The distinction was maintained because of the language that students used. In this case, the language suggested a certain type of person who is inquisitive and has an intrinsic desire to know rather than any student engaging in the action of asking questions. Students reported that: ‘‘The most important expectation of a science student is to have a desire to know why the world is the way it is;’’ ‘‘A science student is likely to be someone who wants to expand their understanding of the world around them.’’

Emerging Science Student Role Expectations. These overall themes (all of the above actions and attributes) were then examined interpretively for further relationships, both those emergent from the students’ responses and those suggested by related literature. Two of the first-level expectation themes remained unchanged after this analysis. No connections were found between the creativity theme and any of the others. Similarly, attributes such as ‘‘Good at math,’’ ‘‘Gets good grades,’’ and ‘‘Able to understand scientific concepts,’’ which were presented together as representing a theme of intelligence, showed no further relevant connections in this second-level analysis.

The skills required in school science did, however, show some connections. The students often linked the need for hands-on skills with the need for experimental skills and described them together as science skills. Some students spoke of them side by side without making an explicit connection. Others explained that these expectations were related and tended to list them together in the same lists: ‘‘They need to be good with doing stuff, being hands-on. Like they need to be good at doing experiments and stuff. It’s what makes science, science.’’ These two themes were therefore collected together as a second-level theme, ‘‘Skilled in Science.’’

A similar re-examination was done of the student responses related to being good students generally and following the rules (especially during experiments). Further review and interpretation of the responses suggested that the salient issue in these student responses was behavior—appropriate behavior for school and appropriate behavior for science. Both were explained by making reference to what the teacher tells them to do and to learning what was appropriate in school science (e.g., ‘‘In science you have to know the right way to do things. You have to listen when your teacher tells you and you have to know what to do.’’). These were therefore brought together under a second-level theme ‘‘Well-behaved.’’

Second-level themes were also identified by drawing on the researchers’ understanding of connections made in the literature, such as those related to scientific attitudes and attributes. Three of the action themes (‘‘Rely on facts and logic,’’ ‘‘Memorize facts and formulas,’’ and ‘‘Make detailed observations’’) were initially grouped under the second-level theme ‘‘Be Objective.’’ The students themselves did not use the word ‘‘objective,’’ but they linked all three of these expectations to the importance of facts in science: ‘‘They stick to theories, laws, and the facts. They stick to what they can see and know.’’ This reliance on facts is reminiscent of Gauld (1982) and Gauld and Hukins’s (1980) descriptions of the sometimes mythical view of objectivity as drawn from the scientific attitudes literature. These may not represent an ideal or sophisticated view of objectivity on the part of the students and some might argue that relying on facts provided by a textbook or a teacher is not, in fact, objective. From the students’ point of view, however, these actions were done in contrast to other classes and areas of life where personal feelings and interpretations are important. For example, ‘‘They’re supposed to put logic and facts before their own beliefs because that’s what science is. It’s finding out the real meaning for everything.’’ Because of this relationship, we felt that objectivity was an appropriate label: these expectations appeared to represent the students’ views of objectivity.

Further examination of the remaining themes suggested, that the relationship to scientific attitudes was also seen in three of the attribute themes: logical, inquisitive, and serious. These are typically understood to be included in the scientific attitude or in lists of scientific habits of mind (e.g., Gauld, 1982, 2005; Gauld & Hukins, 1980). They are also ranked highly in Lee’s (1998) study of teenager’s perceptions of people who want to be scientists. Lee uses the terms inquisitive, systematic, logical, and object oriented to describe students’ views of people who are scientific. Based on these literature connections, we tentatively proposed an expectation theme that straddled the categories of action and attribute—that of being scientific (including the attributes of being logical, inquisitive, and serious with the action of being objective). The use of the term ‘‘scientific’’ was supported in the responses of several students, for example: ‘‘I think they’re supposed to act in a scientific manner and they’re supposed to put logic before their own beliefs because that’s what science is.’’ This possible second-level grouping is examined further in the Phase 2 CFA.

In this second-level analysis, we also returned to the tension between expectations related to inquisitiveness and asking questions. Further examination of the questionnaires and the interviews (especially those that mixed the action and attribute meanings) led us to interpret that the issue of questions themselves was more salient than the distinction between action and attribute. We decided that the best representation of student views would be achieved by integrating the action expectation of asking questions with the attribute expectation of inquisitiveness, and therefore integrating them into the second-level theme of being scientific.

This analysis represents the first iteration in the process of understanding the social structure of school science as represented by patterns in understandings of the science student role (as expressed by science students themselves). From this qualitative analysis, there appeared to be five groups of related expectation themes identified as part of this role, being: creative, intelligent, skilled in science, well behaved, and scientific.

These expectations were also remarkably consistent across genders and different classes and schools. Table 3 illustrates the representation (by percentages) of different groups of students identifying each of the second-level themes. For four of the themes (intelligent, skilled in science, well behaved, and scientific) the response percentages are very close to the percentages indicating the representation of these students in the total sample. Creativity is the one exception, where the students’ school appears to be connected to the expectations they perceived, with the private school students much more likely to have discussed creativity.

Table 3
Representation of students in each of the five second-level themes

	Gender		School			
Theme	Male (54%)[a]	Female (46%)	Inner-City (20%)	Suburban (25%)	Rural (23%)	Urban Private (32%)
Creative	56	44	13	16	11	60
Intelligent	42	58	25	20	20	35
Skilled in science	57	43	16	29	25	30
Well behaved	55	45	25	28	21	26
Scientific	43	57	21	23	25	33

[a] Percentages in parentheses represent the percentage representation of each group in the total sample.

The exact nature of this difference is, however, difficult to pinpoint. While these students addressed creativity more frequently, they did not express stronger views than others that it is an important element of science. Like all of the other students, they generally agreed that ''A science student is less likely to do as well in sports and other arts (music, art, drama, etc.) since he or she will be more focused on the technicalities of life rather than artistic expression.'' They agreed with other students that creative thinking has a place in science: ''Science students or teachers or whatever they do a lot of creativity thinking and all that with experiments. They try to figure out new things and observe new things that haven't been observed before . . .'' but they also expressed the same ambivalence as others, as the student making the previous comment went on to say: ''But I don't think it's creative because a lot of the times you're doing stuff that people have been doing before so you're kind of doing the same thing over and over again and you don't really learn anything new.'' This is a difficult finding to interpret because of the consistency of the mixed views. For some reason, the students from this private school thought about creativity and mentioned it more often in their responses but, whatever the reason, it did not make them any more likely to express its importance in school science. The actual content of the views they shared was the same as for the students at other schools.

The combined themes presented in Table 3 also hide a few other small elements of difference in the students' responses. While the overall percentages were representative of the sample at the second-level themes, there were two the first-level themes that exhibited some gender-based discrepancies. Although female and male students were roughly equally represented in the overall theme of behaving well, the issue of following general classroom behavior rules (as opposed to science safety rules or following directions) was emphasized more by male students. Twelve students addressed this aspect directly, only one of them female. Male students expressed expectations such as: ''A science student is less likely to be expected to be rude to the teacher when he/she is talking or to disrupt the class'' and ''always raise their hand and stuff and not be really loud and talking during class.'' There is evidence that boys engage more frequently in classroom disruptive behaviors than girls and are disciplined more frequently (e.g., Skiba, Michael, Nardo, & Peterson, 2002). It is possible that frequent discipline action in science (especially when labs are concerned) may lead some boys to emphasize this as a major expectation of the science classroom. Similarly, there was one aspect of the intelligence theme that exhibited a gender difference. Ten of the 12 students who described overall good marks as a form of intelligence required in school science were female. They said, for example, ''I think science students would be more focused on school and getting better grades'' Are good grades a particularly gendered view of what it means to be smart? Lyng (2009) in a consideration of identity types in middle school describes the academic ideals of ''golden boys'' and ''golden girls.'' Both appear to recognize the importance of good grades but grades seem much more central to the self-definition of the golden girls. The golden boys discuss grades in a mostly instrumental way, as being important for meeting their future goals. This is similar to the finding in Nieswandt and Shanahan (2008) that perceived instrumentality (of grades and of scientific knowledge) is the main characteristic of boys' motivation in a general science class. The golden girls seem to emphasize grades as an end in their own right. Both of these examples illustrate the potential of some overlap of larger gendered social structures with structural elements of school science. They are, however, small exceptions in an otherwise consistent collection of student responses.

The general consistency of these results (with the above noted exceptions) should not be taken, to mean that every single student (even students of the same gender or from the same school) expressed the exact same views. For example, some students discussed only expectations related to intelligence and did not address the other themes. Other students mentioned elements of each but emphasized one over the others. The patterns that we claim here are not patterns deterministically reproduced on the individual level but instead patterns that tend to be seen across different groups of students in different contexts. When social structure is viewed as the probability for interactions to be influenced in particular ways, we see here a high probability that five groups of perceived expectations will influence the interactions of students in different classes and different schools (the degree and type of influence on interaction is, of course, outside of the bounds of this study).

As further evidence to support our view that these five expectation types are not deterministically reproduced in individual students, we found six students (two from the same class and four others from different classes at other schools) who explicitly resisted the idea of creating a general description of science students. Four of these students felt that the expectations are the same for all school subjects. For example, "Really a science student shouldn't be regarded as any different from any other student—an individual is an individual and this won't change whether they study science or the history of polka dots" and "I don't feel that I have to act different in a science class. In general, I look at every class with the same expectations (i.e., know what is taught, finish assignments on time, etc.). The only difference between science and other classes would be the material presented to you." To ensure that this view has been accounted for, the possibility of the science student role being indistinguishable from or only a part of an overall student role is explored in Phase 2. The remaining two students were sensitive to the stereotypical nature of students' impressions of science students and expressed that these stereotypes are untrue. For example, "Science students are thought of as being the less easy going type. This generality is not true seeing as I personally know at least ten students who are taking three science courses next year but do not fit these stereotypes." It is important to note our exploration of patterns in students' views does not ignore these individual voices and the fact that individual students may challenge and reject these expectation perceptions. They do, however, represent only a small percentage of the responses.

Phase 2

In Phase 2, questionnaire subscales were created to represent each of these five second-level expectation themes, expressing that science students should be: creative, intelligent, skilled in science, well behaved, and scientific. Each subscale included 3–14 items. Creativity was the only subscale with only three items. This is because the subscales were created by writing two to three items to represent each of the first-level themes and subthemes. They were written in this way to ensure that the subscales accurately represented the full range of meanings associated with the second-level themes and to allow the possibility of exploring different factor explanations, should the confirmatory factor analyses not support the decisions we made to combine them. Creativity is the only one that was not created through second level consolidation (like scientific and skilled in science) and did not have discernable subthemes in the first-level analysis (like intelligent did). The aims of Phase 2 were to (a) determine which of these expectations are associated with science students in particular rather than students more generally (profile analysis) and (b) examine and confirm the thematic groupings from the qualitative analysis (CFA). Note that we will now refer to the five expectation themes as subscales and use capital letters to name them (as is conventional in SEM, Schumaker & Lomax, 2004).

Before any meaningful analysis of the subscales could be attempted, the reliability of each was examined through Cronbach's alpha and the reliability of the individual items through squared multiple correlations and item-total correlations. Some non-functioning items were removed based on these analyses. Note that in all cases of item deletion, the removal of an item did not necessarily indicate that that aspect of the role was not important. It means only that with the way that the item was written, students did not respond to it in a manner consistent with the other supposedly related items. This can be attributed to many possible explanations ranging from confusing wording or terminology to underlying theoretical differences. These coefficients cannot explain the reason for the item malfunction but the number of items deleted was minimal and did not contribute to changing the meaning of the themes developed in Phase 1. Table 4 illustrates the finalized subscales that were used in this analysis and their corresponding reliability values.

Profile Analysis. The profile analysis results illustrate that the expectations generated in Phase 1 are, for the most part, associated specifically with the expectations of school science rather than with school in general. All but one of the subscales showed significant mean level differences across all items (with items for science students scoring significantly higher) and significant deviations from parallelism (showing that the items in each subscale were of differing importance for science students and other student). See Table 5 for significance values and effect sizes for all five subscales. To explore these tests further, the profile plots were examined for each subscale to confirm that the significant differences were in the expected direction (i.e., students rating the expectations as more likely for science students than other students) and explore the meaning of possible differences in response patterns over the items. As an example, Figure 3 shows the profile plot for the SKILLED IN SCIENCE subscale. It illustrates that both the mean score for each of the items was higher for science students and that the profile of the item responses was different for the two types of students. Both of these findings support viewing the science student role as a role that is distinct from that of students in general.

Table 4
Subscale reliabilities and items

Subscale	α	Items (After Item Analysis)
CREATIVE	0.85	Think outside of the box
		Find creative solutions to problems
		Be open to new ways of thinking
INTELLIGENT	0.80	Be interested in math
		Comprehend scientific terminology
		Require repeated explanations (reverse scored)
		Remember science concepts easily
		Have above average intelligence
		Think mathematically
		Understand science concepts quickly
		Be a straight A student
SKILLED IN SCIENCE	0.81	Enjoy trial and error experimenting
		Be able to make up their own experiments
		Follow the directions exactly during experiments
		Be able to write detailed observations
		Be aware of what's happening during experiments
WELL BEHAVED	0.81	Be safe with materials
		Act responsibly in the classroom
		Take all the necessary precautions during labs
		Be in class on time
		Willing be work hard
		Always pay attention to lessons
		Do all their homework
		Complete their labs and assignments on time
SCIENTIFIC	0.75	Draw conclusions from results
		Take science learning seriously
		Be serious about their work
		Want to understand world around them
		Always want to learn more
		Ask questions like "how does that happen?"
		Rely on experiments to prove facts
		Want to prove explanations with facts
		Rely on facts when making decisions
		Memorize a lot of facts and formulas

The relatively large effect sizes for INTELLIGENT ($\eta^2 = 0.41$), SKILLED IN SCIENCE ($\eta^2 = 0.41$), and SCIENTIFIC ($\eta^2 = 0.51$) suggest that in these areas in particular a large percentage of the variance is accounted for by the distinction between science and other school subjects. This large effect size was also evident in the profile plots, with visible separations evident between the profiles for science students and other students.

Table 5
Profile analysis results for questionnaire subscales (science students versus other students)

	Mean Subscale Scores		Test for Levels			Test for Parallelism	
Subscale	Science	Other	F	p	η^2	F	p
CREATIVE	3.91	3.70	3.64	0.06	0.01	4.11	0.02
INTELLIGENT	4.10	2.75	175.00	<0.01	0.41	25.21	<0.01
SKILLED IN SCIENCE	4.25	2.99	174.35	<0.01	0.41	10.25	<0.01
WELL BEHAVED	4.09	3.26	157.77	<0.01	0.38	16.55	<0.01
SCIENTIFIC	4.31	3.23	269.46	<0.01	0.51	21.78	<0.01

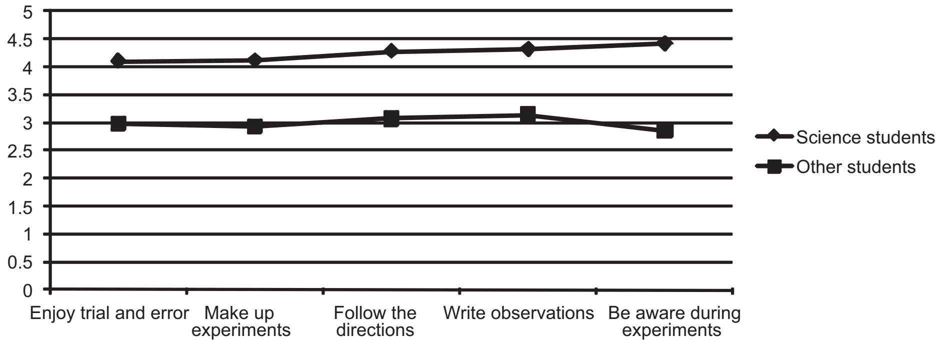

Figure 3. Profile plot for SKILLED IN SCIENCE.

The subscale WELL BEHAVED also showed a strong effect size for the difference, despite the fact that four of the nine items were related to the first-level theme Be Good (a theme representing more general school behaviors). The test for parallelism was also significant but despite the significant result, the differences were not as apparent in all areas of the profile plot (see Figure 4). The Be Good items that were discussed in Phase 1 as potentially representing a more general student role (''be in class on time,'' ''willing be work hard,'' ''always pay attention to lessons,'' and ''do all their homework'') have profiles that are largely parallel for science students and other students. The levels difference is still evident in the plot, supporting what the students said in Phase 1—these are more general expectations but they particularly important in science because it is a difficult course.

The one subscale that was not supported as part of the science student role was CREATIVE. It was rated lower overall and did not show a significant difference between science students and other students in the test of levels, $F(1, 127) = 3.64$, $p = 0.06$. While the significance level is very close to the $\alpha = 0.05$ level, the effect size is only $\eta^2 = 0.01$, much lower than for any of the other scales. In addition, the profile plot showed substantial overlap between the profiles for science students and other students. Based on these results, creativity was not supported as part of students' understanding of a specific science student role. This is in many ways consistent with the mixed views expressed by the students in Phase 1.

Confirmatory Factor Analysis. The second stage in the Phase 2 analysis was the CFA aimed at exploring the degree to which the quantitative data exhibited response patterns consistent with the Phase 1 qualitative analysis. This meant confirming that the items in each subscale loaded on, and represented a single underlying expectation and that the groupings made interpretively in the second-level coding were appropriate. Because of our confirmatory approach, only one-factor models were tested, meaning that each item was allowed to

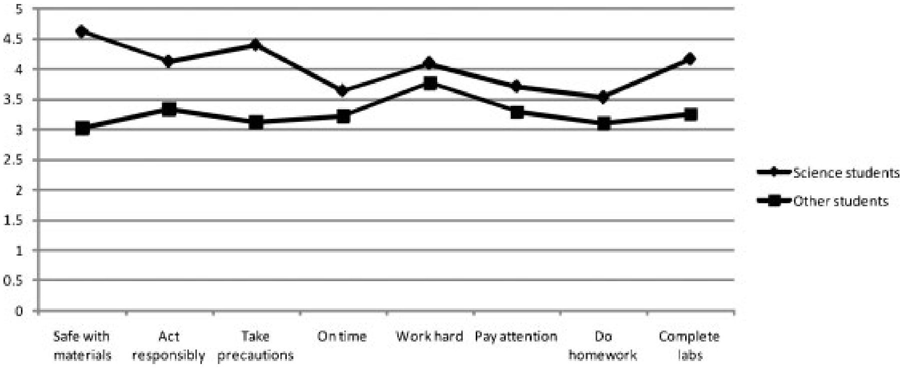

Figure 4. Profile plot for WELL BEHAVED.

load on only one factor (the Phase 1 second-level theme from which the subscale was created). In addition to model fit indices, we also examined the significance of the factor loadings to again ensure that all of the items were interpreted appropriately.

For the INTELLIGENT subscale, an initial model exhibited good fit, $\chi^2(9) = 5.99$, $p = 0.75$, RMSEA = 0.09, GFI = 0.97, and significant factor loadings for six of the seven items. The factor loading for the item ‘‘Be a straight A student’’ was non-significant. The item ‘‘Get good grades,’’ however, did have a significant factor loading. This suggests to us that the low loading for ‘‘Be a straight A student’’ may have more to do with the features of the item (e.g., wording, placement, etc.) rather than the idea that achievement (as represented by grades) may not be important to the science student role. Because it was not felt to impact the meaning of the subscale, it was removed and a final model was tested. The model fit was excellent, $\chi^2(5) = 5.21$, $p = 0.39$, RMSEA = 0.02, GFI = 1.00. The factor loadings for each of the remaining items were significant. These results were taken to support the interpretive analysis done in Phase 1, suggesting that expectations such as be interested in math, get good grades, comprehend scientific terminology, and have above average intelligence can be interpreted to represent a single underlying perceived expectation (a particular type of intelligence as defined by the students).

The SKILLED IN SCIENCE subscale exhibited excellent model fit, $\chi^2(5) = 2.30$, $p = 0.81$, RMSEA = 0.00, GFI = 1.00, and significant factor loadings for all five items. This supports the Phase 1 analysis that grouping together expectations representing what the students identified as scientific skills (enjoying trial and error experimenting, being able to make up their own experiments, following the rules exactly during experiments, being able to write detailed observations, and being aware of what is happening during experiments) was appropriate. It is interesting to note, however, that this subscale, as drawn from the students’ responses in Phase 1, addresses only some of skills that science educators would normally associate with science. Missing in particular from their Phase 1 responses was inference. This is not necessarily surprising, given that it is not explicit in most international science standards (McComas & Olsen, 1998) and studies of students’ understanding of the nature of science have shown that they often neglect this aspect of scientific inquiry (Akerson & Abd-El-Khalick, 2005; Akerson & Volrich, 2006).

Eight items were tested as part of the WELL BEHAVED subscale. This eight-item model had somewhat good model fit, $\chi^2(20) = 36.79$, $p = 0.01$, RMSEA = 0.08, GFI = 0.98. In this model, however, the item ‘‘Be in class on time’’ had a non-significant factor loading. It was removed from the subscale and a new seven-item model was tested. The result was improved model fit, $\chi^2(14) = 23.77$, $p = 0.10$, RMSEA = 0.06, GFI = 0.98. With this model, all of the items had strong and significant factor loadings. Again the removal of this one item was not felt to undermine the meaning of the subscale in any way and the good model fit of the one-factor model was understood as support for the interpretive integration (during the Phase 1 analysis) of the themes related to school behavior and safety in the science classroom.

Finally, 10 items were tested in a one-factor model for the SCIENTIFIC subscale. Items included: ‘‘want to prove explanations with facts,’’ ‘‘always want to learn more,’’ and ‘‘be serious about their work.’’ The model was a very good fit to the data, $\chi^2(18) = 24.47$, $p = 0.14$, RMSEA = 0.06, GFI = 0.98, and all of the factor loadings were significant, again supporting the Phase 1 analysis. Factor confirmation was particular important for this subscale because of the decision to integrate attribute and action expectations to create it. Our findings here suggest that the substantive aspect of these expectations was not their character as actions or attributes but their relationship to what it means to be someone who is scientific.

Overall, the Phase 2 factor analyses support a frame for understanding the science student role through four clusters of expectations typically reproduced amongst students: intelligence (as defined by the students to include mathematical thinking and the ability to understand easily), being and acting scientific (including logical thinking, seriousness, objectivity, and inquisitiveness), being skilled in science (in which the students emphasized experimental skills, including those related to experimental design and the hands-on conduct of investigations according to instructions), and behaving well in class (including being safe and following the rules).

This framework may again appear at first glance to contradict our earlier stated position that there is no single version of the science student role and that each individual may have a personal understanding of the role that exists within a culture of shared meanings and symbols. We do not intend these four groups of expectations to represent the role in a fixed sense but instead the most likely social understandings which guide the school science interactions that students will encounter and which may act as a resource and constraint on their behavior and views of themselves in science. These are expectations that appear to have a high probability of being reproduced across different school science contexts.

To strengthen our understanding of the degree of consistency in these role expectations, scores for WELL BEHAVED, INTELLIGENT, SKILLED IN SCIENCE, and SCIENTIFIC were used to compare the response profiles of male and female students, students at each of the schools and students grouped by science teacher. Between male and female students, no significant differences in mean levels or parallelism were found (levels: $F = 0.18, p = 0.67$; parallelism: $F = 0.69, p = 0.41$). This is particularly noteworthy given that there were some subtle differences in the emphasis placed on particular aspects of these expectation themes by male and female students in Phase 1. Differences in emphasis, if they were significant, would appear in the profile analysis as a difference in parallelism. Our finding of no significant parallelism differences among male and female students suggests that there are not significant gender differences in the patterns of expectations expressed by the students—supporting a consistently defined role. Because there were more female participants in Phase 2 than male participants, we also re-conducted the CFA and profile analysis on a sample consisting of all the male participants and an equal number of randomly selected female participants. The results of this re-analysis did not differ in any significant way from the original.

Finally we conducted profile analyses on the science student ratings, grouping them by school and by teacher. In this analysis, students whose teacher has responsibility for multiple sections were grouped together. From this analysis there appeared to be no overall main effect for the school-based groupings, $F = 4.95, p = 0.10$. There did, however, appear to be a significant difference in levels when the students were grouped by teacher, $F = 2.22, p = 0.04$, suggesting a possible significant teacher influence on students' role understanding. As seen in the Phase 1 analysis, there were at least some connections made by students between the expectations they perceived and the specific activities and preferences of their science teacher. There is also significant support in the literature for the importance of teachers creating alternate ways of being scientific and supporting students in authoring new positions for themselves (e.g., Tan & Calabrese Barton, 2008). We used a follow-up MANOVA with Bonferroni post hoc testing to examine this effect in more detail and found that it was, in fact, quite weak (see Table 6 for test values). The only subscale that exhibited a significant difference was SCIENTIFIC and within that subscale, it was only two of eight teachers that differed from each other—having an overall mean difference on the subscale of approximately 1 unit. Note that these teachers only differed significantly from each other, not from the others in the group. In other words, of a possible 28 paired comparisons between teachers, only one was significant. This suggests the possibility of teacher influence but finding only this one small difference across eight different teachers and three different schools says more to the overall consistency of role understandings than it does to teacher effects. The mostly non-significant result found here could mean that despite the odd anomalous situation, there is no consistent influence of teachers on student role perceptions, suggesting a very strong social structural element. Alternatively, because we have no data representing these teachers' actual practices, these results could also be explained by significant similarities in these teachers' strategies, beliefs, and teaching styles rather than lack of impact. Further research would be necessarily to begin to specify this relationship. Furthermore, the sample size used here is relatively small for making several group comparisons. Future research on the impact of teacher practices and views would be necessary to better support this aspect of our findings.

Table 6
MANOVA results for school-based and teacher-based comparisons by subscale

	By School		By Teacher	
Theme	*F*	*p*	*F*	*p*
Intelligent	2.93	0.09	2.04	0.08
Skilled in science	0.38	0.68	0.71	0.67
Well behaved	2.73	0.09	1.74	0.11
Scientific	4.28	0.02	3.34	0.01

Discussion

We embarked on this study against the backdrop of the literature exploring student identities in relation to science. These studies typically acknowledge the importance of the reciprocal nature of identities and social structures. We recognized that larger societal social structures have received attention in this body of work and so have the historically constructed structures of science. We wondered, however, if there were social structural elements specific to school science. Taking the structural symbolic interactionist perspective, we approached this question from the understanding that repeated patterns in role understandings can serve as evidence of social structure as indexed to a particular social group (in this case, school science). Through our two phases of analysis, we see strong evidence of this proposed aspect of social structural influence. We found a repeated pattern of four typical groups of expectations (intelligence, scientific actions and attributes, scientific skills, and good behavior) that not only are common across different classrooms, teachers, and schools but also differentiate the science student role from the other expectations of school. Additionally, while they are most certainly related to larger structural patterns of science (especially the scientific attitudes and attributes scale), and therefore to students' views of the nature of science (as Archer et al., 2010 suggest), there is clear entanglement between science and school in the students' perceptions, for example, in the importance of grades as a measure of intelligence. As patterned role expectations (entangled but also different from those only of school or science), we suggest that they support our proposal that when considering identities, interactions, and social structures, one relevant aspect of social structure that needs to be considered is that of school science.

In Stryker's (1980[2002]) conceptualization of role, he proposes that roles can be defined with different levels of specificity. Depending on the nature of the social group, some roles can exist as lightly shaded outlines within which individuals perceive and enact only minimally defined versions. Others are highly specified and require precise performance of specific detailed behaviours. ''They can be very clear in their demands or vague and uncertain'' (Stryker, 1980[2002], p. 58). With the exception of creativity, we have found that the science student role appears to be relatively well-defined. The clustering around four specific groups of expectations, that are mostly consistent across groups, suggests a role that is much more than a lightly shaded outline. This appears to be a clearly defined role that students recognize explicitly.

The role also appears to consist of different types of expectations, including both attributes (e.g., being skilled in science) and actions (e.g., behaving well in class). Some of the expectation clusters mix elements of both. The form that the expectations seem to take suggests that the requirements for successfully embodying the role may be complicated by the fact that one must possess certain innate qualities and choose to engage in particular actions. Gee (2000–2001) might describe the role as exhibiting elements related to *n*-identities (natural, in-born identities) and *d*-identities (identities defined by the discourse of others and guided by an individuals' actions and interactions).

It should be noted that the role expectations we explore here likely have embedded in them both perceived and authored elements. For example, some students actively rejected the exercise of exploring the expectations. As discussed in Phase 1 two rejected the idea as emphasizing untrue stereotypes. Four other students from different classes in Phase 2 resisted answering the questions, crossing some of the questions out and writing, for example, ''what does this have to do with anything.'' One interpretation of these actions is as expressing their active rejection of a defined role and their desire to position themselves as authors of an alternative perspective. Other students may have answered the questions with a mixed perspective of what science students must be and what they feel they should be expected to be based on their own personal values. With our method of analysis we cannot tease these apart but from the framework of our definition of social structure, it does not matter that much which elements individual students receive and which they create (even on an individual psychological level it may be impossible to separate the two completely). We have been searching for patterns in the students' views of the expectations associated with the position of science student. If students author and make roles in the same ways across several contexts, this is no less a social structural pattern than if they receive similar expectations from their teachers. As Sewell (1992) argues, structural patterns are often reproduced in the absence of desires to reproduce them and without obvious reproductive mechanisms. Students are not only passive recipients of social structure: they are part of creating it (as was illustrated in Figure 1).

The idea in studying social structure through role is not to deny the dialectic character of agency and social structure or imply a deterministic or necessarily negative impact but instead to provide further resources for understanding what this dialectic means in the context of school science:

> The important questions become, under what conditions does social structure so constrain interaction that novelty is at a minimum; under what conditions is the larger social structure resistant or impervious to alteration through the medium of interaction; or conversely, under what conditions is novelty or creativity in interaction maximized, and under what conditions is social structure maximally open to the impact of altered interactive episodes (Stryker, 1980[2002], p. 52).

These are the important questions that emerge from our study. At this time we have found a large degree of consistency in the common role understandings present across different groups of students. There was, however, the interesting case of creativity. Students could not agree on whether it is important in school science (or even on exactly what it means) and it did not seem to represent an expectation that is particularly science related but some students did recognize its importance—why? Why those students in those classrooms? Why is this potential element of social structure not as rigid as the others? We did see greater mention of creativity among the private school students but they were no more sure about its value than others.

It is interesting, but not surprising, that creativity did not receive significantly different ratings for science students and other students. It reflects the mixed nature of students' responses in Phase 1 to the importance of creativity. In talking about the science student role, students generally agreed that creative, outside-the-box thinking is important in science (''A science student thinks outside of the box'') but they did not view science students as necessarily creative people (''Creativity is unnecessary and artistic representations aren't necessary. Expressive work is uncommon and not the 'typical' criterion for a science student''). The students' views illustrate both their own limited views of science and those of the curricular ecology of their school science experiences. Many science curricula include descriptions of scientific attitudes and skills but these most often focus only on the rational-empirical aspects of science. *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) hints at the importance of creativity by including imagination and inventiveness in a description of scientific habits of mind, but focuses almost exclusively on the more conventionally recognized skills (e.g., quantitative skills, communication skills, and critical thinking skills) and attitudes (e.g., scepticism and curiosity). Despite two chapters of proposed expectations designed to develop other scientific attributes through the grade levels, no attention is given to the development of scientific creativity, imagination, or inventiveness. Imagination is the only one to appear explicitly and it appears in only one specific expectation: ''By the end of 12th Grade, students should know that there is agreement that progress in all fields of science depends on intelligence, hard work, imagination and even chance'' (p. 13). This does nothing, however, to suggest that students should also be encouraged to be imaginative or creative in school science. Kind and Kind (2007) argue cogently for recognizing the differences between teaching students that science is creative and working to develop scientific creativity in students. They also emphasize the importance of both aspects to true inquiry teaching.

So is there a connection between teaching and learning conducted from this perspective and students experiencing interactions that lead them to view creativity as an integral part of the science student role or could there be such a connection? The curious case of creativity in students' role understandings suggest future research directions aimed at examining under which conditions is the social structure of school science impervious to change and adaption and under what circumstances is it maximally malleable and open for students and teachers to create new figured worlds? Under which particular circumstances does creativity become part of the class role understandings and under which circumstances is it rejected or not seen to be related. In depth study of individual classroom situations that integrates the analysis of interactions with the analysis of role perceptions is needed to begin to understand these possible differences.

A second noteworthy group of expectations is that of intelligence, not necessarily due to the fact that it is included but due to the particular way it is defined by the students. As described above, there was an overall sense of the difficulty of science classes and the need for science students to be smart. ''Science people are usually really smart. It's important to have smart science people.'' ''For science students it's all about knowledge and just being smart.'' But what does it mean to students to be smart? There were four main areas of emphasis: knowing a lot (''So if a student doesn't know much then they are basically done for''); understanding easily (''Compared to all other students a science student is more likely to . . . understand everything that goes on in science''); being good at math (''A science student is expected to be more smart in class and in math and technology classes''); and getting good grades (''A science student is more likely to have higher academic marks in school''). These students describe, however, a very impoverished view of intelligence as it relates to science—a view that is much more closely related to the culture of schools than to the culture of science. In general, as children become acculturated to school they move from recognizing a variety of intelligence-related behavioral and affective descriptors towards defining intelligence as a fixed representation of cognitive ability (Kinlaw & Kurtz-Costes, 2003; Kurtz-Costes, McCall, Kinlaw, Weisen, & Joyner, 2005). Just as we see with the students in this study, these representations typically include an inverse relationship between intelligence and the effort required to complete school tasks, the importance of a large body of knowledge, and the unchanging attribute character of intelligence (Kurtz-Costes et al., 2005). It appears that that what makes these attributes scientific is that they are required in order to cope with the extreme difficulty of science as a school subject (''They are expected to be smart because science is a very difficult course''). These students did not express any views of a scientific intelligence.

The ability to generate new explanations, see novel connections, and navigate fluidly between representations are among only some of the aspects of scientific intelligence that have been neglected in students' conceptualizations (Simonton, 1988). Furthermore, research in psychology of science suggests the relatively small impact of conventionally defined intelligence on scientific success (Feist, 2006; Simonton, 1988). Affective and motivational factors are seen to have a much greater impact (Feist, 2006). In a classroom, however, this impoverished view of intelligence is the one that is likely rewarded. Grades are the primary measure of success in school science (and recursively, they are part of the definition of intelligence) and the recall and understanding of scientific information is the key path to gain access to high grades. Students who provide correct answers and understand easily are likely to receive praise. They are likely also to be the ones able to help their peers understand, an action that would reinforce the importance and status associated with understanding quickly and easily. For example, Shanahan and Nieswandt (2009) describes the case of a sixth grade student who defined her abilities in various school subjects by the direction of flow associated with help and assistance. She perceived herself to be a good art student because she was often able to help others, but a poor science student because she was often in need of help. The definition of intelligence that is reproduced as part of the structure of school science is therefore one that is highly indexed to school practices and largely divorced from the practice of science outside of schools.

When dealing with social structure, the question of origin is always salient. Despite the obvious possibilities for malleability and co-construction, the world of school science cannot be completely created in each classroom—when students walk in the door on the first day they walk into a structure already present in the text and other materials, the government documents that guides teachers' plans, the typical activities and pedagogical commitments that the teacher has learned as part of the social world of science teaching (e.g., in teacher education programs, professional development, partnerships, and conversations with other teachers, Barnett & Hodson, 2001). Burke and Stets (2009) propose the idea of flow to explain why social structures are so often recreated even when that recreation may be unconscious or unwanted. They suggest that the dominant direction of flow into positions of power is by those who excel at meeting role expectations. Successful participants in turn support, sustain, and reify the qualities that they themselves possessed. In addition to possibly having the ability to alter and challenge the social structure, teachers may also play a part in its reproduction. Science teachers are often those who have been successful in the science classroom but do not necessarily have laboratory science experience. Their flow into positions of power (e.g., teacher, science department head, district consultant, and curriculum developer) may serve to reinforce the qualities that are valued and accepted in school science as they, for example, mentor new teachers and are welcomed into other classes as experts. This is certainly only one reproduction force among many and it is certainly not the only option for teacher influence, but it does bare consideration as part of the reason why there may be a social structure specific to school science (and definable as separate from science and from school). Further in-depth study of the relationship between teacher-related interactions and teachers own views of their abilities and expectations in science would help to gain access to this element of reproduction.

Future Directions

This exploratory study helps to establish the importance of considering a social structure specific to school science and provides a context for understanding what the salient elements of that structure might be. By providing supporting evidence for this structural element, we hope to inspire and inform further research into the exact nature of its production and reproduction, of the factors that influence its rigidity or malleability and on the degree of influence that it has in relation to other structural elements.

In placing this study within the meta-theoretical framework of the PSSP, one of our goals was to recognize that it only addresses one small aspect of one possible level of analysis. A key area for future research involves moving from the level of social structure to that of interaction and examining both sides of the articulation between social structure and interaction. For example, examining the processes that influence the ways students learn about the role through their interactions with others and, on the other side, that way that interactions work to reproduce the role or recreate and subvert it. In particular, interactions that involve the teacher require further study. The nature and strength of teachers' influences should be explored through the longitudinal examination of role development in classes where teachers employ largely different strategies and hold diverse theoretical and value commitments regarding the purposes of science education. Through examining change and stability across highly differentiated environments, a better understanding of the conditions for role rigidity and malleability may be gained.

A second key area for further investigation is the impact at the level of personality. As Stryker argues, roles can have different normative weight and strength. While this may be a highly defined role, to what degree does it actually influence students, including the way they perceive themselves and the identities that they develop and author in the context of school science? Does it influence how they behave and interact with each other? Are the personal penalties for challenging this role severe and the rewards valuable? Or is the role, in practice, fairly open to be reconstructed by students. Another way to think about this is to ask whether the rewards (e.g., teacher and peer recognition, grades, scholarships, position as a science expert) be achieved equally through authoring new roles? Calabrese Barton and Tan (2010) and Rahm (2008) each working with science outside of school, describe students gaining recognition and confidence in science while defining new positions for themselves in science. Research that moves the level of role analysis to the individual student in their classroom may provide additional understanding about the salience of the school science role for students and the possibilities that exist for reauthoring. From the perspective of both of these areas of future research, we view this study as a starting point rather than an ending point.

Conclusions

We began this exploration by describing the connections between identities and various aspects of social structure that have been embedded in studies that approach science education through a lens of identity. We proposed that a missing piece in the consideration of structure was the structure of school science and sought to use role as a technic for exploring the possibility and meaning of such a social structure. In invoking the concept of role, the question must be asked: What is the connection between role and identity? The concept of role has largely been abandoned by sociocultural researchers because of the connotations of determinism and of reductionist approaches that view identities as no more than role-playing, views that are either overly agentic (where individuals can simply pick and choose whichever roles they like, abandoning them when they are no longer useful, e.g., Strauss, 1969) or overly structural (where individuals have no authoring abilities and must internalize a set of role expectations to become a holder of a particular role identity, e.g., Burke, 1991). The concept of role has largely been seen to have little place in sociocultural approaches that emphasize co-construction of meaning and dialectic understandings.

Abandoning the idea completely is difficult, however, because it appears to have explicit meaning for the participants in social groups. In our study we found significant meaning attached to the concept of role and the students easily understood what we were asking of them—discussing the idea of role and of generalized expectations placed on them by school science seemed to be fairly natural to them. They did not express that it was a question that seemed non-sensical or strange. Similarly in a study of leaders in education and law, Simpson and Carroll (2008) noticed that despite their own resistance to the concept (as self-identified postmodern scholars) their participants continued to use the idea of role as a way of talking about themselves and the way they negotiate who they are in the various social realms they inhabit. From this experience the authors argue that the concept of role can and should have a place in the more complex conceptualizations of identity that characterize contemporary approaches to understanding social groups.

But what exactly is the connection? We defined role as: ''the set of expectations tied to a social position that guide people's attitudes and behaviour'' (Burke & Stets, 2009, p. 114). We emphasized that in a probabilitistic sense it is the embodiment of the reproduction of social structure. A set of expectations that is fairly consistently perceived across different individuals and different settings fits directly with Sewell's definition of social structure as the tendency of patterns of interaction to be reproduced. What our definition did not address is what exactly is the relationship between these reproduced patterns in students' perceptions and their identities in relationship to science.

Role identity theories (e.g., Burke, 1991; Burke & Stets, 2009; Collier and Callero, 2005) emphasize the value of roles as standards used in comparison processes that individuals undertake to ascertain their place in social groups and as models that are gradually internalized as individuals develop a particular identity. Viewing the science student role in this way would suggest a developmental process where students first begin to understand the meaning of the role and begin to view themselves as taking on those characteristics. Gradually viewing themselves as possessing these characteristics leads to the internalization of the role and therefore to students using it as way of defining themselves.

This developmental trajectory approach is not consistent with the evidence of multifaceted negotiations that characterize students' development, rejection and authoring of school science-related identities. To reconcile their own commitments to co-constructed and non-deterministic approaches to identity with their participants' apparent reliance on the concept of role, Simpson and Carroll propose that roles are boundary objects, both intersubjective and intrasubjective, that facilitate negotiation of the multiple identities individuals hold. Boundary objects (a concept drawn from the STS literature and first proposed by Star & Griesemer, 1989) are objects that reside in the spaces between social groups and individuals. They are objects that can facilitate communication by offering shared language and translation back and forth between individuals. They can also be manipulated and used by different individuals or groups for their own purposes. The word object is taken very broadly as anything that people interact with: ''Its materiality derives from action, not from a sense of prefabricated stuff or 'thing'-ness. So, a theory may be a powerful object'' (Star, 2010, p. 602). A role may also be an object (Callero, 1994; Collier and Callero, 2005 similarly call roles ''cultural objects'')—an understanding that resides in the boundary spaces between students, between students and their teachers, and between the multiple identities that students themselves hold.

When roles are viewed as boundary objects they can be seen, for example, as resources for and constraints on communication. When students author new identities and assert new ways of being scientific within the social group of their classroom, communicating what is new and individual about this authored identity is facilitated by the shared understanding of what is typical (and therefore not new) that is embodied by role. When students communicate explicitly about those they view to hold scientific identities and work to understand their place in the social group of the classroom, role offers them support in communicating what it is about those people (or themselves) that is scientific. As students struggle internally to understand what is different about what is being asked of them in school science, role provides both constraints and resources for sense making. A role is, in this view, not of the same kind as an identity. It is not something that becomes an identity. It is instead a socially created object that can constrain and support the many processes involved in creating, negotiating, claiming, and authoring identities.

As we have noted above, further examination of the influence and enactment of the science student role in classroom interactions would be needed to probe the exact connections between the largely shared role understandings that we see in our results and students' identities and the identity processes they engage in. We hypothesize, however, that it would take a form consistent with Simpson and Carroll's conceptualization of roles as boundary objects. Students explicitly appear to perceive and understand a science student role but studies of the various and changing identities that are enacted and authored in science classrooms suggest that viewing it a something that students will internalize is not the most appropriate way of understanding its influence. As a boundary object, however, the connection between role and identity is negotiable and changing. It is among the materials from which identities emerge and are constructed. It has constraining influences, providing potentially limiting views of the permissible ways to be a science student but also can act as a resource of shared understandings with which to communicate both acceptance and challenge. We feel this is also consistent with our conceptualization of social structure—probabilistic reproduction of patterns of understanding. These patterned understandings are then part of materials from which students communicate with each other about their identities and also can act as tools in negotiating the various identities or aspect of their identities that are salient in the science classroom.

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