Utilizing a Construct of Teacher Capacity to Examine National Curriculum Reform in Statistical Thinking: A Comparative Study between China and Australia

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Abstracts

This study uses a construct of Teacher Capacity to examine how Australian and Chinese teachers understand and give effect to new curriculum content in "Statistics and Probability" for the upper primary and junior secondary years. Eighty two teachers – 41from China and 41 from Australia – were involved in the study. A questionnaire was used to test teachers' capacity in teaching of statistical thinking. Their responses to questionnaires were mainly analyzed in quantitative method in terms of four criteria which form the basis of our construct of teacher capacity: Knowledge of Mathematics, Interpretation of the Intentions of the Official Mathematics Curriculum, Understanding of Students' Thinking, and Design of Teaching. These analyses gave rise to three classifications of Teacher Capacity: High, Medium and Low Capacity. Among the four criteria, Design of Teaching appears to be the critical dimension for the implementation of curriculum reform.

Keywords: national curriculum reform, statistical thinking, teacher capacity

1. Introduction

In the official curriculum documents of many countries, statistics and statistical reasoning have become part of the mainstream in school curriculum. In the recently published national mathematics curricula in both China and Australia, "Statistics and Probability" are set as an important single content strand (ACARA, 2010; Ministry of Education, 2011). And very similar intentions – to develop statistical thinking and literacy – are reflected in the both national documents.

These intentions are endorsed by Garfield and Ben-Zvi (2008) who point out that in contrast to traditional approaches to teaching which focus on computations of theoretical probability, new emphases are squarely focused on understanding data and development of statistical thinking and literacy (p. 7). They argue that "the goals for students at the elementary and secondary level tend to focus more on conceptual understanding and attainment of statistical literacy and thinking and less on learning a separate set of tools and procedures." (p. 14). These goals are reflected in the National Curriculum in Australia and China, where students are expected to learn and understand that: (1) explanations supported by data are more powerful than personal opinions or anecdotes; (2) variability is natural and is also predictable and quantifiable; (3) association is not the same as causation; and (4) random sampling allows results of surveys and experiments to be extended to the population from which the sample was taken. (cf. Garfield and Ben-Zvi, 2008, p. 15).

However, the implementation of curriculum change is never simply from the top down.

Teachers' interpretations and responses at the level of practice are never simple reflections of what is contained in official curriculum documents. While curriculum documents set out broad directions for change, any successful implementation of these "big ideas" depends on teachers' capacity to apply subtle interpretations and careful local adaptations (Datnow and Castellano, 2001). We argue that Teacher Capacity is a key dimension in realising that goal.

2. Theoretical construction of teacher capacity

After Shulman (1987) made the milestone contribution to identify pedagogical content knowledge (PCK), which includes the category most likely to distinguish the understanding of the content specialist from that of the expert teacher, Ball et al. (2008) prefer to use the term Mathematical knowledge for teaching (MKT). Within this idea, they identify four constituent domains or categories: (1) Common content knowledge (CCK) defined as the mathematical knowledge and skill used in settings other than teaching; (2) Specialized content knowledge (SCK) as the mathematical knowledge and skill unique to teaching specific topics; (3) Knowledge of content and students (KCS) defined as knowledge that combines knowing about students and knowing about mathematics; and (4) Knowledge of content and teaching (KCT), which combines knowing about teaching and knowing about mathematics.

The term "Teacher capacity" comes out of the literature of school improvement, school leadership and system reform (Fullan, 2010). When used in this context, teacher capacity usually relates to teachers' ability to understand and act on the reforms that policy makers are seeking to implement. It is close to our definition of Teacher Capacity as professionally informed judgment and disposition to act. There are clear parallels here with Ball et al. (2008) who make the equally strong point that any definition of Mathematical knowledge for teaching (MKT) should begin with teaching, not teachers. Any such definition must be "concerned with the tasks involved in teaching and the mathematical demands of these tasks (our emphasis). Because teaching involves showing students how to solve problems, answering students' questions, and checking students' work, it demands an understanding of the content of the school curriculum" (p. 395).

Our construct of Teacher Capacity, as professionally informed judgements and dispositions to act, is intended to capture a common ground between movements for school system and curriculum reform and the construct of Mathematical knowledge for teaching (Ball et al., 2008). Four criteria inform our theoretical model.

Criterion A – Knowledge of Mathematics –is intended to capture the key mathematical ideas for teaching specific content. Criterion B – Interpretation of the Intentions of the Official Mathematics Curriculum – is concerned with how teachers relate what is mandated or recommended in official curriculum documents of China and Australia to what their students to learn. Criterion C – Understanding of Students'

Mathematical Thinking – is directly concerned with teachers' capacity to interpret and differentiate between what students actually do (or did) and to anticipate what they are likely to do. Criterion D – Design of Teaching – places a clear emphasis on teachers' capacity to design teaching in order to move students' thinking forward and to respond to specific examples of students' thinking in the light of official curriculum documents. Each criterion of above was elaborated in terms of four specific indicators (Table 1).

Table 1: Four criteria and associated indicators

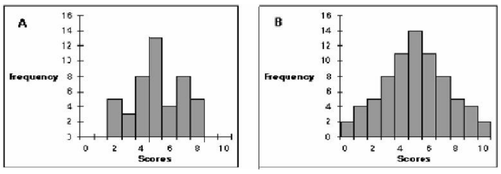
Criterion A – Knowledge of Mathematics	**Criterion C – Understanding of Students' Thinking**
(1) Is the teacher able to solve the theoretical mathematical probability problem and be able to understand relationship between chance of real events and sample size? (2) Does the teacher consistently understand the variability of theoretical probability always happens in natural events in real life, and the variability has a certain range close to the theoretical probability? (3) Does the teacher understand the meaning of "variability" by giving specific certain information? (4) Does the teacher recognize that the difference between association and causation?	(1) Is the teacher able to anticipate students' common difficulties and misconceptions on Question 1 (e) in questionnaire? (2) Does the teacher give clear and reasonable explanations to students' incorrect answers? (3) Is the teacher able to discriminate between students' different levels of understanding statistics according to their answers, especially discriminating between incorrect answers? (4) Does the teacher recognize the importance of using familiar contexts, such as coin tossing or rolling dice, to help students understand the statistical features of (less familiar) situations that contain similar statistical characteristics.
Criterion B – Interpretation of the Intentions of Official Mathematics Curriculum	**Criterion D – Design of Teaching**
(1) Does the teacher realize "statistical thinking" should be valued in teaching and learning beyond the solutions of probability problems or does the teacher refer to relevant statements on statistical thinking in curriculum documents? (2) Does the teacher understand and support the intention of the curriculum of helping students understand key ideas of statistical thinking such as theoretical probability, sampling, sample size and inevitable variability in actual data, rather than calculating theoretical probabilities? (3) Does the teacher think it important to consider statistics and probability by linking natural events and real life? (4) Does the teacher show in his/her descriptions of developing students' ability to understand information which is important for further learning and future life?	(1) In design of teaching, does the teacher focus on the important key conceptions of statistical thinking (theoretical probability, sampling, sample size and inevitable variability in actual data, as well as using familiar contexts to simulate real world events), not focusing too much on general teaching strategies or overall descriptions on statistics and probability? (2) Does the teacher have the subsequent plan in next several lessons to respond students' incorrect answers in Question 1 (e)? (3) Does the teacher have a longer-term plan to consistently develop students' deep understanding of statistical thinking (see 1 above), not just aiming to have students correctly calculate theoretical probability problems? (4) Does the teacher, in his/her teaching, give concrete examples that are familiar and easy for students to understand to help them understand statistical thinking and its relationships with real life?

3. Research method

Teachers were invited to complete a questionnaire consisting of two parts. Part A has four questions which were based on tasks developed in previous research, containing some situations relating to statistical thinking that students are expected to meet.

Question 1:A gumball machine has 100 gumballs in it. 20 are yellow, 30 are blue, and 50 are red. The gumballs are all mixed up inside the machine. (a) Suppose you do the following experiment: you pick out a handful of 10 gumballs, count the reds and write down the number of red gumballs in one handful. How many reds do you expect to get? (b) You replace the handful of 10 gumballs back in the machine and mix them up again. Now you draw another handful of 10 gumballs. Would you expect to get the same number of reds in every handful if you did this several times? Briefly describe why. (c) How many reds would surprise you in a handful of ten? Why would that surprise you? (d) If each time a handful of 10 gumballs is taken, these are replaced and remixed before taking another handful again, what do you think is likely to occur for the numbers of red gumballs that come out for a sequence of five handfuls? Please write the number of reds in each handful here. (e) Look at these possibilities that some students thought likely when they answered question d. Which of these lists do you think best describes what is most likely to happen? (A. 8,9,7,9,10; B. 3,7,5,8,5; C. 5,5,5,5,5; D. 2,4,3,4,3; E. 3,0,9,2,8; F. 7,7,7,7,7). Why do you think the list you chose best describes what is most likely to happen?

Question 2: Look at the histogram of the two distributions on the right. Which of the two distributions you think has more variability?



(a) Distribution A (b) Distribution B. Briefly describe why you think this.

Question 3: Half of all newborns are girls and half are boys. Hospital A records an average of 50 births a day. Hospital B records an average of 10 births a day. On a particular day, which hospital is more likely to record 80% or more female births?

(a) Hospital A (with 50 births a day); (b) Hospital B (with 10 births a day); (c) The two hospitals are equally likely to record such an event; (d) There is no basis for predicting which hospital would have that percentage of female births. Give a brief explanation of why you think like this.

Question 4: For one month, 500 elementary students kept a daily record of the hours they spent watching television. The average number of hours per week spent watching television was 28. The researchers conducting the study also obtained report cards for each of the students. They found that the students who did well in school spent less time watching television than those students who did poorly.

Which of the following statements is (are) correct? (a) The sample of 500 is too small to permit drawing conclusions; (b) If a student decreased the amount of time spent watching television, his or her performance in school would improve; (c) Even though students who did well watched less television, this doesn't necessarily mean that watching television hurts school performance; (d) One month is not a long enough period of time to estimate how many hours the students really spend watching television; (e) The research demonstrates that watching television causes poorer performance in school; (f) I don't agree with any of these statements. For one statement that you agree with, explain why you think that way. For one statement that you disagree with, explain why you think that way.

Part B of the questionnaire had three questions which asked teachers to consider teaching implications arising from the questions in Part A. Specifically they were asked to consider common misunderstandings and difficulties for students in the Part A questions; how the key mathematical ideas or critical points presented in these questions are addressed in their respective country's official curriculum documents; and how to design some lessons to help students to understand these key ideas.

Eighty Australian and Chinese teachers finished the above questionnaire. The Australian sample consisted of 41 Australian teachers, 28 secondary teachers and 13 from primary schools. They were from both urban and rural schools in Melbourne. The China sample comprised 41 teachers randomly selected from training programs in three cities. Twenty eight were secondary and 13 were primary teachers

4. Results

On the basis of qualitative analyses of teachers' responses, quantitative research was the main method used in this paper. By assigning a score of 1 if one of the four indicators was evident in a teacher's response, and 0 if it was omitted from their response or answered inappropriately, it was possible to construct a score of 0 to 4 for each criterion. Australian teachers scored slightly higher on all four criteria than their Chinese counterparts, but there was no statistically significant difference. Table 2 shows means and deviations for each of the Criteria and total score.

Table 2 Means for each criterion and global means and deviations

Sample	Criterion A	Criterion B	Criterion C	Criterion D	Total
Chinese(41)	2.42(0.67)	2.02(0.96)	2.27(0.71)	1.66(0.97)	8.37(2.70)
Australian(41)	2.72(0.86)	2.21(0.83)	2.49(0.76)	1.85(0.93)	9.26(2.63)
CH & AU(82)	2.56(0.82)	2.11(0.90)	2.38(0.76)	1.77(0.97)	8.82(2.79)

Three sub-categories of our construct of teacher capacity were created, with the boundaries set on the basis of the qualitative analysis of teachers' responses. These were High capacity (score 11-16), Medium capacity (score 6-10) and Low capacity (score 0-5). These classifications using the two samples are shown in Table 3.

Table 3 Classifications of teacher capacity

Capacity	Chinese	Australian
High	7(17.1%)	8(19.5%)
Medium	26(63.4%)	26(63.4%)
Low	8(19.5%)	7(17.1%)

There were more High Capacity teachers in Australian sample than in Chinese sample

(8 and 7); less Australian teachers were classified as Low Capacity than Chinese teachers (7 and 8). In both Chinese and Australian samples, Medium Capacity group was the biggest group which included 26 teachers out of 41, that was more than 60%.

5. Conclusions

Our construct of Teacher Capacity, presented here as teachers' professionally informed judgements and dispositions to act, connects to but differs from earlier research into Pedagogical Content Knowledge by Shulman (1986; 1987) and Mathematical knowledge for teaching by Ball et al. (2008). Here Teacher Capacity was investigated in terms of Knowledge of Mathematics, Interpretation of the Intentions of Official Curriculum documents, Understanding of Students' Thinking and Design of Teaching to foster the underlying mathematical ideas. Performance on each criterion was ascertained using a precise set of indicators that were related to the specific mathematical tasks, students expected thinking in relation to those tasks, the relationship between the tasks and official curriculum documents, and teachers' ability to design explicit teaching sequences to support students' learning.

Design of Teaching, informed by the other three criteria, appears to be the critical dimension for the implementation of curriculum reform; and the criterion that most clearly distinguishes between different levels of teachers' capacity to enact reform. Our construct of Teacher capacity strongly reflects the view that effective implementation of any curriculum reform depends on teachers' subtle interpretations of official curriculum documents and their professional dispositions to act on those ideas, which go well beyond general descriptions or statements of intent that are usually embodied in official curriculum advice.

References

Australian Curriculum and Reporting Authority (2010). *The Australian Curriculum: Mathematics*. Sydney: Author.

Ball, D., Thames, M., and Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59,* 389-407.

Datnow, A. and Castellano, M. (2001). Teachers' responses to success for all: how beliefs, experiences and adaptations shape curriculum. *American Educational Research Journal*, *37*, 775-800.

Fullan, M. (2010). *All Systems Go: The Change Imperative For Whole System Reform*. SAGA Publications Inc.

Garfield, J. B., and Ben-Zvi, D. (2008). *Developing students' statistical reasoning*. Milton Keynes, England. Springer.

Ministry of Education of PRC (2011). *Mathematics Curriculum Standards for Compulsory Education* (2011 version). Beijing: Beijing Normal University Press.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57, 1-22.