Journal of Curriculum Studies (J.C.S.)
Vol.7 (27); 2013, 21-44

فصلنامه مطالعات برنامه درسی ایران
سال هفتم، شماره ۲۸ ، بهار۱۳۹۲، ۴۴-۲۱

National Science Education Standards and Pre- Service Programs in the USA

استانداردهای آموزش ملی علوم و برنامه‌های تربیت معلم در آمریکا

Received 2 . April . 2012; accepted 28. December 2012

Lee Yuen Lew[1] (PhD)

لی یوئن لو

The variations in institutional features of Pre-Service Programs are broad. A large scale USA project spanning 40 months and involving ten different Science/Mathematics Teacher Preparation Programs called Salish I, II, and III operated with major federal support and operated in one state for a fifteen year investigation. A final report by National Science Foundation (NSF) concluded that many new graduates from the over 1,250 institution in the USA that prepares science/math teachers are ill-prepared for teaching in the real classrooms (Salish 1, 1997). This paper focused on results from the most effective program in Salish as indicated by the new institutions who sought to expand their own teacher education program. The exemplary program consistently implements strategies as envisioned under the National Science Education Standards with regards to roles of teachers and students for effective teaching and learning. The major finding of the study is that the new teachers from the exemplary program are successful in preparing effective new science teachers who are generally resilient early constructivist teachers. This report touches on some of the institutional features of the exemplary Pre-Service program and the patterns of change regarding the Constructivist beliefs and practices of teachers, from student teaching through the first three years of teaching. It shares the instruments used, discusses implications of findings and provides suggestions for continued research.

Key Words: Pre- Service Programs, Education Standards, Science

ویژگی‌های مؤسسه‌ای برنامه‌های تربیت معلمان پیش از خدمت از تفاوت‌ها و تنوع قابل توجهی برخوردار می‌باشند. یکی از پروژه-های وسیع در آمریکا که ۴۰ ماه به طول انجامید و ۱۰ برنامه‌ی تربیت معلم دروس علوم و ریاضی را در برداشت سالیش (Salish) یک، دو، و سه نام دارد که با حمایت دولت و در یکی از ایالت‌ها به مدت پانزده سال اجرا شد. گزارش نهایی این بررسی که توسط بنیاد ملی علوم (NSF) ارائه شد نشان داد که بسیاری از فارغ‌التحصیلان جدید از بیش از ۱۲۵۰ مؤسسه‌ی تربیت معلم دروس علوم و ریاضی در آمریکا آمادگی لازم جهت تدریس در کلاس درس را دارا نمی‌باشند (سالیش یک، ۱۹۹۷). مقاله‌ی حاضر به نتایج اثربخش‌ترین برنامه‌ی تربیت معلم می‌پردازد که در پژوهش سالیش توسط مؤسساتی که در پی ارتقاء و وسعت بخشی به برنامه‌ی تربیت معلم خود بودند اجرا شد. این برنامه‌ی نمونه و الگو از راهبردهایی مطابق با استانداردهای آموزش ملی علوم و با توجه به نقش معلم و فراگیر در یادگیری و تدریس اثربخش استفاده کرده است. یافته‌های پژوهش حاضر نشان می‌دهد که برنامه‌ی مذکور معلمان جدید و اثربخشی را برای درس علوم آموزش داده است که به طور کل انعطاف‌پذیر و ساخت‌گرا می-باشند. این گزارش، بر اساس تدریس معلمان در سه سال اولیه‌ی تدریس، به برخی از ویژگی‌های مؤسسه‌ای این برنامه‌ی تربیت معلم و الگوهای تغییر با توجه به باورهای ساخت‌گرایی و عملکرد معلمان می‌پردازد. در ادامه ابزار مورد استفاده ذکر شده، دلالت‌های یافته‌ها مورد بحث قرار گفته، و پیشنهاداتی برای پژوهش‌های آینده مطرح شده است.

کلیدواژه‌ها: برنامه‌های تربیت معلم ، استانداردهای آموزش، علوم

1. Assistant Professor, C.W. Post Long Island University, New York/ leeyuenlew@gmail.com

Introduction

The variations in institutional features of Pre-Service Programs are broad. A large scale USA project spanning 40 months and involving ten different Science/Mathematics Teacher Preparation Programs called Salish I, II, and III operated with major federal support and operated in one state for a fifteen year investigation. A final report by National Science Foundation (NSF) concluded:

> "Currently, over 1,250 institutions {in the United States} are preparing teachers in science/mathematics education. Yet many of the graduates of these institutions are ill-prepared for their first professional experience" as a new teacher (Salish I, 1997).

Pre-service Programs must address this problem in order to be more effective. Many of the findings were linked to constructivist theory for indicating successful teaching and learning. For example, Lew (2010) conducted follow-up studies which indicate that new science teachers taught at early constructivist levels for three out of the six sub-categories of constructivist teaching approaches as defined by CLES (Constructivist Learning Environment Survey) (Taylor, Fraser, & While, 1994). Lew's study focused on results from the most effective program in Salish as indicated by the new institutions who sought to expand their own teacher education program.

This report describes the patterns of change regarding Constructivist beliefs and practices of four new science teachers from a model program; from student teaching through the first three years of teaching. The major finding of the study is that the exemplary program is successful in preparing effective new science teachers who are generally resilient early constructivist teachers as envisioned by changes in teaching recommended in the National Science Education Standards (NRC, 1996). There were slight declines in constructivist behaviors during the first two years of teaching. However, by their third year, the new teachers were more student-centered in both their actions and beliefs, regaining the idealism that they developed during their preparation program.

Setting

The sample was selected by the Salish staff as a nationally recognized exemplary program; the main program features included three consecutive science methods courses each with field experience and focuses on student-centeredness. This chapter reports on observed practices and espoused beliefs under three sub-categories which match what the National Science Education Standards (NSES, 1996) indicate pertaining to what students should do in the classrooms (Student Actions or SA), what teachers should do in the classrooms (Teacher Actions or TA), and teacher understanding of science process and content (Teacher and Content or T/C). It provides some suggestions for further research for improving science teacher preparation.

Theoretical Underpinnings

The research literature indicates widespread disagreement about the overall impact of science teacher preparation programs concerning the actual teaching of teachers. On the one hand, there are reports suggesting that teacher education programs fail to achieve their goals, fail to impact pre-service teachers' beliefs and indicate that the overall university teacher education experience may be inconsequential in real classrooms. On the other hand, other studies indicate that beginning teachers are often significantly influenced by their pre-service teacher education programs. This body of literature indicates that how teachers are prepared as professionals affects both their attitudes and teaching practices. The Education Commission of the States (EAC, USA) eloquently summarizes the ongoing disagreements about teacher preparation:

> "How well the nation {USA} is doing at preparing teachers is a matter of considerable debate." (Michael B. Allen, 2003, p.7)

Voluminous literature indicates research and instructional programs using "constructivist instructional strategies" in different parts of the world which may lead to improved science learning – producing students able to think critically and to use their scientific knowledge in new situations (Yager & Weld, 1997). Almost all constructivist classrooms focus on engagement of students and reflect the importance of students' prior knowledge about the learning process. Hence, according to constructivist tenets, schools must provide pupils with ample opportunities to build upon what they already know as they become active learners (Lew, 2010). In this study, constructivist behaviors, namely, constructivist teaching practices, beliefs and knowledge, are guided by the twelve descriptors offered by Brooks & Brooks (1993).

"Beliefs" in this study were examined as a unit interconnected to knowledge; that knowledge impacts one's beliefs and that beliefs, in turn, shape and become known. It is generally agreed that beliefs act as filters for decision-making regarding teacher practices (Borko & Putnam, 1996). Educational beliefs act to determine when, where, and under what conditions different types of knowledge will be considered and used in the classroom (Ennis, et al., 1997, Lew 2010). In turn, it appears that practice plays an important role in shaping teacher beliefs. It is important then that researchers look not only at examining beliefs that drive practices but also practices or rather the experiences of successes and failures in implementing certain practices which in turn influence the construction of beliefs (Lenski et al., 1998, Lew 2010).

Design and Procedure

The sample for this study consisted of four new graduate teachers who took part in the Salish I (1997) study for a period of three years and for whom complete sets of databases existed including "Best Effort" videotapes from student teaching. It is important to realize that the sample for this study has been ultimately determined by the information available, not by a prior statistical specification. The study started with a cohort of ten student teachers but unfortunately due to high dropout rate within 1-3 years of teaching and unwillingness to continue participation in the study (Salish I, 1997), only four complete sets of databases were available for the period studied.

The research design is a combination of qualitative and quantitative methods. Actual classroom practices are viewed from 37 videotaped lessons and quantified using the Expert Science Teacher Educational Evaluation Model (ESTEEM, Burry-Stock & Oxford, 1993.) Teacher beliefs about teaching and learning were gained from open-ended interview questions as outlined in the Philosophy of Teaching and Learning (PTL, Lew 2001). The PTL interview (see Table 1) used in this study consisted of eight open-ended interview questions that were part of the Teacher's Pedagogical Philosophy Interview (TPPI, Richardson and Simmons, 1994) used in the Salish I Research Project (1997).

Table 1: Philosophy of Teaching and Learning (PTL) Interview

Question 1.	What learning in your classroom do you think will be valuable to your students outside the classroom?
Question 2.	Describe the best teaching or learning situation that you have ever experienced (either as a teacher or as a student)
Question 3.	In what ways do you try to model the best teaching or learning situation in your classroom?
Question 4.	How do you believe your students learn best?
Question 5.	How do you know when your students understand a concept?
Question 6.	In what ways do you manipulate the educational environment to maximize student understanding?
Question 7.	What (science) concepts do you believe are the most important for your students to understand by the end of the year?
Question 8.	What values do you want to develop in your students?

Note:The PTL (and accompanying Validated Scoring Guide) was developed by Lew, 2001. The Scoring Guides was validated through highest consensus by a panel of six judges familiar with Constructivist Teaching Approaches

Interview transcripts in this study were quantified by means of a PTL Validated Scoring Guide that is a modified and expanded version of the scoring guide used in the Salish I Research Project. A panel of six science educators familiar with the TPPI validated the PTL Scoring Guide. Simplified Versions of the scoring guides as well as the respective validated scores for the three sub-categories of SA (Student

Actions), TA (Teacher Actions) and T/C (Teacher understanding of Process and Content) are posted as Tables 2a, 2b and 2c respectively. The complete versions can be found in Lew (2001).

Table 2a: A Simplified Scoring Guide and the Respective Validated Scores for Beliefs About What Students Should be Doing in the Classroom (Student Actions, SA) [aligned with NSES and their Assigned Validated Scores]

Student Action Code	Student Action Responses to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
SA1	Application of knowledge to new situation/active problem solving or decision making	5w, 1w, 8w	5
SA2	Application of knowledge to personal life and/or to community/society/world	4x, 1v	5
SA3	Understand nature of science	1x, 8y	5
SA4	Student as responsible citizens/ involve with societal issue	1z, 8x	5
SA5	Creativity/Critical thinking	1u	5
SA6	"Cooperative" learning/student learning from student/peer teaching	4v, 5v , 8u	5
SA7	Learning from various methods; including projects, investigations, brainstorming…	4u	5
SA8	Student understanding that learning is continuous (lifelong learning)	8v	5
SA9	Student desire to learn and/or showing curiosity/inquisitiveness	4p, 1q, 8z	4
SA10	Student questioning and/or generating questions	4r, 5q, 1r	4
SA11	Student thinking/reflecting/explaining with own words	4s, 5p, 1p, 8r	4
SA12	Student communication with teacher and other students	8q	4
SA13	Self assessment	4z, 8s	4
SA14	Student value and/or respect science	8t	4
SA15	Student skepticism	1s	4
SA16	Student use of varied resources (including references, experts, internet)/Learning to learn	4t, 8p	4
SA17	Safe learning environment	8o	3
SA18	Laboratory activities/hands on	4k, 5k	3
SA19	Discussions	4l	3

Student Action Code	Student Action Responses to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
SA20	Worksheet problem solving and/or application questions	5l	3
SA21	Personal learning (e.g., responsibility, respect, honesty, confidence, maturity)	1k, 1l, 1m, 1n, 1o, 8k, 8l, 8m, 8n	3
SA22	Learning personal skills for future (study habits, time management, organizational skills, hard working)	1f, 1h, 1i, 8f, 8g, 8h, 8i	2
SA23	Watching video, reading/seeing	4f, 4g	2
SA24	Learn through repetition/practice/listening	4c, 4d	1
SA25	Learn the way the teacher does	4b	1
SA26	No idea/does not answer question	4a, 5a, 5b, 1a	1

Note: Scores of "1" is indicative of least constructivist and "5" as most constructivist. The complete version of SA Validated Scoring Guide for individual items of the PTL can be found in Lew (2001).

All individual items for quantifying both practices and beliefs were scored on a five point Likert scale with one as indicative of least constructivist and five as most constructivist. Averages of total scores were reduced to a continuum from 1 to 5. Statistical Analysis using SPSS version 9.0 was carried out using a repeated measure analysis (ANOVA), and whenever relevant, followed-up by a Tukey test for determining presence or absence of significant changes.

Table 2b: A Simplified Scoring Guide and the Respective Validated Scores for Beliefs About What Teachers Should be Doing in the Classroom (Teacher Actions, TA) [aligned with NSES and their Assigned Validated Scores]

Teacher Action Code	Teacher Action Responses to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
TA1	Lead by/use students ideas in decision on learning (activities, assessment)	6w, 3w, 4y	5
TA2	Relate to real life or to community/society/world	6x	
TA3	Relate to current issues/challenging issue	6y, 4w	5

Teacher Action Code	Teacher Action Responses to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
TA4	Application of knowledge/active problem solving or decision making	3u	5
TA5	"Cooperative" learning/student learning from student	6v, 3v	5
TA6	Different learning styles-varied methods of teaching; including projects, investigations, brainstorming…	6u,	5
TA7	Use multiple ways of assessment	5u	5
TA8	Model lifelong learning/ learning with students	6z, 3x, 1y	5
TA9	Motivate students desire to learn/make learning science exciting	6p, 3p	4
TA10	Encouraging student questioning, curiosity, inquisitiveness	6r, 3r, 3t	4
TA11	Teacher as facilitator/coach	3s	4
TA12	Use of varied resources (including references, experts, internet)/Learning to learn	1t	4
TA13	Teacher caring/give individual attention	6q, 3q, 4q	4
TA14	Laboratory activities/hands on	6k, 3k	3
TA15	Learning extended to outside of classroom	6l, 3l	3
TA16	Group learning	3n	3
TA17	Clarity of expectations/assessment	3z	3
TA18	Teacher–student interaction/discussion/ teacher questioning	6n, 3m, 4m	3
TA19	Physical environment or organization which promotes learning	6i, 6j	2
TA20	Demonstrations	6h, 3g	2
TA21	Make learning fun	6g	2
TA22	Student answering questions (worksheet)	3h	2
TA23	Assess students based on grades/tests/students' writings	5f, 5g	2
TA24	Use of technology/watch videos	6f, 3f	2
TA25	Assess students based on student self report or teacher inferences	5c, 5d	1
TA26	Model by "direct copying"	3b	1
TA27	Use of repetition	3c	1
TA28	No idea/Does not answer question	6a, 3a	1

Note: Scores of "1" is indicative of least constructivist and "5" as most constructivist. The complete version of TA Validated Scoring Guide for individual items of the PTL can be found in Lew (2001).

Table 2c: Simplified Scoring Guide and the Respective Validated Scores for Beliefs About Teacher Understanding of Process and Content (T/C) [aligned with NSES and their Assigned Validated Scores]

Teacher And Content Codes	Responses on Teacher Understanding of Content and Process to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
T/C1	Lead by/use students ideas or interest in decision on learning (activities, assessment)	7z, 2y	5
T/C2	Relate/application to real life or to community/society/world	7x, 7w, 2w	5
T/C3	Relate/application to current/controversial issues	7u	5
T/C4	Encourage creativity/critical thinking	2x	5
T/C5	"Cooperative" learning/student learning from student	7v, 2v	5
T/C6	Varied methods of teaching; including projects, investigations, brainstorming…/ multiple ways of assessment	2u	5
T/C7	Model continued learning/ learning with students	7y	5
T/C8	Science has limitation/is changing/is controversial	7p.7q, 7r	4
T/C9	Teacher-student and student-student interactions	2z	4
T/C10	Teacher as facilitator/reflective practitioner	2s, 2r	4
T/C11	Motivation/invite student desire to learn	2p	4
T/C12	Use of varied resources (including references, experts, internet, ,,,)/Learning to learn	7s, 2t	4
T/C13	Connections/relatedness between concepts (previous and between discipline)	6s	4
T/C14	Teacher caring/give individual attention	2q	4
T/C15	Relate learning to ethics	6t	4
T/C16	Learning extended to outside of classroom	2l	3
T/C17	Teacher-student interactions	2o	3
T/C18	Group work	7k, 2n	3
T/C19	Laboratory activities/hands on	2k	3
T/C20	Personal learning (respect, confidence, maturity, responsibility)	7m, 7n, 2m	3
T/C21	Concepts that (teacher thinks) are useful	7l	3
T/C22	Basic concepts/basic content	7g, 1g	2
T/C23	Experiments-process skills	7f	2
T/C24	Make learning fun for students	2g	2
T/C25	Affirmation by others	2h	2
T/C26	Focus on conferences/conventions as models	2f	2

Teacher And Content Codes	Responses on Teacher Understanding of Content and Process to Items in PTL	Code Assigned under Individual PTL Items	Validated Score
T/C27	Focus on teacher "direct copy" others	2c	1
T/C28	Practice and review	2b	1
T/C29	No idea/Does not answer question	7a, 2a, 8a	1

Note: Scores of "1" is indicative of least constructivist and "5" as most constructivist. The complete Version of T/C Validated Scoring Guide for individual items of the PTL can be found in Lew (2001).

Videotape transcripts and interview transcripts provided the basis for qualitative descriptions and direct quotations regarding the new teachers' actual classroom practices and beliefs. Numerical data were also plotted on a "Model of Constructivist Behavior : Teacher Expertise Level" (MCBTEL) as defined in Table 2d (Lew, 2001, 2010). Under this definition, "Novice and Beginners" concerning constructivist practices are also described as being teacher-centered in their approaches to teaching, "Transitional" in constructivist practices are also described as between teacher-centered and student-centered, and "Early Constructivist" are described as mainly student-centered.

Table 2d: Model of Constructivist Behavior: Teacher Expertise Level (MCBTEL)

Classroom Practices or Beliefs	Teacher Centered		Transitional	Student Centered	
	Novice	Beginner	Transitional	Early Constructivist	Expert Constructivist
Mean Scores	1.00 - 1.49	1.50 - 2.49	2.50 - 3.49	3.50 - 4.49	4.50 - 5.00

Note:It was found that changes in constructivist behaviours of the new teachers were generally within the context of early constructivist. In order to get a clearer perspective of change in level of teacher expertise, mean scores of 3.50 to 3.99 are used to describe "marginally early constructivist," while scores of 4.00 to 4.49 are used to describe "strongly early constructivist."

Frequent triangulations via comparison of qualitative and quantitative data were carried out during data analyses in order to lend strength to the results. Comparing level of teacher expertise with regards to constructivist behaviors substantiated statistical analyses.

Vision of the National Science Education Standards

Constructivist beliefs and practices were compiled into three sub-categories pertaining to (1) what students should be doing in the classrooms (Student Actions or SA), (2) what teachers should be doing in the classrooms (Teacher Actions or TA) and, (3) teacher understanding of process and content (Teacher and Content or T/C); as envisioned in the National Science Education Standards (NSES, 1 NSES (NRC 1996)

<u>What Students should be Doing in the Classroom (Student Actions or SA) as advocated by NSES</u>

NSES (NRC 1996) call for less emphasis on student learning through lecture and reading but more emphasis on students being involved in active and extended scientific inquiry: “Learning science is something students do, not something that is done to them” (p.20.) At the same time NSES cautioned that hands-on activities, while essential, are not enough. “Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry(NRC, 1996 p.23). Students must have “minds-on” experiences as well. The standards outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels. The following passage sums up NSES of “Hands-on, Minds-on” scientific inquiry:

> The Standards call for more than “science as a process,” in which students learn such skills as observing, inferring, and experimenting. Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills (NRC, 1996, p.23).

<u>What Teachers should be Doing in the Classroom (Teacher Actions or TA) as advocated by NSES</u>

NSES call for less focus on maintaining responsibility and authority {by teachers} but more emphasis on sharing responsibility for learning with students. "Attaining understanding {in science} cannot be achieved by any single teaching strategy or learning experience" (NRC 1996, p, 23). That is, teachers are encouraged to use varied means of teaching approaches and varied assessments.

TA is reflected in the following ways that are recommended for improving in the NSES (NRC, 1996, p. 52). These conditions for more emphasis include:

- Understanding and responding to individual student's interests, strengths, experiences, and needs;
- Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes;
- Guiding students in active and extended scientific inquiry;
- Providing opportunities for scientific discussion and debate among students;
- Continuously assessing student understanding;
- Sharing responsibility for learning with students;
- Supporting classroom community with cooperation, shared responsibility, and respect; (NRC, 1996, p. 52)

<u>Teacher Understanding of Process and Content (Teacher and Content or T/C) as advocated by NSES</u>

To become a successful constructivist science teacher, the teachers need to know and understand what is science and the processes involved in the generation of what constitute scientific knowledge. "Teachers must have theoretical and practical knowledge and abilities about science, learning, and science teaching." ..." (NRC 1996, p. 28).

NSES (NCR 1996) maintain that understanding science requires that an individual integrates a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, and reasons for these relationships, ways to use their ideas to explain and predict other natural phenomena, and ways to apply them to many events.

> "An important purpose of science education is to give students a means to understand and act on personal and social issues…help students develop decision-making skills…decisions they will face as citizens." NSES also assert that students should develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture." (NCR 1996, p.21)

NSES (NRC 1996) present a vision of teachers of science as educators responsible for their own professional development and for the maintenance of the teaching profession. NSES encourages teachers to select and adapt curriculum in accordance to their students' needs. NSES also recommend a change of emphasis from individual teachers working alone to more emphasis on working with other teachers to enhance the science program.

Summary of Findings and Conclusions

Tables 3 and .4 summarize and compare changes in the new teachers' observed practices and beliefs, respectively. The three sub-categories of constructivist teaching, from student-teaching across the first three years of teaching ; pertaining to (1) what students should be doing in the classroom (SA), (2) what teachers should be doing in the classroom (TA), and (3) teacher understanding of process and content (T/C) as envisioned under NSES are discussed.

Patterns of Change in Observed Practices

Observed Teacher Practices are summarized below in Table 3 The new teachers (NTs) were found to be strong "early constructivists" via SA practices. During student teaching; for example, they facilitated the learning process by sharing responsibilities of learning with students, guiding student engagement in activities and experiences, used novelty, do not depend completely on textbooks but use varied resources. Table 3 indicates a slight decline in ability to facilitate learning from constructivist perspectives from student teaching during year 1, with improvements following from years 1 to 3 of teaching.

Table 3: Patterns of Change in Constructivist Expertise Levelsof Observed Practices

Total Mean (SD)	Student Teach	Year 1	Year 2	Year 3
SA Practices	*Early C (4.03, SD=0.48)	Early C (3.77, SD=0.47)	*Early C (4.03, SD=0.45)	*Early C (4.12, SD=0.34)
TA Practices	Early C (3.92, SD=0.30)	Early C (3.74, SD=0.23)	Early C (3.83, SD=0.57)	*Early C (4.11, SD=0.19)
T/C Practices	Early C (3.96, SD=0.21)	Early C (3.68, SD=0.20)	Early C (3.86, SD=0.47)	*Early C (4.21, SD=0.21)
Overall Practices	*Early C (4.00, SD=0.09)	Early C (3.77, SD=0.06)	Early C (3.86, SD=0.11)	*Early C (4.13, SD=0.05)

Note: Early C = Marginally early constructivist;
*Early C = Strongly early constructivist

In general, students of these NTs were observed to bring in articles, materials, or content to class that led science lessons. Students were also observed to formulate assessment criteria {rubrics}, do self and peer evaluations, and write quiz questions.

The new teachers (NTs) were found to be marginally "early constructivists" regarding TA practices from student teaching to their second year of teaching. For example, they were observed to include activities that related to guiding their student understanding of concepts and activities which had relevance and connections to student lives. They used various teaching methods that incorporated teaching of higher order thinking skills, integration of content and process skills, and integration with other disciplines. There was also evidence of teachers adjusting their strategies based on interactions with students, they dealt with misconceptions, demonstrated interpersonal skills, and modified lessons to meet individual student needs. Table 3 indicates improvement of the teachers to "strong early constructivists" concerning TA practices by year 3. In general, the NTs were frequently observed asking higher order thinking questions, giving students wait-time, and working with students on a one-to-one basis.

The pattern of change for sub-category T/C is very similar to that for T/C practices; that is, the new teachers (NTs) were marginally "early constructivists" from student teaching till their second year and they improved to strong "early constructivists" by their third year of teaching. Examples of the teachers' understanding of process and science content are demonstrated in their use of correct content, ability to integrate concepts and skills, their use of exemplars, and teaching a lesson with appropriate balance between depth and coverage. The NTs were observed selecting and modifying lessons based on current events that suited the contexts and interests of students.

Overall, the new teachers were observed to be better at facilitating student learning (SA) compared to the extent they demonstrated what a teacher should do in the classroom (TA) and in their understanding of process and content (T/C

By their third year of teaching, the new teachers used the most constructivist approaches in their classroom performances in all three sub-categories of constructivist practices.

Patterns of Change in Teacher Beliefs

Teacher Beliefs as elicited from the use of Philosophy of Teaching and Learning (PTL) interviews are summarized below in Table 4

"Best Effort" videotapes taken during student teaching provide qualitative data that indicated that the new teachers were generally student-centered in their beliefs. This is not at all surprising since substantial research including the extensive research of the over-all Salish I Research Project involved new teachers from ten different programs across the United States. The results reported elsewhere reported that beginning teachers generally are student-centred in their beliefs about teaching and learning. It appears that new teachers, regardless of varied preparation programs, tend to hold student-centered beliefs (Lew, 2001).

Table 4 indicates that the new teachers' (in this study) espoused beliefs for the three sub-categories, student actions (SA), teacher actions (TA), and teacher understanding of process and content (T/C), resulted in very similar patterns of change. In general, there was an observed decline (from year 1) in the student-centeredness of beliefs in year 2, followed by improvements in year 3. In year 2 of teaching, it was found that student-centred beliefs were partially replaced by a greater focus on use of worksheets, importance of classroom organization, physical environment, classroom management, and review and practice.

Table4: Patterns of Change in Constructivist Expertise Levels of Espoused Beliefs

Total Mean (SD)	Student Teach	Year 1	Year 2	Year 3
SA Beliefs	N/A	*Early C 4.01 (SD= 0.18)	Early C 3.96 (SD = 0.22)	*Early C 4.32 (SD = 0.20)
TA Beliefs	N/A	Early C 3.94 (SD=0.35)	Transitional 3.38 (SD = 0.75)	Early C 3.75 (SD = 0.35)
T/C Beliefs	N/A	Early C 3.64, (SD=0.28)	Transitional 3.16, (SD=1.25)	Early C 3.95, (SD=0.62)
Overall Beliefs	N/A	Early C 3.86 (SD=0.20)	Early C 3.50 (SD = 0.41)	Early C 4.01 (SD = 0.29)

Note: Early C = Marginally early constructivist;
*Early C = Strongly early constructivist

The new science teachers (NTs) in this study were most confident in their beliefs pertaining to what students should do in the classroom (SA). The NTs reported that learning should be centered on the students and not the teachers. They were strong proponents that students should be active participants of their learning while the teachers guide them. This is the only sub-category where improvement from year 2 to year 3 of teaching was large enough to be statistically significant.

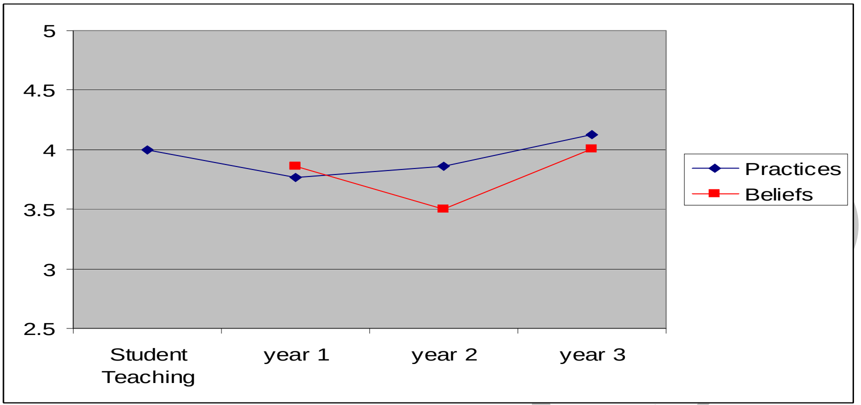
The new teachers were less student-centered when it comes to their beliefs pertaining to what teachers should do in the classroom (TA) and actual teacher knowledge of process and content (T/C). Indeed, in year 2 of teaching, constructivist expertise levels for both these sub-categories dropped to transitional (between teacher-centered and student-centered).

The new teachers were most constructivist in their beliefs, in all three sub-categories (SA, TA and T/C), in year 3 of their teaching. For example, the NTs expressed that teachers should not be the center of learning but instead mediators of student ideas and their learning environment. In various ways, they articulated their beliefs that teachers were not simply givers of information but persons who help students "search" rather than "follow" (TA). The NTs in this study believed that it is very important for teachers to understand what constitute real learning as compared to superficial memorization and regurgitation of information (T/C).

Comparing Patterns of Change in Observed Practices and spoused Beliefs

Figure .1 summarizes the patterns of change in observed teacher practices and espoused beliefs pertaining to constructivist teaching and learning. Assuming that the new teachers held early constructivist beliefs during student teaching (only qualitative data available), of particular interest is the finding that the new teacher beliefs matched observed performances extremely well during student teaching and their first year of teaching (Refer Figure.1, Tables 3 and.4). Data triangulations strongly suggest student-centered, constructivist behaviours; both in the new teacher actions and thinking (with only minimal declines); something that literature research suggests is uncommon in beginning teachers.

Figure 1: Patterns of Change in Overall Teacher Practices and Beliefs



During the second year of teaching, however, although not statistically significant, there was a definite dip in the mean scores for the new teachers' beliefs compared to those concerning their practices. This decline from the cognitive perspectives during the second year of teaching corresponds to certain observations reported by the Salish I researchers on year 2 new teachers (1997, p. 34):

> "During the second year of teaching, the new teachers sort and organize their beliefs with their classroom actions and the culture of the school; they appear to "tighten" their beliefs..."

Accordingly, the new teachers in this study began questioning and reflecting on their preparation and their teaching practices during their second year of teaching – something difficult for the majority of first year teachers (Salish I, 1997). It appears that new teachers in this study indicated the pressures of full time responsibilities and various socialization factors that impinged on them during their first year as professional teachers. It tended to affect their beliefs negatively more so than their actions.

By their third year of teaching, however, the new teachers became more constructivist in their classroom practices, as they did regarding their beliefs. Quantitative and qualitative data indicate strong congruence between new teachers student-centred classroom practices and student-centred espoused beliefs. The actions of teachers are deeply influenced by their perceptions of science as an enterprise and a subject to be taught and learned (NCR 1996, p. 28). This NSES vision was found embedded in both the NTs' espoused beliefs and then observed practices.

It is evident that teacher beliefs influence what occurs in the classrooms; practice, in turn, appears to play an important role in shaping teachers' beliefs (Ennis, Cothran, & Loftus, 1997, Lew 2010). The success of these new teachers in their implementation of constructivist teaching approaches reinforces their student-centered beliefs. There is a large body of research in science education related to the relationship between an individual teacher's beliefs about teaching and learning and their instructional decisions. Below are two pertinent comparisons between findings in this study and those from the whole Salish I Research Project (1997). They are the general findings on ten different programs over a period of 3 years.

- "Observed teaching practices contrasted starkly with teacher beliefs." (p.35). Apparently, while most new teachers professed student-centered beliefs, they behaved in teacher-centered ways. In contrast, the new teachers in this study generally professed student-centered beliefs as well as behaved in student-centered ways.
- Both studies found that classroom practices of third year teachers converged more closely with their beliefs. However, how the convergence occurred differed. For Salish I, there was convergence between beliefs and practices which occurred in year 3. This appeared to be because the new action of teachers became less teacher-centered and their beliefs became more teacher- centered. In this study, greater convergence between beliefs and practices occurred because both practices and beliefs became more student-centered.

Significance of the Study

The major finding of the study is that an exemplary program is successful in preparing new teachers who are generally student-centered. New teachers from the program put into practice their own research frameworks, are aware of the visions described in the National Science Education Standards, and can present evidence that they are "early constructivist" teachers. These findings contrast with research that reported most the tendency for beginning teachers to revert back to traditional practices as they experienced the reality of the classroom.

The Salish I (1997) involved ten programs across the U.S. The major findings stressed the connection of successful implementation of student-centred practices to certain programs features. These include:

- New teachers with student-centered classroom practices completed programs including at least 30 weeks of student teaching experiences. (p. 62)
- When teachers completed nine or more credit hours of subject-specific methods, they were more likely to be student-centered in their classroom practices. (p.62)

The program of the new teachers in this study provided them with a significant amount of field experiences (up to 149 hours through three consecutive science methods classes and culminating in 16 weeks of student teaching) compared to many other science teacher preparation programs. They coped well, were aware of their abilities, and felt positive about their teaching during their very first year as full-time teachers. The results of this study add to the body of literature that supports the premise that how teachers are prepared as professionals affects both their beliefs and teaching practices. This increases confidence for adoption of particular program features, such as the extended amount of field experiences and more methods courses, as mentioned above.

Other researchers also evaluated the trend reported in the sample studied. Lumpe, Haney, and Czerniak (2000) reported a significant correlation between the number of teaching-methods courses taken and a teacher's disposition towards effective science instruction. Roehrig and Luft (2006) contended that:

> "Teachers from a pre-service program with an extensive student teaching experience and two science methods courses held beliefs aligned with student-centered practices and implemented more reform-based lessons than did other teachers during the year {year 1}" (p.964)

Such a course provides pre-service teachers with a general overview of science-specific strategies along with brief explorations of the domain of science. The inclusion of a second methods course (Ab-El-Khalick, Bell, & Lederman, 1998) offers the potential of an in-depth exploration of the results of the teaching of science. Notions of teaching science that were developed in the first methods course can be built upon to foster a deeper understanding of teaching science (Roehrig & Luft, 2006). The new teachers studied in this report were from a program with three consecutive science methods, each one building on the other. In essence, it includes an increase in critical time for professional growth and development, reflection, and articulation of epistemological conceptions, and greater opportunities for varied field experiences.

It should be remembered that a majority of preparatory programs consist of a single science method course. Some programs do not require a mandatory science method course.

Implications

Given research evidence of such strong links between the need for quality science method(s) courses and effective science teachers, policy makers should make it mandatory that all programs and certification pathways should make a quality science method course(s), mandatory. The National Science Teacher Association (NSTA, 1998) recommends allocating a minimum of 3 semester hours to science methods courses that incorporate the topics from the NSES as well as planning, curriculum, technology and assessment. An important implication for future research is the identification and close examination of exemplary program features to further inform educators about effective practices for the preparation of effective constructivist science teachers.

Another implication is that related to the roles of induction programs. Research has indicated the importance of induction programs for teachers in order that they maintain the idealism they learned from their preparatory programs. Roehrig and Luft (2006) suggest the need for specialized support programs for beginning science teachers.

> "…when supported by a science-focused induction program, beginning teachers experienced fewer constraints, and were more likely to implement inquiry-based instruction in their classrooms than did secondary science teachers receiving general induction support or no formal induction" (p.964)

The new teachers in this report were regularly mentored by professors from the program; that is, their induction was both specific to science and mostly on a one-on-one support through the duration of the study (3 years).

Three years is considered minimum to observe the induction process (Salish I, 1997 p.viii). Further research which examines the influence of an exemplary program over a longer period of time would provide an even better understanding to discern whether or not the impact of the program is long lasting or if it dissipates over a certain period of time. Indeed, with the current critical shortage of quality science teachers and problems pertaining to their retention, induction and research that extend to the 5^{th} or 6^{th} year of teaching could be most beneficial. Developers of science-focused induction program would be better informed about the stages of development for inquiry based teaching via a longitudinal study. Such a study would provide invaluable information on formulating the structure of induction programs (Roehrig & Luft, 2006, Lew 2010).

Finally, few studies examined the classroom practices of new graduates while they were still in the program, as student teachers or while in method(s) course. Indeed, the longitudinal or cross-sectional study could trace developments from methods course(s), to student teaching, induction, and professional developments. With such a starting point, findings may provide further clues to the effects of socialization and the induction process as well as other pressures on teachers.

One of the main problems of a longitudinal in-depth study pertains to the locating, recruiting, and retaining of new teachers. With regards to this study, initially ten new teachers were involved but only six completed the three years of study. Of these six new teachers, data sets for only four were available and hence could be included in this study. Additional research with a larger sample size is necessary for better statistical analysis of quantitative data that would provide greater strength for the findings. To ensure retention of new teachers, the study itself has to become a university priority, and its importance conveyed to teacher candidates.

References

- science and instructional practice: Making the unnatural natural. Science Education, 82, 417-436.
- Allen, M.B. (2003). Eight Questions on Teacher Preparation: What Does the Research Say? An Education Commission of the States (ECS, USA) Teaching Quality Research Report.
- Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner & R. C. Calfee (eds.), Handbook of Educational Psychology, 673-708. New York: Simon & Schuster Macmillan.
- Brooks, J., & Brooks, M.G. (1993). The case for constructivist classrooms. Alexandria, VA: Association for Supervision and Curriculum Development.
- Burry-Stock, J. A., & Oxford, R. L. (1993). Expert science teaching educational evaluation model (ESTEEM) for measuring excellence in science teaching for professional development. Kalamazoo, MI: Center for Research on Educational Accountability and Teacher Evaluation (CREATE), Western Michigan University.
- Ennis, C. D., Cothran, D. J., & Loftus, S. J. (1997). The influence of teachers' educational belief on their knowledge organization. Journal of Research and Development in Education, 30(2), 73-86.

- Lenski, S.D., Wham, M. A., & Griffey, D. C. (1998). Literacy orientation survey: a survey to clarify teachers' beliefs and practices. Reading Research and Instruction, 37(30, 217-236.
- Lew, L. Y. (2010). The Use of Constructivist Teaching practices by Four new Secondary School Science Teachers: A Comparison of new Teachers and Experienced Constructivist Teachers. Science Educator, Fall 2010 Vol. 19, No. 2, p. 10-20
- Lew, L.Y. (2001). Development of constructivist behaviors among four new science teachers prepared at The University of Iowa. Unpublished doctoral dissertation in science education, Iowa City, The University of Iowa.
- Lochhead, J., & Yager, R.E. (1996). Is science sinking in a sea of knowledge? A theory of conceptual drift. In R.E. Yager (ed.), Science/Technology/Society as reform in science education, 25-380. Albany, NY : State University of New York Press.
- Lumpe, A.T., Haney, J.J., & Czerniak, C. M. (2000). Assessing Teachers' beliefs about their science teaching context. Journal of Research in Science Teaching, 37, 275-292.
- National Research Council (1996). National Science Education Standards. Washington D.C. National Academy Press.
- Richardson, L., & Simmons, P. (1997). Teachers' pedagogical philosophy interview. In Salish I Research Project (1997b). Secondary Science and Mathematics Teacher Preparation Program: Influences on New Teachers and Their Students. Instrument Package & User's guide, Science Education Center, Iowa City, The University of Iowa.
- Roehrig, G. H. & Luft, J. A. (2006). Does One Size Fit All ? The Induction Experience of Beginning Science Teachers from Different Teacher-Preparation Programs. Journal of Research in Science Teaching, 43(9), 963-985.
- Salish I Research Project (1997). Secondary Science and Mathematics Teacher Preparation Program: Influences on New Teachers and Their Students. Science Education Center, Iowa City, The University of Iowa.
- Taylor, P. C., Fraser, B. J., & White, L. R. (1994). The revised CLES: A questionnaire for educators interested in the constructivist reform of school science and mathematics. Paper presented at the annual meeting of the AERA. Atlanta, GA.
- Yager, R.E., & Weld, J.D. (1997). Scope, sequence, and coordination : A national reform effort in the U.S. The Iowa Project. Science Education Center, Iowa City, The University of Iowa.