

## **Science coursework and pedagogical beliefs of science teachers: The case of science teachers in the Philippines**

Eva B. Macugay<sup>\*</sup>, Allan B. I. Bernardo<sup>†‡</sup>

**ABSTRACT:** Science coursework is an important element of the pre-service education of science teachers. In this study we test the hypothesis that more science coursework influences pedagogical beliefs of science teachers by studying the pedagogical beliefs of 305 Filipino science teachers. We compared pedagogical beliefs of primary school (less science coursework) versus secondary school (more coursework) science teachers, and also science majors versus non-science majors. Results of the comparisons indicated that more science coursework is related to stronger endorsement of the belief that teaching involves providing support for learning, and to weaker endorsement of the belief that learning is limited by ability and by cultural beliefs. The results are discussed in terms of strong science content knowledge providing the anchors for reflecting on their teaching.

**KEY WORDS:** science coursework, pedagogical beliefs, content knowledge, science teacher education, Philippines

### **INTRODUCTION**

As educators, researchers, and policy makers in different parts of the world continue to debate the standards and qualities of good science teaching (Bolyard & Moyer-Packenham, 2008) and of pre-service education of science teachers (Darling-Hammond & Youngs, 2002; Windschitl, 2009), there are some points where most stakeholders agree. One of these points of agreement is on the importance of teachers' coursework in science in predicting science achievement of their students (Rice, 2003). Yet in different parts of the world, there are still wide variations in the level of science-related course work of science teachers. The International Report of the TIMSS 2007 (Martin, Mullis, & Foy, 2008) indicated that in Armenia, for example, 90% of primary school students had science teachers who either majored in science (90%) in their postsecondary education. In contrast, 95% of primary school students in Austria had science teachers who majored in education without a specialization in science. The variation is also found in Asia. In Chinese Taipei, 56% of students have sci-

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\* Mariano Marcos State University, Philippines

† University of Macau, Macau SAR China

‡ Corresponding Author: allanbibernardo@umac.mo

ence teachers who either majored in science (17%) or majored in education with a specialization in science (39%), but in Japan, 55% of students have science teachers who majored in education without a specialization in science.

No data are available for the Philippines in this 2007 report, but the 2003 report showed that only 13% of students have teachers who majored in education with a specialization in science, and another 4% had teachers who majored in science (Martin, Mullis, Gonzalez, & Chrostowski, 2004) in their postsecondary education; 54% had science teachers who majored in education without a specialization in science, and 18% had teachers who majored in education with a specialization in mathematics. The Philippine national government had recognized this problem long before that survey, and in response, the government with partners in the private sector initiated inservice teacher education programs to improve science content knowledge of science teachers who were not science majors (Bernardo, 1999). Evaluation of the preservice teacher education curriculum for science also indicated that even those who major in science do not have sufficient number of science content courses in their required coursework (Golla & De Guzman, 1998). So the problems of preservice science teacher education in the Philippines seem to relate to at least two major concerns: (a) very few preservice teachers major in science, and thus there are not enough teachers with a science major to teach science in all the schools, and (b) even those preservice teacher who major in science do not have enough science content coursework to prepare them to effectively teach science to primary and secondary students in Philippine schools (Golla & De Guzman, 1998; Ogena, 2005).

In response to the latter concern, the government also later increased the minimum number of college courses in science for all preservice teachers, and nearly doubled the required college science course for preservice teachers majoring in science (Bernardo, 2007). But most of the teachers who were in the teaching service during the time of the TIMSS 2003, and the overwhelming majority of science teachers in the Philippines today, were prepared following the old national standards that required only a minimum of three college courses in science for non-science majors, and 10 to 12 college courses in science for the science majors (Golla & De Guzman, 1998).

In the Philippines, most proponents of increasing the science course work argue on the basis of the assumption that one cannot teach what one does not understand (Golla & De Guzman, 1998; Ogena, 2005). In this study, we propose that more intensive science coursework for science teachers has added benefits, which is that the science teachers develop pedagogical beliefs related to teaching and learning practices known to be associated with better student learning.

Why focus on science teachers' pedagogical beliefs? Various definitions have been provided for teachers' belief regarding their students, the academic material to be taught, the learning and teaching processes, among other curriculum related aspects of their teaching (Calderhead, 1995; Kagan, 1992), and research has shown that these pedagogical beliefs guide how teachers plan for their classroom activities and shape the teachers' cognitions and behaviors while in the classroom (Calderhead, 1995; Pajares, 1992). But teacher beliefs are often unconscious, stable and resistant to change (Kagan, 1992; Pajares, 1992; Wilson, Miller, & Yerkes, 1993). It is not surprising therefore, that many advocates of teacher development have emphasized the need to focus on teacher beliefs in the processes of educational reforms (Appleton & Asoko, 1996; Ertmer, 2005; Woolfolk-Hoy, Davis, & Pape, 2006). This push has certainly applied to the area of science education reform (Mansour, 2009; Richie, Tobin, & Hook, 1997).

Education researchers have also focused on more intensive studies on the nature and structure of science teachers' beliefs (Atweh & Abadi, 2012; Luft, 2001, Tsai, 2002; Wong, Chan, & Lai, 2009), and special attention being paid to the development of such beliefs among preservice teachers (Chai, Teo, & Lee, 2010; Haney & McArthur, 2002; Yilmaz-Tuzun, 2008). Research has also looked into how preservice science teachers' beliefs are changed by their learning experiences such as collaborative online learning experiences (Hong & Lin, 2010), inquiry-based field experiences (Battacharyya, Volk, & Lumpe, 2009), and induction programs (Luft, Roehrig, & Patterson, 2003).

Because most studies on the development of pedagogical beliefs draw from knowledge-building and knowledge-construction approaches to teachers' development (see e.g., Hong & Lin, 2010; Luft, 2001; Tsai, 2002), the focus of the studies has been on the design features of preservice and inservice teacher development programs that allow for intensive reflections on specific actions of the teacher in the classroom. Interestingly, a similar focus on reflections on teacher actions is said to be important in the development of pedagogical content knowledge of science teachers (Loughran, Mulhall, & Berry, 2004; Park & Oliver, 2008). The teachers' content or subject matter knowledge seems to serve as an important prerequisite for their ability to reflect on their teaching experiences to develop their pedagogical content knowledge (Loughran et al., 2004; van Driel, Verloop, & de Vos, 1998). It is on the basis of this prerequisite role of content or subject matter knowledge that we explore the possible effects of science coursework on pedagogical beliefs of science teachers.

In our study, we explored the possible role of science coursework by comparing beliefs of Filipino science teachers with different levels of college science courses. Most of the science teachers referred to in the survey we cited earlier were educated using preservice curricula that prescribe

different sets of minimum required science courses. For example, primary school teachers follow the curriculum for Bachelor of Elementary Education, which does not require any specialization, but allows the student to develop an area of concentration. Those who do not have any specialization, are required to take only three science-related courses, and those who have a concentration in science, are required to take three more. In general, secondary school science teachers have more science courses in their postsecondary education than primary school teachers. They follow the curriculum for Bachelor of Secondary Education, and are required to have a major in some subject area (e.g., mathematics, social studies, general science, biology, chemistry, etc.). Those who do not major in science, are still required to take three or four basic science courses, but those who major in science will take a total of 10 to 12 science courses (Golla & de Guzman, 1998; this requirement was increased recently, Bernardo, 2007). Our first analysis involved comparing these two groups of science teachers. As the teachers in both categories may not have majored in science, our second analysis involved comparing science teachers who majored and science to those who did not major in science.

In the Philippines, previous research on preservice teacher beliefs has focused on epistemological beliefs (Bernardo, 2008; Magno, 2010, 2011). But in this study, we focused only on three sets of beliefs related to (a) science teaching, (b) successful learning in science, and (c) cultural beliefs. Most scholars on teacher beliefs have long maintained the importance of focusing on beliefs that relate to the nature of the teaching and learning processes (Ertmer, 2005; Woofolk-Hoy et al., 2006). Thus we focused on these two aspects of the teachers' pedagogical beliefs, and we contrasted between two specific types of beliefs in each of the two sets of pedagogical beliefs (as we explain in the following paragraphs).

Regarding science teaching, many proposals, have been made to capture dimensions of teachers beliefs about science teaching, but in many of the proposals the important contrasts relate to the role of the teacher vis-à-vis the knowledge acquisition processes in the learning. Larkin (2000) used the terms broadcast model and learning support model to contrast the two views (other scholars used other specific terms to refer to similar models, e.g., Jackson, 1986, use the term transitional vs. transformational, and Kember, 1997, used the terms such as teacher-centered vs. learner-centered). The belief the teaching science is like broadcasting puts the teacher in the role of the authoritative source of scientific knowledge who lectures and explains the scientific concepts accurately and clearly, provides assignments so students can be assessed and graded. The belief that teaching science involves supporting learning, casts the teacher into a role of someone who analyzes the learning task and learning processes of the student, and designs learning activities that would support the students' diverse learning approaches and processes.

Beliefs about successful learning are wide-ranging and even include beliefs regarding the nature of knowledge that needs to be learned, about effective approaches to learning, the products of the learning process, among others (Chan, 2010; Chai, Deng, Wong, & Qian, 2010; Tsai, 2001). In this study, we focused on the role of two very specific factors that were identified by Stevenson and Stigler (1992) as contrasting beliefs that underlie the learning experiences of learners from western and eastern cultures: ability and effort. Firstly, the belief that successful learning is largely dependent on the student's intelligence and/or learning ability is premised on the assumption that the complex and higher level cognitive processes involved in learning different subject matter requires some minimum level of intelligence or ability. Students attain different levels of success in learning because students possess different levels of this ability. Secondly, the belief that successful learning depends on effort is premised on the assumption that learning is a gradual and incremental process that requires sustained work and persistence over time. Thus, successful learning depends more on the amount of effort that the students put into the learning tasks, and whether this effort is sustained over time.

We decided to include a set of beliefs that are not, strictly speaking, pedagogical beliefs. Science teachers may hold knowledge and beliefs regarding the natural environment, physical phenomena, health and human development that reflect their folk beliefs and other forms of cultural beliefs and knowledge. Teachers' cultural beliefs also reflect on their beliefs regarding the nature of knowledge or the subject matter they teach in science and are relevant to their pedagogical knowledge (Handa & Tippins, 2012). Even as these beliefs are not verified using scientific approaches, and may even contradict established scientific principles, they can be seen as important knowledge resources that shape science teachers practices. Indeed, other scholars have pointed to the significance of such cultural beliefs in the experience of both students and teachers (Handa & Tippins, 2012; Lindenman, Svedholm, Takada, Lonnqvist, & Verkasalo, 2011). To summarize the focus of our investigation, we inquired into the following specific beliefs of Filipino science teachers: (a) teaching as broadcasting, (b) teaching as learning support, (c) learning driven by ability, (d) learning driven by effort, and (e) cultural beliefs. We grouped teachers in two ways: first, primary school vs. secondary school, then, science-major vs. non-science major; and compared the degree to which teachers in the groups endorsed the different beliefs.

**METHOD**

***Participants***

The participants in the study were 305 primary and secondary school science teachers from a province in the northern region of the Philippines. The teachers were selected to participate using a stratified random sampling of the schools. First, five school districts were randomly sampled from the 25 school districts in the province; then half of the schools in the five school districts were randomly selected for the study. All the teachers in the selected primary and secondary schools were invited to participate in the study, and all gave their informed consent to answer the research questionnaire. Some of the relevant characteristics of the participants are summarized in Table 1.

**Table 1. Characteristics of participants**

	Primary School (N = 179)	Secondary School (N = 126)
<i>Gender</i>		
• Male	21	30
• Female	157	92
• No data	1	4
<i>Age</i>		
• < 30 years	38	29
• 31 – 40 years	75	40
• 41 – 50 years	42	34
• > 50 years	14	14
<i>Experience in science teaching</i>		
• < 10 years	39	53
• 11 – 20 years	90	57
• > 20 years	37	11
• No data	13	5
<i>Postsecondary degree</i>		
• Bachelor of Elementary Education	174	0
• Bachelor of Secondary Education	0	102
• Bachelor of Science	5	24
<i>Postsecondary major/specialization</i>		
• Science	45	60
• Non-science	110	66
• No specialization	24	0

## **INSTRUMENT**

A questionnaire was developed to assess different pedagogical beliefs and to obtain information about the educational and demographic background of the science teachers. Different scales were developed by the researchers to assess the different dimensions of pedagogical beliefs.

### ***Beliefs about teaching scales***

To assess beliefs on the two models of teaching, 12 items were created. The items were drawn from the propositions specified by Larkin (2000) in contrasting between the broadcast and learning-support models of teaching. The initial draft set of items were reviewed by an science education professor who had no knowledge of the research questions or hypothesis, but who was given detailed explanations regarding the two models according to Larkin (2000). This reviewer evaluated whether the items were consistent with the specifications of the two models and suggestion only minor revisions in the wording of the items. Six items assessed belief about teaching as broadcasting (e.g., “The primary goal of science teachers is to tell students scientific facts, principles and procedures”, Cronbach  $\alpha = 0.79$ ), and the remaining 6 items stated beliefs about teaching as learning support (e.g., “The primary goal of science teachers is to guide students in active and extended inquiry”,  $\alpha = 0.58$ ). The reliability of the scales, although not very high, were considered adequate (DeVellis, 1991; Nunnally, 1967) for the exploratory purpose of the current study.

### ***Beliefs about learning scales***

Beliefs about learning were assessed using 16 items. The items were drawn from the propositions stated by Stevenson and Stigler (1991) to contrast between the effort- and ability-models of learning. The items were also evaluated in the same process as the previous scale by the same independent reviewer. Half of the items referred to the belief that success in learning is depended on the students' abilities (e.g., “The level of learning attained depends on how hard a student studies”,  $\alpha = 0.58$ ), and the rest referred to the belief that success in learning is dependent on the students' effort and hard work (e.g., “The level of learning attained is limited by the students' intelligence”,  $\alpha = 0.56$ ). Again, the reliability of the scales were not very high, but were considered adequate (DeVellis, 1991; Nunnally, 1967) for the exploratory purpose of the current study.

### ***Cultural beliefs scale***

The scale comprised ten items referring to common cultural beliefs popular in the local culture of the participants (e.g., “When building a house, pour blood on the first post erected to strengthen the foundation,” and

“When you dream of losing a tooth, a close relative will die.”). The researchers generated a long list of possible items, and three science teachers (who were not knowledgeable of the research questions and hypotheses) were asked to identify ten which were most popular or well-known among teachers. The scale comprising of the selected ten items had good reliability/internal consistency ( $\alpha = 0.92$ ).

All the scales required the participants to indicate the degree of their agreement with the items using a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). All the items were written in Ilocano, the first language of all the participants.

## RESULTS

We predicted that different levels of science coursework would be associated with different patterns of endorsement of different pedagogical beliefs and cultural beliefs. We tested this prediction in two ways, first, by comparing primary and secondary school teachers, then, by comparing science majors and non-science majors. Both comparisons revealed differences consistent with the predictions.

In general, secondary school science teachers in the Philippine are required to take more college courses in science compared to primary school science teachers. This difference seems to have an impact on the beliefs they have as teachers. As shown in Table 2, both primary and secondary school science teachers tend to endorse the learning-support model of teaching, as the means are in the higher range of the 5-point scale of agreement. However, the statistical analysis indicated that secondary school science teachers are more likely to endorse beliefs about teaching as providing support for the learning processes of students. There is no statistically significant difference between the primary and secondary school science teachers' endorsement of the broadcast model of teaching.

Table 2 also indicates that the two groups of teachers are not clearly favor either the ability-driven or effort-driven models of learning, as the respective means are just slightly higher than the midpoint of the 5-point scale. However, the statistical tests indicate that the secondary school science teachers are less likely to believe that success in learning is dependent on the ability of students. There is no significant difference in the two groups of teachers' endorsement of the effort-driven model of learning.

Regarding the endorsement of cultural beliefs, both groups of science teachers tend not to endorse these beliefs, as indicated by the means that are below the midpoint of the 5-point scale. However, the statistical analysis indicated that the secondary school science teachers are also less likely to believe in these cultural beliefs.

The same pattern is found when we compare teachers who actually majored in science to those who did not. As shown in Table 3, the means



for this grouping of science teachers are in the same range as in the previous comparison. More importantly, the teachers who majored in science are also more likely to endorse beliefs about teaching as providing support for the learning processes of students, and less likely to believe that success in learning is dependent on the ability of students. The science majors are also less likely to believe in the cultural beliefs. This pattern of results mirrors the pattern contrasting the primary and secondary science teachers, and provide convergent evidence for the hypothesis regarding the possible role of science coursework in the beliefs of science teachers in the Philippines.

**Table 2. Pedagogical beliefs of primary and secondary school science teachers**

Beliefs	Primary School (N = 179)		Secondary School (N = 126)		F (1, 303)
	M	SD	M	SD	
Teaching as broadcasting	3.67	.66	3.63	.79	0.00
Teaching as learning support	4.19	.52	4.24	.62	4.38*
Learning driven by ability	3.38	.56	3.31	.58	5.62*
Learning driven by effort	3.63	.54	3.63	.57	0.92
Superstitious beliefs	2.30	.95	2.10	.90	36.09***

\* $p < .05$ , \*\*\* $p < .0001$

**Table 3. Pedagogical beliefs of science majors and non-science majors**

Beliefs	Science Major (N = 105)		Non-Science Major (N = 200)		F (1, 303)
	M	SD	M	SD	
Teaching as broadcasting	3.55	1.00	3.67	.66	1.70
Teaching as learning support	4.33	.78	4.19	.52	3.34
Learning driven by ability	3.18	.60	3.38	.56	8.52**
Learning driven by effort	3.63	.61	3.63	.54	0.12
Superstitious beliefs	1.70	.66	2.30	.95	33.94***

\*\* $p < .01$ , \*\*\* $p < .0001$

## DISCUSSION

The study was conducted to test the possibility that science course work also impacts on the teaching of science teachers by influencing their ped-

agogical beliefs. The results of the study, comparing groups of science teachers who differ in the amount of college science courses they took in their preservice teacher education programs provide support for this hypothesis. In particular, more science coursework seems to lead to stronger endorsement of beliefs regarding teaching as a process of providing support for the learning process, and weaker endorsement of beliefs regarding the limiting role of ability in successful learning in science. More science coursework also seems to be associated with weaker endorsement of cultural beliefs. Before we discuss the implications of our findings, we wish to note some important limitations in the scope of our investigation.

We recognize that our investigation is truly preliminary in that we considered a limited range of beliefs regarding teaching and learning. It would be important to test the same hypothesis in a wider range of beliefs, like those related to the nature of science, the nature of the products of science learning, the role and nature of assessment in science learning, and even the epistemological beliefs of the science teachers. Some methodological limitations should also be mentioned. First, in assessing the beliefs of the science teachers, we relied on self-reports of the teachers. Self-reports using questionnaires are a commonly used method of assessing beliefs in various social and behavioral sciences, however, beliefs can be inherently complex, and thus, some scholars suggest that more qualitative and in-depth methods should be used to illuminate on teachers beliefs. We agree that such qualitative data could help in strengthening the test of the hypothesis. Second, we based the measure of science coursework on grouping variables (preservice curriculum and major), which are not direct measures of the number of science subjects that the teachers actually took in their preservice education. In the Philippines, the national government regulates the curriculum of all college programs, and thus we can be confident that there are certain minimum requirements that are met, and that the comparisons of the groups we undertook are valid based on such minimum specifications. However, there is always the possibility that even if the teacher was not a science major, she may have taken more science courses in her preservice program as allowed by her school, or that the primary school teacher actually graduated from the curriculum for secondary school teachers. Although we cannot rule out these possibilities, the likelihood that they happened is small, given how strictly regulated the curriculum is in the Philippines.

These limitations notwithstanding, we believe that our findings address an important facet of discussion on science teacher education in the Philippines. Even as the national government has moved to increase the science coursework for science education teachers, there is still resistance among many sectors. The argument against the move is that the teachers do not need to know a lot of advanced science content to teach the science curriculum (e.g., primary school science teachers do not teach physics

anyway, so why should they be required to take physics subjects). Our initial findings suggest that the increased coursework in science helps in science teaching not only in terms of ensuring content knowledge; increased coursework could actually foster beliefs about science teaching and learning that are more aligned with contemporary theories of effective science education (i.e., learning as knowledge construction sustained by active and effortful work by the student, instead of being directed by the teacher). In so far as the research on teacher beliefs suggest that they are important predictors of actual teaching behaviors in the classroom, this impact of science coursework on beliefs may have far-reaching implications.

The question is why and how science coursework would influence science teachers' beliefs at all. Our current study does not allow us to provide direct answers to this question. However, we can glean from the research on pedagogical content knowledge (Loughran et al., 2004; van Driel, Verloop, & de Vos, 1998) that content knowledge may provide specific knowledge anchors that teachers use when they reflect on their classroom actions. In a study on pedagogical content knowledge of mathematics teachers, Lowenberg Ball, Thames, and Phelps (2008) identified specific types of content knowledge (i.e., knowledge of content and students, knowledge of content and teaching, and specialized content knowledge) needed by mathematics teachers. If we assume that similar categories of pedagogical content knowledge are important for science teachers, perhaps the beliefs that emerge from their development as teachers change partly as a function of the level of specific content knowledge that they have.

We recognize that the level of science teachers' content knowledge is not simply a function of the number of courses the science teachers take in the preservice program. It is very likely that there are also differences in how the various science courses are taught in different preservice teacher education programs in the Philippines. Indeed, there may even be a possibility that the content and pedagogy of these science courses vary depending on whether the students are intending to be primary school or secondary school teachers, or whether they are science majors or non-science majors. If so, there is a possibility that it is not the number of science courses taken that makes a difference, but the content and pedagogy of these courses. These possibilities can be explored and ruled out in future research.

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REFERENCES

- Appleton, K., & Asoko, H. (1996). A case study of a teacher's progress toward using a constructivist view of learning to inform teaching in elementary science. *Science Education*, 80(2), 165-180.
- Atweh, B., & Abadi (2012). Investigating teachers' pedagogical beliefs in Indonesia and Australia. *The Asia-Pacific Education Researcher*, 21(2), 325-335.
- Bhattacharyya, S., Volk, T., & Lumpe, A. (2009). The influence of an extensive inquiry-based field experience on pre-service elementary student teachers' science teaching beliefs. *Journal of Science Teacher Education*, 20(3), 199-218.
- Bernardo, A. B. I. (1999). The striving and the struggle for teacher development: The contexts, issues, trends, and opportunities in in-service teacher training in the Philippines. In Y. Tabata & L. Griek (Eds.), *Ensuring opportunities for the professional development of teachers* (pp. 141-158). Higashi-Hiroshima City, Japan: Hiroshima University UNESCO-APEID Associated Centre.
- Bernardo, A. B. I. (2007). Contrasting the old and the new Philippine pre-service teacher education curriculum. In B. Atweh, M. U. Balagtas, A. B. I. Bernardo, M. B. Ferido, & I. Macpherson (Eds.) *Ripples of change: A journey of teacher education reform in the Philippines* (pp. 24-35). Pasig City: CHED.
- Bernardo, A. B. I. (2008). Exploring epistemological beliefs of bilingual Filipino preservice teachers in the Filipino and English languages. *The Journal of Psychology*, 142(2), 193-208.
- Bolyard, J. J., & Moyer-Packenham, P. S. (2008). A review of the literature on mathematics and science teacher quality. *Peabody Journal of Education*, 83(4), 509-535.
- Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709-725). New York: Macmillan.
- Chai, C. S., Deng, F., Wong, B., & Qian, Y. (2010). South China education majors' epistemological beliefs and their conceptions of the nature of science. *The Asia-Pacific Education Researcher*, 19(1), 111-125.
- Chai, C. S., Teo, T., & Lee, C. B. (2010). Modelling the relationships among beliefs about learning, knowledge, and teaching of pre-service teachers in Singapore. *The Asia-Pacific Education Researcher*, 19(1), 25-42.
- Chan, K.W. (2010). The role of epistemological beliefs in Hong Kong pre-service teachers' learning. *Asia-Pacific Education Researcher*, 19(1), 7-24.

- Darling-Hammond, L., & Youngs, P. (2002). Defining “highly qualified teachers”: What does “scientifically-based research” actually tell us? *Educational Researcher*, 31(9), 13–25.
- DeVellis R. F. (1991). *Scale development*. Newbury Park, NJ: Sage Publications.
- Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration. *Educational Technology Research and Development*, 53(4), 25-39
- Golla, E. F., & de Guzman, E. S. (1998). Teacher preparation in science and mathematics education: A situational analysis. In E. B. Ogena & F. G. Brawner (Eds.) *Science education in the Philippines: Challenges for development* (Vol. 1) (pp. 41-77). Manila, National Academy of Science and Technology.
- Handa, V. C., & Tippins, D. J. (2012). Cultural memory banking in pre-service science teacher education. *Research in Science Education*, 42(6), 1201-1217.
- Haney, J. J., & McArthur, J. (2002). Four case studies of prospective science teachers’ beliefs concerning constructivist teaching practices. *Science Education*, 86(6), 783-802.
- Hong, H.-Y., & Lin, S.-P. (2010). Teacher-education students’ epistemological change through collaborative knowledge. *The Asia-Pacific Education Researcher*, 19(1), 99-110.
- Jackson, P. W. (1986). *The practice of teaching*. New York, NY: Teachers College Press.
- Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist*, 27(1), 65–90.
- Kember, D. (1997) A reconceptualisation of the research into university academics’ conceptions of teaching. *Learning and Instruction*, 7(3), 255–275.
- Larkin, J. H. (2000). Restructuring science and mathematics education. *Journal of Applied Developmental Psychology*, 21(1), 109 - 114.
- Lindenman, M., Svedholm, A. M., Takada, M., Lonnqvist, J., & Verkasalo, M. (2011). Core knowledge confusions among university students. *Science & Education*, 20(5-6), 439-451.
- Loewenberg Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59(5), 389-407.
- Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, 41(4), 370-391.
- Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning

- and experienced secondary science teachers. *International Journal of Science Education*, 23(5), 517-534.
- Luft, J. A., Roehrig, G. H., & Patterson, N. C. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Journal of Research in Science Teaching*, 40(1), 77-97.
- Magno, C. (2010). Looking at Filipino pre-service teachers' value for education through epistemological beliefs about learning and Asian values. *The Asia-Pacific Education Researcher*, 19(1), 61-68.
- Magno, C. (2011). Exploring the relationship between epistemological beliefs and self-determination. *The International Journal of Research and Review*, 7(1), 1-23.
- Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications and research agenda. *International Journal of Environmental & Science Education*, 4(1), 25-48.
- Martin, M.O., Mullis, I.V.S., & Foy, P. (with Olson, J.F., Erberber, E., Preuschoff, C., & Galia, J.). (2008). TIMSS 2007 international science report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
- Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., & Chrostowski, S.J. (2004). TIMSS 2003 international science report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
- Nunnally J. C. (1967). *Psychometric theory*. New York: McGraw-Hill.
- Ogena, E. B. (2005). *Science education in the Philippines: Challenges for development*. Taguig, Philippines: Science Education Institute.
- Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332.
- Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professional. *Research in Science Education*, 38(3), 261-284.
- Rice, J. K. (2003). *Teacher quality: Understanding the effectiveness of teacher attributes*. Washington, DC: Economic Policy Institute.
- Richie, S. M., Tobin, K., & Hook, K. S. (1997). Viability of mental model in learning chemistry. *Journal of Research in Science Teaching*, 34(2), 223-238.
- Stevenson, H., & Stigler, J. (1992). *The learning gap: Why our schools are failing and what we can learn from Japanese and Chinese education*. New York, NY: Simon & Schuster.

- Tsai, C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education*, 24(8), 771-783.
- Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35(6), 673-695.
- Wilson, S. M., Miller, C., & Yerkes, C. (1993). Deeply rooted change: A tale of learning to teach adventurously. In D. K. Cohen, M. W. McLaughlin, & J. E. Talbert (Eds.), *Teaching for understanding: Challenges for policy and practice* (pp. 84-129). San Francisco, CA: Jossey-Bass.
- Windschitl, M. (2009). Cultivating 21st century skills in science learners: How systems of teacher preparation and professional development will have to evolve. National Academies of Science. Retrieved 22 June 2011 from <http://education.washington.edu/research/reports/21stCenturySkills.pdf>.
- Wong, A. K., Chan, K-W., & Lai, P-Y. (2009). Revisiting the relationships of epistemological beliefs and conceptions about teaching and learning of pre-service teachers in Hong Kong. *The Asia-Pacific Education Researcher*, 18(1), 1-19.
- Woolfolk-Hoy, A., Davis, H., & Pape, S. J. (2006). Teacher knowledge and beliefs. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology (2nd ed.)*, (pp. 715-737). Mahwah, NJ: Lawrence Erlbaum.
- Yilmaz-Tuzun, O. (2008). Preservice elementary teachers' beliefs about science teaching. *Journal of Science Teacher Education*, 19(2), 183-204.