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Design Study Approach to Teacher Professional Development to Support the Implementation of the Revised 2013 Lower Secondary Science Curriculum

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KEY IMPLICATIONS

1. The place and value of the LSS curriculum in developing students' scientific literacy and as an important bridge between primary and upper secondary science should be emphasized.
2. Teachers need support in interpreting the goals and emphases of the curriculum in relation to their established practices within their individual school context.
3. The active involvement of teachers in the process of collaborative curriculum making is important for developing a deeper understanding of how to translate curriculum goals into practice.

ABSTRACT

This project investigated how a researcher-teacher collaborative design study approach served as a professional development (PD) model to support teachers in implementing the revised 2013 Singapore lower secondary science (LSS) curriculum. The researchers worked collaboratively with teachers to develop instructional strategies and materials which catered to the needs of their school and their students. The cross-case analysis provides useful insights and key factors necessary in each phase of our design study PD model to support teachers in implementing and addressing the goals of any new curriculum.

INTRODUCTION

Current PD programs have been highly criticized as ineffective in improving the quality of teachers and teaching. This is in part due to the design of PD as short-term workshops offering quick-fix remedies, with content that is not adapted to the teachers' school context and issues (Guskey & Huberman, 1995). In this PD model, we sought to engage teachers as co-constructors of the PD program where researchers and teachers work collaboratively as a "design study team" (Bannan-Ritland, 2008) in a specific school setting to problem solve and develop instructional strategies and materials, using investigative case-based learning (ICBL) as the platform to engage teachers in curriculum making for the revised LSS syllabus.

In recent years there has been much discussion internationally about 'scientific literacy' being an essential part of the school science curriculum. In the most recent curriculum revisions, the development of students' scientific literacy and 21st century competencies have been added as important components of the '2014 Primary Science' and '2013 Lower Secondary Science' syllabuses. The goal is not only to develop students' basic understanding of the knowledge and processes in science, but also their understanding of the applications of science in real-world contexts. This includes understanding

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the nature of science and the interactions science has with the society, technology and the environment.

This study aimed to create and extend knowledge about developing, enacting, and sustaining innovative PD programs within schools to support the translation of policy to practice. The three research questions addressed in this study were:

1. What are teachers' beliefs and understandings regarding the goal of the LSS curriculum to develop students' scientific literacy?
2. What are the key issues and challenges faced by teachers in implementing the LSS curriculum to develop students' scientific literacy?
3. How does a design study approach serve as a PD model to support teachers in translating the goal of the LSS curriculum to develop students' scientific literacy?

RESEARCH DESIGN

The multiple case study approach was employed to obtain in-depth insights into the processes of change in curriculum making. Four secondary schools with students of a range of academic ability participated in the study. A group of teachers from each school participated in the design, implementation and refinement of an ICBL package for their students in one class each. The design study PD model was carried out for each school in four phases: 1) Training and Preparation; 2) Planning and Development; 3) Implementation and Reflection-in-Action; and 4) Evaluation and Consolidation.

The data sources obtained in this study including transcripts of lesson observations, planning meetings, interviews and post-lesson discussions were coded qualitatively and analyzed to identify key themes. The *Teacher Beliefs Interview* (TBI) protocol (Luft & Roehrig, 2007) and the *Reformed Teaching Observation Protocol* (RTOP) (Piburn et al., 2000) were used to assess teacher beliefs and practices.

KEY FINDINGS

Teachers' Beliefs, Views and Practices

As part of the baseline study, the epistemological beliefs about science teaching and learning and practices of four teachers, one from each of the four schools, were examined. The teachers predominantly expressed a greater inclination to focus on *teacher-directed instruction*, but at the same time believed in *engaging students* and *capturing their interest in science*, as well as providing opportunities for students to ask questions to clarify their understanding and demonstrate their thinking and prior knowledge. Teachers' observed practices were *more reformed* in their presentation of *propositional knowledge* and *least reformed* in providing opportunities for students to engage in *scientific reasoning*, *investigation* and *problem solving*, as well as student-teacher and student-student *generative discussions*, and *critique* of alternative thinking, interpretations or solutions.

Teachers' viewed the LSS curriculum as fulfilling two goals: 1) to help develop interest and positive attitudes towards science, and 2) to provide a good foundation of science knowledge and skills. The prevalent view on the role of the LSS curriculum seems to be limited to the preparation of students for 'higher level' studies in science rather than to develop the scientific literacy of all students.

Implementation Issues and Challenges for the Lower Secondary Science Curriculum

Teachers faced various constraints and tensions when implementing the LSS curriculum. The issues and challenges faced by the teachers in implementing the LSS curriculum can be categorised into four main areas: 1) *Learner-related*: e.g., disparity in students' science foundation and ability in Secondary One; 2) *Teacher-related*: e.g., lack of content mastery and confidence in teaching science subjects that are not within the teacher's area of specialisation and the need for training in pedagogical skills to develop and implement lessons that emphasize the development of students' scientific literacy (SL); 3) *Curriculum-related*: e.g., the difficulty of balancing the breadth and depth of the curriculum, and teaching for understanding; and 4) *Systemic issues*: e.g., the results-driven nature of schools, infrastructure and manpower, and expectations from stakeholders.

Insights from Design study PD Model

The insights and key factors gathered from each phase of this study serve as important indicators for thinking about planning and implementing PD for teachers, especially in aligning classroom practices to meet the goals and emphases of a new curriculum (see Table 1). At the start of the PD cycle, it is essential to address teachers' beliefs and understandings, and to explore how the curriculum goals and

emphasis might be realized in practice. Rather than a sequential process, this model assumes that both beliefs and practices are inextricably interwoven, and not addressing one or the other concurrently impedes teacher learning. It may be necessary to equip teachers with specific teaching approaches and strategies that support the intended outcomes of the new curriculum. The final stage of the PD cycle is important not only for the teachers involved to consolidate their learning, but also for them to share their learning with others through networked learning communities.

Our design study PD model involves teachers in active sense-making and problem solving in a reflective cycle of learn-apply-do-review. This PD model differs from other general models in the deliberate and intentional interventions throughout the cycle of interpreting, training, planning, implementing and evaluating new pedagogical practices to bring about student outcomes desired in a new science curriculum. Teachers are engaged concurrently in both changes in practice and in thinking about their role as a science teacher, through a collaborative culture and support from "knowledgeable others".

IMPLICATIONS

For Policy

It should be emphasized that the LSS curriculum serves as an important bridge between primary and upper secondary science. This affects how teachers perceive their role in sustaining students' interest in science at the lower secondary level, and to help students see the relevance of science to daily life. Greater focus could be given to equipping teachers with a good understanding of the big ideas in science and how they can be introduced in an age-appropriate way using real-world contexts. Other than the efficient delivery of knowledge and skills to be mastered, a greater focus needs to be given to viewing science as dynamic, and set in a social and cultural context. This includes the ability to understand media accounts of science, to recognize and appreciate the contributions of science in society, and to be able to use science in decision-making for both everyday and

Table 1. Design study approach as a PD model to support implementation of a new curriculum.

Phase	Purpose	Key Factors
1. Training and Preparation	To understand the goals and intent of the new curriculum, and receive training in relevant instructional approaches to implement the curriculum	• Address teachers' preconceptions of the goals and emphases of the new curriculum • Engage teachers in professional conversations and collaboration with knowledgeable others • Support teachers through targeted, situated and continuous professional development
2. Planning and Development	To plan and develop an instructional unit aligned to the new curriculum and school goals, customised to the needs of students	• Recognise and support the challenging work of curriculum making, especially from the school leadership • Engage teachers in active curriculum making and adaptation, taking into account students' learning profiles, teaching practices and school culture • Engender strong team leadership and ownership for the planning and development of the instructional unit
3. Implementation and Reflection-in-Action	To implement and make observations of planned lessons and conduct post-lesson discussions	• Seek the help of observers as critical friends in the classroom to check and identify areas for improvement • Conduct timely post-lesson discussions for reflection and feedback • Adjust instruction in between lessons using different kinds of scaffolding
4. Evaluation and Consolidation	To refine the instructional unit, consolidate learning and share experiences	• Provide opportunities for teachers to reflect on their learning and to reconceptualise their role in light of the goals and emphases of the new curriculum • Evaluate how the students' learning has met the intended goals and outcomes • Seek opportunities to share the team's learning and experiences with other practitioners

socio-scientific issues. There may be a need to strengthen the identity of LSS teachers, and to help them develop a broader view of their role in developing students' scientific literacy, rather than just to prepare students for science studies in upper secondary.

For Practice

Teachers need support in relating the curriculum, especially at its initial cycle of implementation, to their established practices in their individual school context, and require a collaborative culture within and beyond their school to explore and share their experiences in designing, implementing and evaluating new classroom practices that are aligned with the goals and emphases of the curriculum.

For Teacher Training

Traditional "one-shot" workshops where individual teachers are left to apply their learning to their school context, have limited impact in changing classroom practices that are aligned to meet the goals and intent of the curriculum. In recent years, there has been increasing emphasis on viewing each school as a professional learning community where teachers in teams collectively engage in an ongoing cycle of reflection that promotes deep team learning through shared experience. Support from external "knowledgeable others" such as curriculum specialists, master teachers, and teacher educators can further enhance the success of teachers in their efforts to explore innovative classroom practices and translate curriculum intent into workable approaches and strategies in the classroom. To sustain and propagate workable innovative practices, teachers can learn from each other through networked learning communities across schools. Moving forward, we should leverage on partnerships and networked learning to create opportunities for teachers to be actively involved in the process of collaborative curriculum making and to reflect on their practices in the light of the broader aims and goals of the curriculum.

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