Canadian Journal of Science, Mathematics and Technology Education

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ucjs20

Predictors of Science Subject Discipline Identities: A Statistical Analysis

Martina Nieswandt [a] , Sarah E. Barrett [b] & Elizabeth H. McEneaney [a]

[a] Department of Teacher Education and Curriculum Studies, University of Massachusetts Amherst, Amherst, Massachusetts

[b] Faculty of Education, York University, Toronto, Ontario, Canada

To cite this article: Martina Nieswandt , Sarah E. Barrett & Elizabeth H. McEneaney (2013): Predictors of Science Subject Discipline Identities: A Statistical Analysis, Canadian Journal of Science, Mathematics and Technology Education, 13:1, 90-110

To link to this article: http://dx.doi.org/10.1080/14926156.2013.758329

CANADIAN JOURNAL OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION, *13*(1), 90–110, 2013

ISSN: 1492-6156 print / 1942-4051 online
DOI: 10.1080/14926156.2013.758329

Routledge
Taylor & Francis Group

Predictors of Science Subject Discipline Identities: A Statistical Analysis

Martina Nieswandt
Department of Teacher Education and Curriculum Studies, University of Massachusetts Amherst, Amherst, Massachusetts

Sarah E. Barrett
Faculty of Education, York University, Toronto, Ontario, Canada

Elizabeth H. McEneaney
Department of Teacher Education and Curriculum Studies, University of Massachusetts Amherst, Amherst, Massachusetts

Abstract: This quantitative study ($n = 247$) explores whether preservice science teachers express science-specific identities that reflect multiple areas of their beliefs (e.g., purpose for science teaching, inclusion of science-technology-society-environment issues into science teaching, and nature of science) as well as other individual characteristics (e.g., focus of university training, perception of self within professional communities, and interest in becoming a teacher). Hierarchical cluster analysis showed a three-cluster solution representing three subject-specific identities: Model Citizen, Model Science Teacher, and Model Non-Science Teacher. Additional analysis (multinomial logistic regression) revealed cluster membership associated with preservice science teachers' most comfortable teaching subject.

Résumé: Cette étude quantitative (n = 247) vise à déterminer si les futurs enseignants de sciences expriment une identité spécifique aux différentes disciplines scientifiques, reflétant des aspects multiples de leurs valeurs (par exemple la motivation qui les pousse à l'enseignement des sciences, l'inclusion de questions liées aux sciences, technologies, société et environnement dans leur enseignement, ou encore la nature des sciences) ainsi que d'autres aspects plus personnels (par exemple l'orientation de leur formation universitaire, leur image de soi au sein des communautés professionnelles et leur intérêt personnel pour l'enseignement). Une analyse par regroupements hiérarchiques met en évidence trois regroupements représentant trois identités spécifiques : le citoyen modèle, l'enseignant modèle en sciences et l'enseignant modèle dans les domaines non scientifiques. Une analyse plus approfondie (par régression logistique multinomiale) montre que les regroupements sont liés aux disciplines dans lesquelles les enseignants en formation se sentent le plus à leur aise.

Address correspondence to Dr. Martina Nieswandt, Department of Teacher Education and Curriculum Studies, University of Massachusetts Amherst, 813 North Pleasant Street, Amherst, MA 01003-9308. E-mail: mnieswan@educ.umass.edu

Identity—both in terms of how teachers view themselves in the present and the types of teachers they aspire to be in the future—is central to teachers' decision making about how and what to teach. This study sought to determine whether four archetypal ideals to which teacher candidates aspired in a smaller qualitative study reflect statistically significant clusters of belief in a larger population (research question #1) and to what extend gender, academic preparation, and science teaching subject predict their identity (research question #2).

The original study involved 12 teacher candidates and examined their beliefs about including socioscientific issues in their teaching (Barrett, 2007). Socioscientific issues are issues with moral overtones (Zeidler & Sadler, 2008). The participants' beliefs about them were expected to relate to identity because beliefs and values are central to identity (Helms, 1998). Indeed, it was found that the participants' beliefs about the place of ethics in science education and appropriate goals for science education were exemplified by a desire to be a particular type of science teacher—model scientist/engineer, model teacher, model citizen, and model individual (Barrett, 2007; Barrett & Nieswandt, 2010). These archetypal ideals were named *subject discipline identities* (SDI) because they were related to how the teacher candidates saw themselves in relation to science.

The use of the title *model* is to draw attention to the fact that the participants, with their particular professional learning trajectories, aspired to be ideal versions of each SDI. These SDIs are defined in terms of (a) identity and thus teachers' learning trajectories with respect to the community of scientists (i.e., where a teacher sees herself with respect to an imagined border around the community of scientists); (b) goals for or purpose of science education (e.g., to produce more scientists or develop more informed citizens); (c) perception of the place of nontraditional content (e.g., inclusion of socioscientific issues) in science education; and (d) future intentions with respect to nontraditional approaches to teaching science (e.g., teaching about the nature of science). Taken together, these four components define each of the four archetypes (see Table 1).

By verifying the findings from the smaller qualitative study in a larger quantitative one, our ultimate goal is to work toward an assessment instrument that teacher educators can use to tailor their instruction to more readily meet teacher candidates where they are not only conceptually but also emotionally and thus lead them to be more open to changing teaching practice.

THEORETICAL FRAMEWORK

Beliefs are viewed as the foundation of action and learning, a theoretical framework in which to judge (Feldman, 2002), and a filter for accepting or rejecting new information that opposes existing beliefs (Kagan, 1992; Kane, Sandretto, & Heath, 2002; Knowles, 1992; Munby, 1982; Pajares, 1992). We were interested in exploring how preservice science teachers view themselves as future biology, chemistry, or physics teachers and what content and skills they think should be taught and learned in school science. Based on their undergraduate and, in some instances, graduate work in biology, chemistry, or physics, teacher candidates will have acquired not only discipline-specific content knowledge and scientific skills but also perceptions of how the scientific community views science and rituals inherent to the specific community (Becher & Trowler, 2001). For example, future high school science teachers may view science as a predetermined body of concepts that are confirmed in laboratory activities following recipe-like procedures. Other teacher candidates

TABLE 1
Characteristics of Science Teacher Archetypes

Archetype	Purpose of science education	Perception of place of nontraditional content (inclusion of socioscientific issues)	Nature of science	Identity
Model scientist	Develop and recruit scientists (career orientation), prepare students for further study	Does not belong	Sophisticated (understanding of fallibility of science and social character of scientific practice)	Mostly scientist
Model individual	Progressive (develop scientific literacy in all students)	Undecided	Naïve (understands scientific endeavor as isolated from social networks)	Mostly teacher
Model teacher	Progressive (develop scientific literacy in all students), prepare students for further study	Belongs if it keeps students interested	Varies	Mostly teacher
Model citizen	Progressive (develop scientific literacy in all students)	Must be there	Sophisticated (understanding of fallibility of science and social character of scientific practice)	Both teacher and scientist

might have experienced inquiry-based research during their undergraduate studies and thus view science as a more fluent body of concepts that, through explorative and open-ended laboratories, may change and result in the creation of new knowledge. In addition and derived from such beliefs, future science teachers express beliefs about instructional practice that may reflect a focus on abstract concepts and their avoidance of context except where it might enhance the learning of the abstract concepts (Carlone, 2004). Further, their beliefs about instructional practices may reflect ideas of reform-based teaching approaches and the application of scientific concepts to students' everyday lives and the discussion of ethical issues in science (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006). Research has shown that particularly the inclusion of the latter in high school biology, chemistry, and physics courses is unlikely unless teacher candidates have experienced such issues during their academic discipline training and thus have identified and interrogated beliefs about biology, chemistry, and physics as subjects of study (Bryan & Atwater, 2002).

These beliefs are also central to identity (Helms, 1998). Science teachers' identities are expected to influence whether or not they choose to teach about and through socioscientific issues. Our conception of identity is a dialogue with the self and others. It is derived from Wenger's (1998) concept of identity, which he described as a negotiation between the self, other people, and the context in which people live and work. Teacher candidates as science students have not only learned science content and skills; they also learned how to *be* as a science student (undergraduate or graduate). They have incorporated to various degrees the practices, rituals, and discourses of their specific and the general science community. Wenger (1998) has described identity in terms of communities of practice, where individuals define themselves with respect to the community in which they work or expect to work in the future. This theory, which originated in a study based on work culture, views identity as relational and multifaceted. Individuals' identities evolve in the context of their interactions with coworkers in the past and present and imagined interactions in the future. The workplace is described as a community of practice because it is defined by its daily work but individual identities are defined by the act of relating to others within that context. In our case, there are two communities of practice that are of concern and that are both characterized by subject specialty—the science disciplines community (specifically of physicists, chemists, and biologists) and the high schools in which teacher candidates will work as future biology, chemistry, and physics teachers (Hargreaves, 1990). As students, they become initiated into that discipline, have learned not only about the content of science but how to be a science student in association with the community of scientists (Becher & Trowler, 2001), and adopt an identity in relation to that community; an identity that we call subject discipline identity.

As noted above, in a smaller qualitative study (Barrett, 2008) we identified four archetypal ideal SDIs (see Table 1). Teacher candidates who express a model scientist SDI identify strongly with the community of scientists. They are concerned mainly with teaching concepts and preparing students for undergraduate science study, and their goal is to develop scientists. These teacher candidates have a sophisticated notion of science practice. But, based on their own undergraduate experiences, they do not believe that teaching through reform-based approaches such as inquiry is relevant to preparing high school science students for further study in science. Preservice teachers with a model individual SDI look to the community of scientists for knowledge but do not see themselves as part of it. Their idea of science practice is naïve because they have very little experience with science practice beyond undergraduate work. They are not necessarily trying to develop scientists. Rather, they aim for self-actualization for their students. Their sense of self is not really dependent on teaching approaches in science because they have very little investment in being a science teacher (as opposed to a teacher of any other subject). Teacher candidates with the model teacher SDI also look to the community of scientists for knowledge without seeing themselves as belonging to it. Their identity is highly invested in being a science teacher. Their goal is developing informed citizens as well as a few scientists. They are therefore motivated to do whatever it takes to improve their students' achievement but they may feel uncomfortable with inquiry-based teaching because they have little experience with it and believe that it may not prepare students for the next level of schooling, which is their main concern. In addition, they may find implementing reform-based teaching threatening because the newness of such approaches threatens their status as experts—as both experts on the science content that they teach and experts on how to teach it. Preservice teachers with the model citizen SDI feel part of the community of scientists and the community of science teachers. Their goals for science teaching are developing informed citizens and scientists who recognize the impact of their work on society from a social justice perspective. It is possible that these teacher candidates would use reform-based teaching to give their students a more robust understanding of the nature of science that would help to make them more informed and critical citizens. Their sense of self is not threatened by reform-based teaching or the inclusion of ethical issues because they feel secure as a member of both communities and have already assumed that part of the role of a science teacher is to facilitate communication between the communities of scientists and citizens.

For science teacher educators, an understanding of these archetypes representing the subject-specific identities of biology, chemistry, and physics teacher candidates could help them to more readily address the questions and concerns that their preservice teachers have with respect to teaching science in a way that may be unfamiliar to them, such as contextualizing science, bringing ethics into high school science curricula, or implementing reform-based teaching approaches that take into account the diversity of their student population. For example, the resistance of physics or chemistry teachers to contextualizing science may be because teachers' subject discipline identities are deeply invested in the decontextualized version of the physical sciences that has been predominant in science education. As science students, teacher candidates have been socialized to appreciate and accept the university approach to undergraduate science that uses a transmission model of teaching (i.e., lecturing) with lab work that consists mainly of verification labs (where the outcomes are known) rather than inquiry. Further, most preservice science teachers have not done graduate work and therefore have not experienced inquiry work (as scientists practice it); thus, they have developed an understanding of themselves as excellent students of science rather than scientists (Varelas, House, & Wenzel, 2005). Thus, survey questions were developed from the interview questions, participant data, and findings and conclusions from the previous qualitative study.

Research Questions

Based on the original qualitative study, this quantitative study explores whether preservice science teachers express science subject-specific identities that reflect their beliefs about contextualizing science. Within this we focused on two major research questions:

1. Do the beliefs of preservice science teachers cluster in a pattern resembling the beliefs associated with the four subject-specific identities (archetypes)?
2. To what extent do gender, academic preparation, and preferred teaching field predict subject-specific identity?

Ultimately, we will consider the implications of the presence and nature of these archetypes for teacher education programs.

METHODOLOGY

Participants

This quantitative study was conducted with secondary science teacher candidates ($n = 247$; 168 female and 79 male) who were enrolled in general science, chemistry, physics, and biology methods courses at three different universities in southern Canada (see Table 2). The gender distribution (more female than male teacher candidates) seems quite typical for teacher education programs across North America (Coopersmith, 2009).

Although all three universities are racially and ethnically diverse, the majority of teacher candidates in the post-baccalaureate teacher education certificate programs were, in all cases, White and female. Despite differences within the programs (for example, the kinds and number of courses to be taken may vary across the programs), a review of the course syllabi revealed that the secondary science methods courses at each of the three universities showed major similarities. Although the order of topics varied, all science discipline-specific methods courses provided teacher candidates with theoretical and practical understanding of instructional methods, assessment/evaluation strategies, unit and lesson planning in a variety of classroom contexts, the integration of technology into teaching, and creating inclusive and motivating learning environments.

Data Collection

For this study, a questionnaire was developed that addressed teacher candidates' beliefs about the purposes of science and science teaching and the inclusion of controversial issues. It asked how they view themselves as future science teachers (self-concept) and inquired about their reasons

TABLE 2
Distribution of Participants Across the Universities by Sex

University	Sex, *n* (%) Male	Female	Total, *n* (%)
University 1	27 (28.1)	69 (71.09)	96 (100.0)
University 2	41 (33.6)	81 (66.4)	122 (100.0)
University 3	11 (37.9)	18 (62.1)	29 (100.0)
Total	79 (32.0)	168 (68.0)	247 (100.0)

for becoming science teachers. The items were developed based on results of the qualitative study (Barrett, 2007; Barrett & Nieswandt, 2010), which followed 12 preservice science teacher candidates throughout their 9-month teacher education program in order to ascertain their beliefs about the purposes of science teaching and resulted in the four different archetypes as described above. The administered questionnaire included 68 items addressing aspects of the four qualitative components of SDI that had emerged as patterns in the 2010 study. These included (a) goals or purpose of science education measured with a total of 17 items and reflecting criteria distinguishing all four of the original archetypes such as "to encourage students to become scientists," "to draw my students' attention to societal problems," "to follow the curriculum documents," and "to focus on applications." The next component (b), referring to perceptions of the place of nontraditional content (e.g., inclusion of socioscientific issues) in science education, was reflected in two sections of the questionnaire: in one section, six items addressed attitudes toward including controversial issues, and five items highlighted the level of comfort that teacher candidates reported with integrating science, technology, society, and environment (STSE) topics in their teaching.

The administered questionnaire addressed another previously isolated qualitative component (c) of SDI, the nature of science, with 10 items. A final SDI component, identity (d), was measured in the following subareas:

1. Interest in becoming a science teacher (six items)
2. Focus of university education (eight items)
3. Sense of belonging to science community (eight items)
4. Sense of belonging to school community (eight items)

Thus, the prior qualitative work suggested that we would find eight different quantitative factors related to SDI.

Answers to all items were on a 5-point Likert scale ranging from *strongly agree* (5) to *strongly disagree* (1). In all components of the administered survey, a few of the items were negatively worded to reduce the tendency toward response set (Neuman, 2000); coding for these items was reversed prior to analysis.

Additionally, the questionnaire collected demographic data such as gender, number of science courses taken, highest degree earned, and experiences working in research inside or outside of academia. Finally, participants were asked to indicate in which of the three science teaching fields (biology, chemistry, or physics) they felt most comfortable; the option "other" was given as well. The questionnaire was administered in the absence of the course instructors, and after its purpose was discussed, questions about the study were answered and teacher candidates gave their written consent to their participation. Participants were instructed orally and on the questionnaire to respond to the statements with respect to the one science teaching subject that they felt most comfortable teaching. Participants needed an average of 25 minutes to fill out the questionnaire.

Data Analysis

There were three steps involved in the analysis of the data. First, using both exploratory and confirmatory factor analysis, we checked whether the items that corresponded to each of the components of SDI based on the prior qualitative study did in fact represent distinct factors in a statistical sense. Second, using the factors isolated from this process, we conducted a cluster analysis to determine whether teacher candidates tended to cluster in patterns that align with the four archetypes previously identified through qualitative methods. (We address our research question 1 with the results of this cluster analysis.) In the third step, we sought to predict cluster membership on the basis of specific characteristics of the teacher candidates, such as gender, level of academic preparation, and preferred teaching field. For this aspect of the statistical analysis, which addresses our second research question, we used multinomial logistic regression.

After entering questionnaire data into SPSS (available for purchase at www.spss.com, Chicago, IL), exploratory factor analysis was conducted for each of the eight sets of items representing potential factors contributing to SDI. Principal component factoring with varimax rotation was used to extract factors with eigenvalues greater than 1.0. Although Tabachnick and Fidell (2001) cited 0.32 as a good rule of thumb for the minimum loading of an item, we used a more stringent standard by retaining only those items with factor loadings over 0.4 and in the expected direction to create these single factors.

Confirmatory factor analysis allowing measurement error of the items to be correlated was also performed. Because sets of items used the same item stem in the questionnaire, there was reason to believe that measurement error might be correlated across items, a phenomenon that is not explicitly modeled in exploratory factor analysis.

After isolating items that loaded heavily on a factor and dropping items that did not load strongly, we constructed each factor's score by weighting these items equally; that is, by summing the items that loaded together and then dividing them by the number of items.

To address research question 1, we used the various factor scores based on the 68-item SDI instrument to try to differentiate teacher candidates into profile groups using hierarchical cluster analysis using Ward's minimum variance technique (Ward, 1963). Examination of group factor score means for each cluster isolated allowed for a characterization of the clusters, laying the groundwork for a comparison of the quantitatively determined clusters with the four original qualitatively determined archetypes.

To address the second research question regarding whether cluster membership could be predicted based on several aspects of the teacher candidates' backgrounds (i.e., gender, university program, academic preparation, and preferred teaching field), we used a multinomial logistic regression approach. We took as the dependent variable the cluster (we expected the number of different clusters to be four, because four archetypes were found in the original qualitative study), and the teacher candidate background variables were treated as independent or predictor variables. In such situations, a multinomial logistic regression approach is recommended because the dependent variable (cluster membership) is a categorical variable with more than two categories, and the predictor variables are a mix of dummy variables and continuous variables (Kremelberg, 2011). The core logic of this modeling strategy is to assess whether variables can predict the odds of individual cases falling into one category versus another. Thus, if there are four categories in the dependent variable, multinomial logistic regression would produce a set of three equations related to these relative odds.

RESULTS

Of the eight potential factors implied by the previous qualitative study, seven were reflected with substantial correspondence by both exploratory factor analysis and confirmatory factor analysis. The set of items about belonging to a school community did not load on a single factor and were among the items dropped from the analysis. Where there were sufficient degrees of freedom to permit it, confirmatory factor analysis models were estimated with correlated error, producing well-fitting models with a comparative fit index (CFI) higher than the minimum standard of 0.9 (Hu & Bentler, 1999). This alternative approach supported the results of the exploratory factor analysis in that all of the items with factor loadings over 0.4 in the exploratory factor analysis were positive and significant in the confirmatory factor analysis.

The reliability of each of these seven factors was assessed using Cronbach's alpha, which provides an internal consistency estimate of reliability of questionnaire items (Cronbach, 1951).[1] Table 3 shows exploratory factor analysis loadings and Cronbach's alpha for each factor. The first factor, purpose of science education, included eight items (originally 17) that explained 49.5% of variance and revealed only two of the four archetypes: model citizen and model teacher. In order to better reflect these results we labeled this factor "progressive purpose of science education." The second factor referring to perceptions of the place of nontraditional content (inclusion of socioscientific issues) in science education was originally composed of six items. The factor analysis resulted in a factor with three items (explaining 78.1% of variance), which we labeled "aversion to including controversial issues." Being comfortable with STSE was another facet related to the place of nontraditional content: its factor retained four of the original five items, explaining 52.2% of variance. The set of nature of science items ended up with a three-item solution (originally 10 items) explaining 53.5% of variance, and in order to better represent the retained items of the nature of science, we labeled the factor "traditional views of nature of science." Identities or preservice teachers' trajectories were reflected through four different aspects, of which three formed reliable factors: interest in becoming a science teacher, with four items (originally six items) explaining 41.0% of variance; focus of university education (originally eight items) comprised of five items (48.7% of variance) stressing application aspects, which resulted in relabeling the factor as "focus on application in university education"; and sense of belonging to science community, with six items (originally eight items) explaining 47.4% of variance. As noted above, the item intended to tap a sense of belonging to a school community did not load on a single factor.

To examine whether these seven factors could reliably differentiate teacher candidates into groups aligning with the four archetypes of Barrett and Nieswandt's (2010) previous study and thus to answer the first research question, we conducted a hierarchical cluster analysis using Ward's minimum variance technique (Ward, 1963). The basic idea is that archetypes or profile groups would be reflected in a tendency for subsets of teacher candidates to cluster together based on similarities in their scores across all of the factors. As an essentially descriptive statistical technique, cluster analysis does not rely on hypothesis testing as, for example, analysis of variance approaches do. Following suggestions by Buehl and Alexander (2005), we verified the stability of the cluster solution in three ways. First, we repeated the analysis using a split sample ($n_1 = 144$ and $n_2 = 143$) and compared for consistency in the solution across these randomly chosen subsamples (Everitt, 1993). Dendograms that visually represent possibilities for grouping the teacher candidates into various sets of clusters showed a similar pattern for the full sample analysis as well as each of the subsamples that suggested either a two-cluster or a three-cluster solution. Second, we assessed the validity of the two possible solutions in light of theoretical considerations; in the end, we chose to use the three-cluster solution because it drew more strongly from all seven factors. Finally, using the three-cluster solution, we generated a cluster membership variable and then verified the distinguishability of the clusters by running

TABLE 3
Factors, Items, and Cronbach's Alpha for Each Factor

	Items and factor loading	Cronbach's alpha
Progressive purpose of science education		.85
	With respect to teaching the science subject that I feel most comfortable teaching, I want to . . .	
	help my students become more informed citizens (0.53)	
	draw my students' attention to societal problems (0.74)	
	focus on skills (0.64)	
	focus on applications (0.68)	
	emphasize environmental problems (0.84)	
	include discussions about local economic issues (0.75)	
	include discussions about global economic issues (0.76)	
	emphasize the impacts of science and technology on society (0.64)	
Aversion to including controversial issues		.87
	With respect to teaching the science subject that I feel most comfortable teaching, including controversial issues in my science teaching . . .	
	would take time away from preparing students for their next level of schooling (0.81)	
	would take time away from teaching theories (0.93)	
	would take time away from teaching facts (0.91)	
Focus on application in university education		.72
	My university education . . .	
	included discussions about industrial applications (0.54)	
	included discussions about controversial issues (0.77)	
	focused on environmental issues (0.74)	
	focused on how my science impacts society (0.86)	
	focused on how scientists do their day-to-day work (0.52)	
Interest in becoming a science teacher		.49
	I want to be a science teacher because . . .	
	I have always wanted to teach science (0.65)	
	I want to share what I know about science (0.80)	
	I want to encourage my future students to study science (0.63)	
	I want my students to become informed citizens (0.44)	

TABLE 3
Factors, Items, and Cronbach's Alpha for Each Factor *(Continued)*

	Items and factor loading	Cronbach's alpha
Sense of belonging in science community		.73
	I felt very comfortable within the science department at university (0.67)	
	I would feel comfortable being a scientist (0.72)	
	Compared to other subjects in university, science is prestigious (0.56)	
	The great scientists are my role models (0.72)	
	I found many role models during my science study (0.70)	
	I consider myself to be a scientist who teaches (0.75)	
Comfort with STSE		.68
	We have discussed STSE in my curriculum methods courses (0.68)	
	I feel comfortable teaching STSE topics in my primary science (0.83)	
	I have taught STSE lessons during my practicum (0.75)	
	My associate teacher already taught STSE lessons regularly (0.62)	
Traditional views of nature of science		.53
	Science is based on theory development (0.76)	
	Science is based on experimentation (0.83)	
	Science is essentially a method (0.58)	

Note. Answers to all items were on a 5-point Likert scale ranging from strongly agree (5) to strongly disagree (1).

a discriminant analysis using the seven factors. The discriminant analysis correctly predicted cluster membership in 96.2% of the cases, with Cohen's kappa equaling 0.943, suggesting that our three-cluster approach constitutes a valid solution (Romesburg, 1984).

Having verified the stability of the cluster solution, we found that 82 teacher candidates were categorized into the first cluster, with the second and third clusters comprising 88 and 69 cases, respectively. There were 8 cases with missing data that could not be classified. As a check, analysis of variance models showed that the mutually exclusive clusters varied significantly on all seven of the factors ($p < .001$), except for a somewhat less significant association with the second factor, aversion to including controversial issues ($p = .031$). Table 4 shows descriptive statistics of the seven factors across each of the three clusters. As we will discuss in more depth later, two of the clusters mapped closely onto an archetype from the previous study (Barrett, 2007; Barrett & Nieswandt, 2010). The first cluster (C1) maps onto the model science teacher archetype (we have changed the name slightly, from model teacher for the sake of clarity), and the third (C3) maps onto the model citizen archetype. However, the second cluster (C2) did not correspond to any of the archetypes from the previous study. We named this third archetype, based on the second cluster (C2), non-science teacher but without including the descriptor model. The latter reflects, as we will show, that this archetype is not an ideal to which preservice science teachers

TABLE 4
Descriptive Statistics of Factors by Cluster Membership

	Minimum	Maximum	Unstandardized mean	Standard deviation	Standardized mean
			Factor 1: Progressive purpose of science education		
Cluster 1: Model teacher	3.63	5.00	4.58	0.328	0.424
Cluster 2: Model non-science teacher	2.63	4.88	4.01	0.451	−0.768
Cluster 3: Model citizen	3.88	5.00	4.61	0.335	0.495
			Factor 2: Aversion to including controversial issues		
Cluster 1: Model science teacher	1.00	4.33	2.20	0.702	−0.083
Cluster 2: Model non-science teacher	1.00	5.00	2.39	0.678	0.170
Cluster 3: Model citizen	1.00	4.00	2.09	0.787	−0.233
			Factor 3: Focus on application in university education		
Cluster 1: Model science teacher	1.00	4.40	2.42	0.705	−0.626
Cluster 2: Model non-science teacher	1.00	4.80	2.98	0.689	0.060
Cluster 3: Model citizen	2.00	5.00	3.48	0.692	0.680
			Factor 4: Interest in becoming a science teacher		
Cluster 1: Model science teacher	3.00	5.00	4.06	0.405	0.167
Cluster 2: Non-science teacher	1.75	4.75	3.59	0.473	−0.712
Cluster 3: Model citizen	3.50	5.00	4.38	0.381	0.763
			Factor 5: Sense of belonging in science community		
Cluster 1: Model science teacher	1.17	4.33	2.79	0.714	−0.212
Cluster 2: Non-science teacher	1.00	4.50	2.61	0.681	−0.445
Cluster 3: Model citizen	2.00	5.00	3.60	0.679	0.798
			Factor 6: Comfort with STSE		
Cluster 1: Model science teacher	1.00	5.00	3.72	0.715	0.244
Cluster 2: Non-science teacher	2.00	4.75	3.04	0.550	−0.668
Cluster 3: Model citizen	2.00	5.00	3.96	0.648	0.561
			Factor 7: Traditional views of nature of science		
Cluster 1: Model science teacher	2.67	5.00	3.90	0.561	0.429
Cluster 2: Non-science teacher	2.00	4.33	3.55	0.452	−0.142
Cluster 3: Model citizen	1.00	5.00	3.46	0.713	−0.302

Note. Answers to all items were on a 5-point Likert scale ranging from strongly agree (5) to strongly disagree (1).

should aspire. We will also show that all three of these quantitatively based profiles go beyond the archetypes found in our previous study. In addition, in this study, we did not find profiles that matched the model scientist and the model individual archetypes.

To describe the nature of the profiles identified through the cluster analysis, we cite both the unstandardized mean for each factor across clusters and the mean of the standardized scores. Each mean reveals a slightly different aspect of the cluster: the unstandardized mean shows the general level of that characteristic present in the clusters, especially compared to other factors, and the mean of the standardized scores highlights the magnitude of differences between the clusters within a particular factor (because the standardized factor score is set to 0 for all members within a cluster). Table 4 indicates that all three profile groups are characterized by generally high scores on the first factor, progressive purpose of science education (all unstandardized means above 4.0 out of 5), suggesting that the teacher candidates believe that their mission as science teachers is broad and encompassing, regardless of cluster membership. Standardized scores indicate that model science teacher (C1) and model citizen (C3) scored the highest on this factor, with means on the standardized purpose of science factor of 0.424 and 0.495, respectively, whereas non-science teacher (C2) tended to be relatively lower, at a mean of −0.768. In contrast, the three clusters in general rated the second factor, an aversion to including controversial issues in their teaching, somewhat low with unstandardized means between 2.0 and 2.4 for all clusters. Non-science teacher (C2) was somewhat more averse, with a standardized mean of 0.170, followed by model science teacher (C1) with a mean of −0.083 and model citizen (C3) with −0.233.

For the third factor, the focus of application in teacher candidates' university education, unstandardized scores varied more widely across the clusters, with over a one-point difference between the means in two of the clusters. Model citizen (C3) respondents clearly tended to score higher (mean of standardized factor 0.680), meaning that their undergraduate program emphasized applications of science to a high degree. Non-science teacher (C2) rated in the middle, with a standardized mean of 0.060, and model science teacher (C1) had the lowest degree of applications-oriented focus, with a mean of −0.626.

The profile groups differed only somewhat on the fourth factor, their interest in becoming a science teacher. All clusters tended to score fairly high on this factor, with unstandardized cluster means between 3.5 and 4.4. The model citizen (C3) showed the strongest basis for interest with a mean standardized factor score of 0.763; model science teacher (C1) had more moderate levels of interest with a standardized mean of 0.167 and non-science teacher (C2) had relatively weak sources of interest with a mean standardized score of −0.712.

Another factor, the sense of belonging to the science community (self-concept), showed clear differentiation between clusters but generally reflected a somewhat low sense of self as a scientist, with unstandardized cluster means ranging from 2.61 to 3.60. There were relatively narrow differences between model science teacher (C1) and non-science teacher (C2) on this dimension with means of the standardized factors −0.212 and −0.445, respectively, and model citizen (C3) showed relatively strong belonging to the science community with a mean standardized score of 0.798.

Regarding the sixth factor, the level of comfort that respondents had with respect to teaching STSE topics was only moderate, generally speaking, with all unstandardized cluster means falling between 3.0 and 4.0 on the 5-point scale. The third cluster, model citizen, showed the most comfort with including STSE topics with a standardized score of 0.561, followed by model science teacher at a mean of 0.244. The second cluster, non-science teacher, was relatively less comfortable with STSE topics, showing a standardized mean of −0.668.

Finally, there was a comparatively narrow gap between clusters in terms of their views of nature of science and, in general, those views tended to be slightly traditional, with unstandardized means ranging across clusters from 3.46 to 3.90 out of a maximum of 5. Relatively speaking, model science teacher (C1) had the most traditional views of nature of science, with a mean standardized factor score of 0.429, and the non-science teacher (C2) and model citizen (C3) clusters had less traditional views with standardized mean scores of −0.142 and −0.302, respectively.

Figure 1 visually highlights the profile differences across the three clusters based on the standardized cluster mean of each factor. The profile of model citizen (C3) was characterized by a relatively high focus on science in the university education, strong sources of interest in becoming a science teacher, and a high degree of comfort teaching STSE topics. In some ways, the profile of non-science teacher was the converse of the model citizen: relatively low sources of interest in becoming a science teacher (at least in terms of the potential sources asked about in the survey), weaker sense of belonging to the scientific community, and low levels of comfort with STSE issues and stronger aversion to inclusion of controversial issues. In addition, the profile of the non-science teacher was characterized by a relatively narrow framing of the purpose of science education. The profile of the model science teacher was rather mixed, with generally

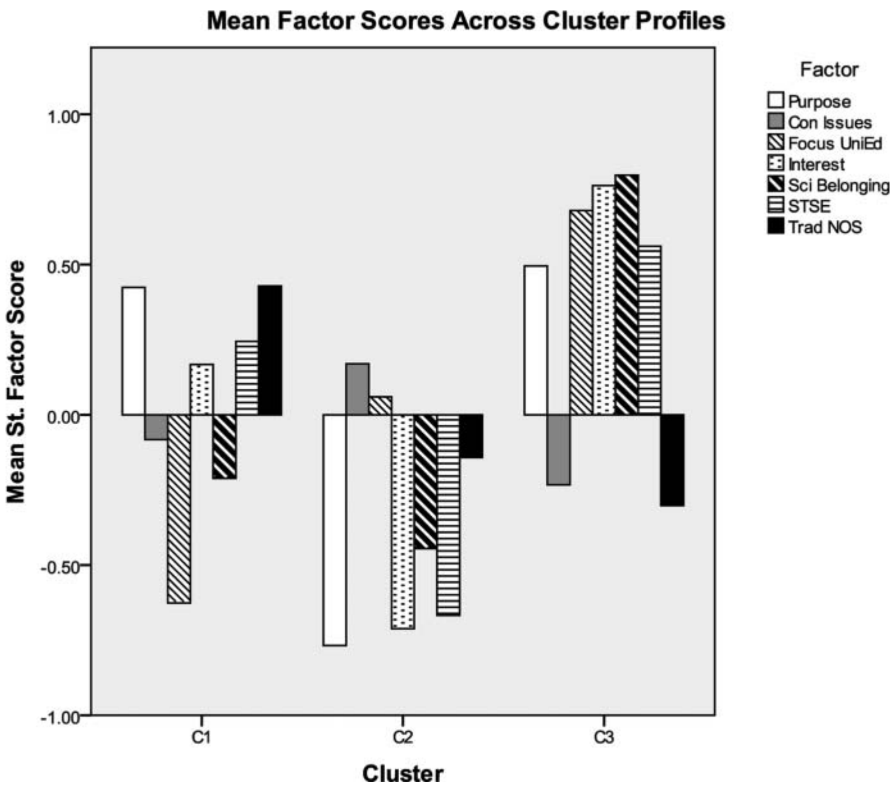

FIGURE 1 Profiles of Three-Cluster Solution: Model Science Teacher (C1), Non-Science Teacher (C2), and Model Citizen (C3).

moderate scores across factors compared to the other clusters, except for a relatively weak focus on science applications in their undergraduate preparation and somewhat more traditional views of the nature of science.

Taking a step back from the details of the data analysis, we can say that though there surely are different profiles that would serve as foundations for development as an effective science teacher, the profile of non-science teacher is perhaps most problematic, reflecting a less than expansive view of science and science teaching.

Though these profiles give us indicators of preservice science teachers' beliefs within each cluster, they do not provide any information about what causes these cluster membership patterns. In order to develop a better understanding of this (research question 2), we ran a multinomial logistic regression (nominal regression in SPSS) with the three-category cluster membership as the dependent variable. As independent variables we used gender, university (U1, U2, U3), number of subject-specific science courses taken, whether or not the teacher candidate had conducted research as part of his or her science training, and which subject she or he was most comfortable teaching. Most of these characteristics were not significantly associated with cluster membership, except for university attended (likelihood ratio chi-square test, $p = .003$) and the subject that respondents were most comfortable teaching (likelihood ratio chi-square test, $p < .001$). More specifically, teacher candidates at university 1 were somewhat more likely to be in the non-science teacher cluster than respondents from other universities, after controlling for other variables. Preservice science teachers who felt most comfortable teaching in the disciplines of biology, physics, and especially chemistry were significantly less likely to be in the non-science teacher cluster than teacher candidates who preferred teaching a non-science field such as mathematics or physical education, even after controlling for other effects such as the number of science courses taken. There were no statistically significant differences in the pattern of cluster membership between those who claimed that their most comfortable subject was general science and those who preferred teaching in a non-science field. Figure 2 shows the general pattern of cluster membership across preferred teaching fields.

Although the distribution of clusters by teaching field varied significantly, these groups are not representative of all students in a given field but, rather, are representative of a subgroup of students who chose to become teachers. The prevalence of non-science teacher identities in general science and out of field was not completely a surprise, though it is unclear what exactly caused this tendency. However, the distribution within the physics, chemistry, and biology groups requires further study.

DISCUSSION

This study was developed based on the results of our earlier project, which involved examining 12 physics and chemistry teacher candidates' beliefs about including socioscientific issues in Grade 12 university-bound physics and chemistry (Barrett & Nieswandt, 2010). The four archetypes that were developed based on those qualitative results were model scientist/engineer, model individual, model teacher, and model citizen. The title model derived from the fact that all of the participants seemed to aspire to these identities. In the present study, the absence of the model scientist archetype was a surprise; however, even in the original qualitative study, only one of the 12 participants had been identified as such. Similarly, only 2 of the 12 participants in

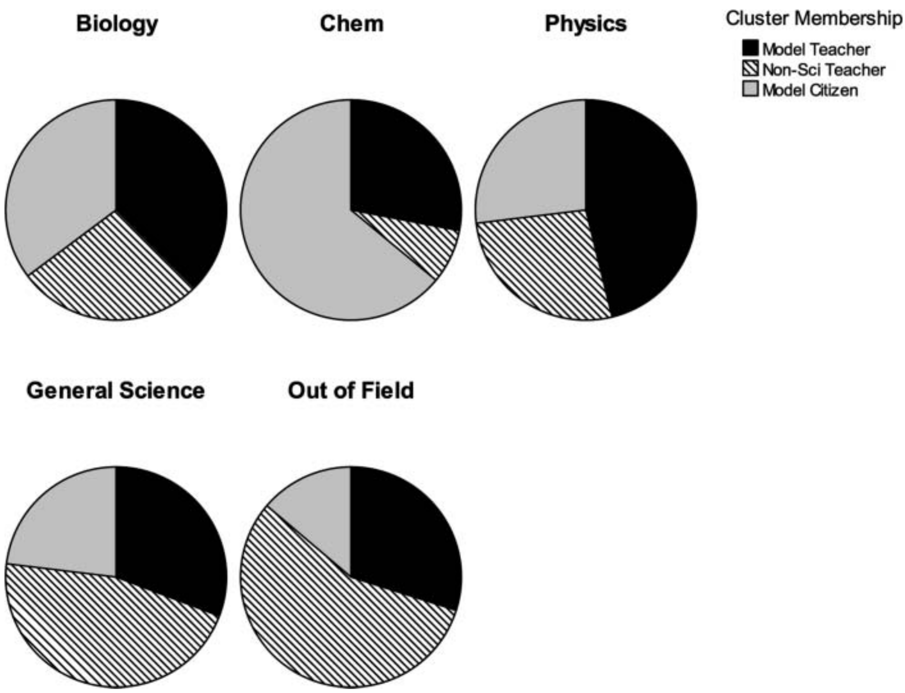

FIGURE 2 Cluster Membership by Teaching Field. *Note.* Membership in non-science teacher cluster for those most comfortable teaching biology, chemistry, and physics is significantly less likely ($p < .05$) than for those most comfortable teaching out of the science field (multinomial logistic regression analysis).

the original study were categorized as the model individual archetype. This archetype was fairly specific to the subject matter of the original study; therefore, it follows that it did not inform the results of the present survey very much.

As for the new cluster revealed in this study, non-science teacher, it is a more generalized version of the model individual. Recall that the model individual had the least amount of specialized knowledge about socioscientific issues. Similarly, the non-science teacher in this study seemed to have the least amount of specialized knowledge about science in general. This may be the result of the fact that, in this particular jurisdiction (southern Canada), it is possible to become qualified to teach any science subject with only three university science courses. Though most science teacher candidates enter teacher education programs with more than this, a significant minority do not. The results of our study indicate that this group of preservice teachers is more likely to be in the non-science teacher cluster. Thus, the existence of this category is not surprising. Again, the reason that the title model is not part of the non-science teacher label is because this is not expected to be an ideal to which participants aspire.

What follows is a discussion of the results for each of the seven factors used to distinguish the model citizen, model science teacher, and non-science teacher from each other. We refer to our original study (Barrett & Nieswandt, 2010) for comparison and relate the results to other relevant research studies.

Factor 1: Progressive Purpose for Science Education

The low scores for the non-science teachers were most likely due to their lack of confidence in the subject matter, which was likely a result of low number of required university science content courses. Lack of experience would make it more difficult for a non-science teacher to have a less traditional idea of the purpose of science education and we tend to be most aware of stereotypical versions of complex activities with which we are not familiar. Similarly, the model science teachers and model citizens would be expected to be fairly confident in their understanding of what they want to accomplish in their teaching and therefore be more able to imagine alternative approaches and goals.

Factor 2: Aversion to Including Controversial Issues

For the most part, the participants in this study were not averse to including controversial issues in their teaching. As expected, the model citizens were the least averse. In the original model (Barrett & Nieswandt, 2010), the model citizens believed that controversial issues were an essential part of preparing students to be informed citizens. The results of this study indicate that the model citizens' opinion of this matter was not quite so strong. The difference might be explained by the fact that the model citizens in the original study had self-selected to participate in the 9-month study because they were interested in discussing the inclusion of controversial issues in their teaching. This sort of bias was not present in the current study.

The non-science teachers' somewhat averse orientation to controversy could stem from their lack of confidence in the subject matter. Roth, Assor, Kanat-Maymon, and Kaplan (2007) found strong, positive relationships among teachers' ratings of self-efficacy for teaching and their perceptions of personal accomplishments, and Ross (1998) concluded that teachers' efficacy is generally higher when they are working in the area of their expertise. Our results demonstrate that the teacher candidates in the non-science teachers cluster were more comfortable teaching some other subject. Thus, teaching in any of the sciences is like teaching in a non-expert field. Efficacy research also found that when teachers demonstrate high levels of efficacy they tend to be more open to new ideas and more willing to experiment with new methods (Cousins & Walker, 2000; Guskey, 1988; Hani, Czerniak, & Lumpe, 1996). It seems that our participants in the non-science teacher cluster lacked the efficacy to include new ideas, such as controversial issues. However, only further research specifically addressing teacher candidates' efficacy in these areas would provide us with clear results.

Finally, the model science teachers' priority, according to the original study, is finding the most efficient way to teach their students the traditional theory and facts. They would not be expected to have a strong opinion either way and their scores in this study reflect this.

Factor 3: Focus on Applications in University Education

The high scores for the model citizens were expected. If we agree that our beliefs are a reflection of our socialization and cultural background, then this focus on their university education is the reason why they are model citizens. The low scores for the model science teachers are not so easily explained. However, the defining characteristic of the model science teacher is to see nontraditional content as a means to convey traditional content as efficiently as possible. It may be the case that a teacher candidate with a more traditional university science education would be more likely to aspire to be a model science teacher, as we have defined it, because it is more closely aligned with his or her beliefs about what and how to teach.

Factors 4 and 5: Interest in Becoming a Science Teacher and Sense of Belonging in Science Community

We discuss these two factors together because they define the three clusters conceptually. By definition, the model citizen feels comfortable in both the community of scientists and the community of teachers. The scores for these factors bear this out. The model science teacher was expected to identify strongly with becoming a teacher (factor 4) but not with being a scientist (factor 5). Again, the results were as expected. Finally, the non-science teacher was not expected to identify with either group and this was indeed the case.

Factors 6 and 7: Comfort With STSE and Traditional Views of Nature of Science

Factors 6 and 7 were expected to go in opposite directions. That is, a high score in one should be coupled with a low score in the other. The model citizen, as expected, had a higher score in factor 6 and lower score in factor 7. This follows because the model citizen's concern for bringing societal issues into teaching of science (through STSE) implies that members of this model have a sophisticated view of the nature of science. Indeed, this was one of their defining characteristics in the original study. Interestingly, the model science teacher was moderately comfortable with including STSE but had relatively conservative views about the nature of science. In addition, the non-science teacher was least comfortable with teaching STSE, probably due to lack of confidence, but had less traditional views of the nature of science than the model science teacher. The lack of confidence in teaching STSE may be explained in a way that is similar to the aversion to including controversial issues. That is, it may be due to low efficacy. However, these results require further study.

Predicting Cluster Membership

Given these three distinctive profiles for science teacher candidates, our analysis indicates that two characteristics predict membership: the university program in which the candidate is enrolled and the field in which the candidate feels most comfortable teaching. Candidates in one of the three universities in the study were significantly more likely to display characteristics of the non-science teacher, as were candidates who indicated more comfort teaching in non-science fields such as mathematics and physical education. In trying to understand the development of these science teacher candidates' identities, it was interesting to note the variables that did *not* predict cluster membership, such as gender, number of university science courses taken, and whether the candidate had the opportunity to conduct research. Science preparation in the form of courses taken and involvement in research may have a nonlinear effect on the development of identity in that there could be a threshold level of preparation that must be met to impact identity. The quality of these prior experiences in science may also figure in to the process.

Although the content of the science teaching methods courses at the three universities was carefully examined at the start of this study and deemed to be essentially equivalent, the significant differences in the pattern of cluster membership across the three universities bears more scrutiny. Universities may have different admissions criteria or attract varying types of applicants in ways that explain this finding. More germane to the purposes of this analysis, there may be other aspects of the teacher education programs at these three institutions that shape subject-specific identity. Finally, perhaps the most important finding in terms of predicting cluster membership is the fact that teacher candidates who express greater comfort teaching in non-science fields were indeed more likely to display a non-science teacher profile. As we have discussed, although there are many paths toward effective science teaching, it is unlikely that candidates with this particular profile will access one of these paths.

CONCLUSIONS AND IMPLICATIONS

The results of our study suggest that science teacher candidates do fit into specific subject-specific identities. The three archetypes identified here were discernible through cluster analysis. This method depends on clear criteria for each archetype and specific contexts. That is, identity is a complex ontological and epistemological concept. Without clear boundaries about what aspects of identity are being examined, a statistical approach would be impossible. Given that this particular questionnaire did result in clear, identifiable groups that follow logically from the original study (Barrett, 2007; Barrett & Nieswandt, 2010), we see a couple of immediate implications. First, and a more practice-oriented step, would be to develop a short questionnaire that a teacher educator could use to get to know her students. The information gleaned would assist her in catering to the conceptual and emotional needs of her students. For example, conceptually, the model teacher needs to learn more sophisticated notions of the nature of science. However, traditional conceptions of the nature of science imply a type of science education that is given higher status within schools (Carlone, 2003), which in turn confers status onto the teacher. Thus, teacher educators must also attend to the model teacher's dependence on that status if they wish to motivate such teacher candidates to teach in a nontraditional way. The model citizen has the requisite conceptual understanding but needs to learn techniques to implement a less traditional approach to science teaching. Finally, the non-science teacher needs to gain confidence and probably more science subject-specific content knowledge. As our study shows, the current practice in Canada of allowing teacher candidates who prefer to teach in another subject area to become credentialed to teach science indeed has costs. The more secure the teacher candidates were in their content knowledge, the more open they were to reform-based teaching practices and the less secure, the more conservative they were. If we view identified non-science teachers similar to elementary teachers, who often demonstrate low levels of self-efficacy and lack of content knowledge in teaching science, they would need more science content courses prior to their science methods courses but courses "that are positive, meaningful, and engaging" (Hechter, 2011, p. 199). Such experiences would then have the potential to increase their self-efficacy in teaching science. Highly confident preservice teachers are then more likely to try out various approaches in their lessons and are less afraid of innovations than less confident teachers (Gurvitch & Metzler, 2009; Kind, 2009).

Another follow-up of this study would be administering our survey to current high school science teachers. The lack of implementation of reform-based teaching approaches is a common complaint across the science education research community (e.g., Davis, 2003). Identifying which of our identified models is more prevalent among practicing science teachers has the potential to develop targeted professional development for each group that, similar to the preservice science teacher courses, would cater to the conceptual and emotional needs of these teachers.

In the end, our goal is to encourage preservice science teachers to become progressive and innovative teachers and practicing science teachers who meaningfully integrate innovative teaching methods and techniques into their teaching. To that end, more research needs to be done on specific approaches to teacher education that derive from the archetypes we have described.

NOTE

1. Given the complexity of the theoretical model of identity, with as many as eight factors measured by 68 items, our sample size of 247 was not sufficient to proceed with the suggested "split-half" analysis, in which the data are randomly divided in two, with exploratory factor analysis conducted on one half of the data, which then informs the confirmatory factor analysis on the second half (Loehlin, 1998). In fact, a confirmatory factor analysis of all possible factors was not possible even with the entire set of 247 cases, because that would violate the general accepted rule of at least 5 cases per parameter estimated. For this reason, confirmatory factor analysis of separate sets of items was intended merely as a check against the exploratory analysis. Because both exploratory and confirmatory factor analyses as well as Cronbach's alpha supported inclusion of items within each index, our approach to forming the factors seemed justified.

REFERENCES

Barrett, S. E. (2007). *Teacher candidates' beliefs about including socioscientific issues in physics and chemistry* (Unpublished doctoral dissertation). University of Toronto, Toronto, Canada.

Barrett, S. E. (2008). Mutual misunderstanding: Preservice teachers' and instructors' mismatching(?) priorities. *Canadian Journal of Science, Mathematics and Technology Education*, *8*(4), 313–330.

Barrett, S. E., & Nieswandt, M. (2010). Teaching ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching*, *47*(4), 380–401.

Becher, T., & Trowler, P. (2001). *Academic tribes and territories: Intellectual enquiry and the culture of disciplines* (2nd ed.). Philadelphia, PA: Open University Press.

Bryan, L. A., & Atwater, M. M. (2002). Teacher beliefs and cultural models: A challenge for science teacher education programs. *Science Education*, *86*, 821–839.

Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal*, *42*(4), 697–726.

Carlone, H. B. (2003). Innovative science within and against a culture of "achievement." *Science Education*, *87*(3), 307–328.

Carlone, H. B. (2004). The cultural production of science in reform-based physics: Girls' access, participation and resistance. *Journal of Research in Science Teaching*, *41*(4), 392–414.

Coopersmith, J. (2009). *Characteristics of public, private, and Bureau of Indian Education elementary and secondary school teachers in the United States: Results from the 2007–08 Schools and Staffing Survey* (NCES 2009–324). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Cousins, J. B., & Walker, C. A. (2000). Predictors of educators' valuing of systemic inquiry in schools. *Canadian Journal of Program Evaluation*, *15*, 25–53.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*, 297–334.

Davis, K. (2003). “Change is hard”: What science teachers are telling us about reform and teacher learning of innovative practices. *Science Education*, *87*, 3–30.

Everitt, B. S. (1993). *Cluster analysis* (3rd ed.). New York, NY: Edward Arnold.

Feldman, A. (2002). Multiple perspectives for the study of teaching: Knowledge, reason, understanding and being. *Journal of Research in Science Teaching*, *39*(10), 1032–1035.

Gurvitch, R., & Metzler, M. (2009). The effects of laboratory-based and field-based practicum experience on pre-service teachers’ self-efficacy. *Teaching and Teacher Education*, *25*(3), 437–443.

Guskey, T. R. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education*, *32*, 44–51.

Hani, J., Czerniak, C., & Lumpe, A. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching*, *33*, 971–993.

Hargreaves, A. (1990). The occupational culture of teachers. In P. Woods (Ed.), *Teacher skills and strategies* (pp. 125–148). London, England: Falmer Press.

Hechter, R. P. (2011). Changes in preservice elementary teachers’ personal science teaching efficacy and science teaching outcome expectancies: The influence of context. *Journal of Science Teacher Education*, *22*, 187–202.

Helms, J. V. (1998). Science and me: Subject matter and identity in secondary school science teachers. *Journal of Research in Science Teaching*, *35*(7), 811–834.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist*, *27*(1), 65–90.

Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research*, *72*(2), 177–228.

Kind, V. (2009). A conflict in your head: An exploration of trainee science teachers’ subject matter knowledge development and its impact on teacher self-confidence. *International Journal of Science Education*, *31*(11), 1529–1562.

Knowles, J. G. (1992). Models for understanding pre-service and beginning teachers’ biographies: Illustrations from case studies. In I. Goodson (Ed.), *Studying teachers’ lives* (pp. 99–152). London, England: Routledge.

Kremelberg, D. (2011). *Practical statistics*. Newbury Park, CA: Sage.

Loehlin, J. C. (1998). *Latent variable models: An introduction to factor, path, and structural analysis (3rd ed.)*. Mahwah, NJ: Erlbaum.

Munby, H. (1982). The place of teachers’ beliefs in research on teacher thinking and decision making, and an alternative methodology. *Instructional Science*, *11*(3), 201–225.

Neuman, W. L. (2000). *Social research methods* (4th ed.). Boston, MA: Allyn & Bacon.

Pajares, M. F. (1992). Teachers’ beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, *62*, 307–332.

Romesburg, H. C. (1984). *Cluster analysis for researchers*. Belmont, CA: Lifetime Learning.

Ross, J. A. (1998). The antecedents and consequences of teacher efficacy. In J. Brophy (Ed.), *Advances in research on teaching* (Vol. 7, pp. 49–73). Greenwich, CT: JAI.

Roth, G., Assor, A., Kanat-Maymon, Y., & Kaplan, H. (2007). Autonomous motivation for teaching: How self-determined teaching may lead to self-determined learning. *Journal of Educational Psychology*, *99*(4), 761–774.

Sadler, T. D., Amirshokoohi, A., Kazempour, M., & Allspaw, K. M. (2006). Socioscience and ethics in science classrooms: Teacher perspectives and strategies. *Journal of Research in Science Teaching*, *43*(4), 353–376.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics*. Boston, MA: Allyn and Bacon.

Varelas, M., House, R., & Wenzel, S. (2005). Beginning teachers immersed into science: Scientist and science teacher identities. *Science Education*, *89*(3), 492–516.

Ward, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*, *58*, 236–244.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, England: Cambridge University Press.

Zeidler, D. L., & Sadler, T. D. (2008). Social and ethical issues in science education: A prelude to action. *Science and Education*, *17*, 799–803.