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High School Physics Teachers' Conceptions about Teaching: The Ideal Versus Enacted

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Abstract

This paper reports on four New Zealand physics teachers' conceptions about teaching and how these related to their teaching practices. A case study method was employed. Interviews and observations provided data that was analysed using a cross-case thematic approach. The study identified and described each teacher's conceptions about teaching physics as well as the system enablers or constraints that influenced how these were implemented. We propose that until assessment changes from a heavy emphasis on conceptual understanding to assessing inquiry and problem-solving skills, teachers will continue to be constrained by the assessment system and rightly so, align their teaching approaches to what is valued by the system.

Key words: Conceptions about teaching; physics teachers; teaching practice; New Zealand curriculum

Introduction

This study was designed to explore conceptions and/or views about teaching held by New Zealand physics teachers in a context of a curriculum which places the student at the centre of teaching and learning process. The *New Zealand Curriculum (NZC)* identifies key ideas that students should encounter in their science education in order to understand, enjoy and interact with our natural, physical world and the wider universe (Ministry of Education, 2007). In the science learning area, students are expected to explore both how the natural physical world and science itself work, so that they can participate as "critical, informed and responsible citizens in a society in which science plays a significant role" (Ministry of Education, 2007, p. 17).

In addition, the *NZC* emphasises the importance of creating and encouraging reflective thought and action; enhancing relevance; facilitating shared learning; making connections to prior learning and experience; providing sufficient opportunities to learn; and inquiring into the teaching and learning relationship – which are key elements of inquiry-based and problem-solving approaches to learning. Teachers are required to use the *NZC*, together with the qualifications framework, to design their own localised learning programmes to meet the needs

of their communities and students (Education Review Office, 2012; Ministry of Education, 2007). Furthermore, teachers are required to encourage "reflective thought and action" and "facilitate shared learning" (p. 34). In order words, teachers need to conceptualise knowledge as "actively constructed by and not given to" students (Pillay, 2002, p. 14).

To make the objectives of the *NZC* achievable, schools are encouraged to keep assessment to levels that are manageable and reasonable for both students and teachers. The *NZC* further stresses that, "not all aspects of the curriculum need to be formally assessed, and excessive high stakes assessment in Years 11-13 is to be avoided" (Ministry of Education, 2007, p. 41). Harlen (2010) accentuated that high stakes assessments results in what is taught being determined by what is assessed rather by what is of value in adding to a growing understanding of key ideas and development of reasoning skills and attitudes. This study therefore explored, qualitatively, conceptions about teaching held by NZ high school physics teachers and examined them in light of constructivist epistemology. The relationship between the physics teachers' conceptions about teaching and their teaching practice was also considered. However, this study potentially identifies what physics teachers need to consider to be able to implement constructivist-based methods of instruction. The study was guided by the following two research questions:

1. What are the conceptions about teaching held by New Zealand high school physics teachers?
2. How do these conceptions influence their teaching practice?

Methodology

In this study, we were concerned with the lived experiences (Cohen, Manion, & Morrison, 2007) of physics teachers who were involved in the issue under study; hence a case study method was adopted. Heitzmann (2008) asserts that the case study method provides "many opportunities and strategies to gain insight into events that occur within the school and classroom" (p. 523). Yin (2009) also defined a case study as an "empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context" (p. 18). The embedded multiple-case study design (Gray, 2009; Yin, 2009) was specifically adopted. Multiple-case designs make it possible to replicate a case under review in one study. Moreover, independent conclusions arising from two or more cases are more trustworthy than those from a single case (Yin, 2009).

This study was conducted as part of a three-year long doctoral thesis, the aim of which was to enhance physics teaching and learning practices in accordance with the visions of the *NZC*. Four exemplary physics teachers (three males and one female) from four secondary schools (two state schools, one integrated school and one independent school) in Christchurch, New Zealand voluntarily participated in the study. They were purposefully sampled as a convenience sample for on-going observation (Creswell, 2007). Information about the teachers and their schools are presented using pseudonyms in order to conceal their identities.

The research instruments used for data collection for this study were interview protocols and classroom observation. Semi-structured interview protocols were designed for the physics teachers. The semi-structured interview is suitable for probing views and opinions and permits respondents to develop and expand on their own responses (Fraenkel, Wallen, & Hyun, 2012; Gray, 2009). A Classroom Observational Guide (COG) was also developed to measure physics

classroom practices, including teacher preparedness in terms of both content and pedagogy, among many others. Data gathered during interviews were transcribed. Nvivo 10 for Windows (QSR International Pty Ltd. Version 10, 2012) was used to organize the materials by coding them into nodes which provided easy retrieval of the themes that emerged. The production of accurate and verbatim transcripts was integral to establishing the credibility and trustworthiness of the data.

Detailed descriptions of classroom observations/practices were also recorded as a reference for indicating what actually occurred. A cross-case analysis approach (Yin, 2009), also called comparative analysis (Schwandt, 2001) was adopted for this purpose. A detailed report of the individual case studies was presented, and using comparative analysis, the similarities and differences between the cases were discussed. The comparison was helpful to identify how different contexts and individual expertise affect policies and practices regarding physics teaching and learning in high schools.

Results

The summary of the case studies is presented in Table 1. The main findings related to conceptions about teaching, teaching approaches, constraining factors and ways for improving upon physics teaching and learning and the number of students (and possibly teachers) involved are highlighted.

Conceptions about Teaching

As indicated in Table 1, the classroom observation of the four teachers and post observation interviews revealed the conceptions which underpin their teaching. All of them, with the exception of Vicky, held two main conceptions about teaching. Vicky held three main conceptions. Bernard's conceptions of teaching were seeing himself as a teacher of students first and foremost rather than as a teacher of physics and helping students to think and become logical thinkers. Nick's conceptions were about the importance of telling the history of physics to help students see how discoveries developed and providing learning opportunities for students to help themselves and help others. Philip believed in getting students engaged and establishing a good relationship with them. Vicky stated that, students learn by performing activities, and that it was important for her to create an atmosphere of togetherness and giving students content knowledge and detailed explanations. The dominant conception about teaching, held by the participants, that can be inferred were to help students to be able to think for themselves, so they would become useful to themselves and society at large.

Teaching Practices

Analysis of classroom observation data showed that Philip used a variety of teaching methods to engage his students, which included practical demonstrations, problem solving and lecture methods. The predominant instructional method was lecturing and problem solving, nonetheless videos and the use of interactive demonstrations were also used as and when necessary. Philip emphasised collaborative learning by encouraging students to work on physics problems in groups. For Nick, there was not much variety during his lessons in terms of teaching methods. Lessons were predominantly characterized by activities such as workbook exercises and copying notes from PowerPoint slides. Collaborative learning was not strongly promoted and students often worked individually on computational physics problems.

However, there were indications of collaboration during some of the few practical sessions observed, with students working in groups of three and four. Limited availability of equipment may explain why he allowed students to work in groups during practical lessons.

Bernard's classes used problem solving, simulations, demonstrations, discussions and teacher-centred instruction, with the latter being the dominant teaching method. Similar to Philip, two main types of lessons were observed for Bernard – those that involved practical work for students and those that did not. Bernard placed emphasis on collaborative learning by encouraging students to work on physics problems in groups. Lessons usually began for Vicky's classes with her outlining the activities/objectives to be undertaken on the white board. Students' previous knowledge was reviewed orally. The day's lesson was introduced and students were taken through the activities as outlined on the board. PowerPoint presentations accompanied with white board illustrations and videos were a common feature in all the lessons observed in Vicky's class. Similar to Nick, there was no organised practical lesson on its own but practical activities ranging between 10 to 20 minutes were incorporated into the lessons.

Case studies by their very nature imply individual responses to decisions about teaching and learning, nonetheless, the teachers in the present case study were somewhat similar in terms of classroom practices. Even though they all hold constructivist view of teaching and learning to a considerable extent, their approach to physics instruction is content-oriented, because of the nature of the assessment. Concerns about content predominate planning and reflections about students' perspectives play rather a minor role.

Discussion and Implications

There was a strong relationship between the teachers' conceptions and their teaching practice. For example, Nick's conception of telling the history of physics helped students see how discoveries developed, was linked to how he often provided anecdotal connections with the history of physics and stories about scientists during lessons. Also, Bernard, thought that helping students to think and to become logical thinkers was important so he spent time engaging students with activities where the students found their own solutions to problems.

As indicated by Koballa, Glynn, and Upson (2005), Ladachart (2011), and Tsai (2002) the context (conditions) in which teachers teach can influence their conceptions about teaching and the extent to which these conceptions are practiced in the classroom. However, Buaraphan (2007) argued that conceptions about teaching are often resistant to change. Therefore, the contextual constraints may cause teachers to compromise or reinforce their lived-long conceptions about teaching (Buaraphan & Sung-Ong, 2009; Friedrichsen & Dana, 2005; Koballa et al., 2005). As presented in this study, Nick and Vicky had a set of strongly-held ideas about teaching, including "providing learning opportunities for students to help themselves and help others" and "students learn by doing" respectively. However, both teachers compromised their beliefs about teaching due to contextual constraints. Lack of time and the demands of assessment rendered Nick's desire for a "minds on" approach practically impossible to implement. Vicky experienced discordancy between her previously developed conceptions (students learn by doing), because of the emphasis in her new school context on achievement in external high stakes assessment. This led to the formation of a new conception about teaching (i.e. feeding students with content knowledge and detailed explanations). She knew the aspirations of the curriculum were much broader than "content filling" but was

frustrated that she felt she could not implement them due to the external pressures for her students to achieve standards for admission to university.

The assessment demands in the senior secondary school system of New Zealand compelled some of the participant teachers to compromise their long-held conceptions about teaching. For example, Vicky wanted students to engage in hands-on activities and Nick (a proponent of peer instruction) wanted to emphasize minds on approaches to teaching and learning and run discussion groups, but both found there was limited time available for these things. This finding also agrees with Harlen (2010) who observed that high stakes assessments result in what is taught being determined by what is assessed, rather than by what is of broader value educationally.

The participant teachers were very aware and capable of designing and implementing interactive teaching and learning approaches. Their conceptions of what was valued by the system, and therefore what they actually did in their teaching was compromised by the time spent addressing assessment requirements. Therefore, there is a need to challenge teachers' notions of what is important for learning physics, so that they can enact and provide experiences for students in alignment with what they believe is useful for learning and for students' futures. Currently the teachers profiled here were not able to meet the aspirations of the *NZC* as indicated earlier, because the assessment in physics does not reflect these aspirations in terms of what it values (assesses).

Currently the external national assessments in physics focus on content recall and explanations of phenomena. In order to shift pedagogical practices in physics, there would need to be a change in what is emphasised in the physics assessments. This would involve assessing inquiry and problem-solving skills more than in the current standards assessments. This change in approach would be more consistent with research that shows that systems change can support learners for their futures (OECD, 2013). If the assessment emphasis changed, then teachers would be able to justfy and align the experiences they provided students to be consistent with their knowledge about how to help sudents learn using inquiry and problem-solving approaches and they would be more likely to meet the outcomes that are promulgated in the curriculum documents.

Table 1: Summary of Case Studies

Characteristics/Case names	Philip	Nick	Vicky	Bernard
Qualification	Physics graduate and also holds a Graduate Diploma.	PhD in Physics and also holds a Graduate Diploma.	Physics graduate and also holds a Graduate Diploma	Master of Science (Marine Biology), Bachelor of Science and Graduate Diploma
Teaching Experience	30+ years.	12 years.	10 years.	25 years.
Conception about Teaching	Getting students engaged. Establishing a good relationship with students.	Telling the history of Physics to make students see how things developed. Providing learning opportunities for students to help themselves and help others.	Students learn by doing activities. Creating an atmosphere of togetherness. Giving students content knowledge and detailed explanations.	Seeing himself as a teacher of students rather than a teacher of Physics. Helping students to think and become logical thinkers.
Teaching approaches	Practical demonstration, Problem solving, Collaborative learning, Simulations, Lecture method.	Predominantly lecture with note-taking from PowerPoint, Problem solving techniques.	Hands-on activities, Collaborative learning, Interactive demonstrations, Lecture method.	Problem solving, Simulations, Demonstration, Discussion. Collaborative earning, Lecture method.

Constraining factors (Decreasing order of importance as indicated by the teacher)	Time constraints, Assessment demands, Alignment of achievement standards with the curriculum, Increased workload, Poor tuition of physics at junior levels, Mathematical incompetency on the part of students.	Lack of time, Dichotomy between curriculum and assessment, Assessment demands and teacher work load, Inadequate qualified physics teachers, Public perception about physics, Nature and structure of junior science.	Premium on high stakes assessment, Time constraints, Assessments requirements, Alignment of achievement standards with the curriculum, Teacher workload, Nature of the physics curriculum Poor public perception about teaching profession	Lack of qualified physics teachers, Alignment of the curriculum to the NCEA achievement standards, Students' preoccupation with assessments, Physics curriculum itself.
Way forward for improving upon physics teaching and learning	Reduction in the number of assessments, Reintroduction of a single internally assessment standard, Improved remuneration and status of teachers, Provision of professional development opportunities for teachers.	Allocation of more time, Re-alignment of achievement standards and curriculum, Encouraging postgraduate physicists into teaching, Provision of professional learning courses, Better remuneration.	Reduction in NCEA assessment requirements, Provision of better remuneration package for teachers, Provision of professional development courses for teachers.	More qualified physics teachers, Content preparation through professional learning courses, Mentoring and teacher collaboration, Provision of good support mechanism for teachers and better remuneration, Allocation of more time for teaching.

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