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STORYTELLING AS A PEDAGOGICAL STRATEGY FOR CULTURALLY RESPONSIVE MATHEMATICS TEACHING

Emily S.W. Sum[1], Miranda K. Y. Wong[1], and Wee Tiong Seah[2]

[1]Faculty of Education, The University of Hong Kong, HKSAR
[2]Melbourne Graduate School of Education, The University of Melbourne, Australia

This paper reports an intervention study with 60 Primary three students in Hong Kong mathematics classrooms in which the language of instruction (English) was not the first language for neither the teachers nor their students. The purpose of this study is to investigate the effectiveness of storytelling to develop fraction language and concepts based on the theory of culturally responsive teaching. The pre-test scores of the intervention group was significantly lower than the control group, yet post-test scores showed that both groups performed comparably well. These initial findings suggested that integrating storytelling with a culturally responsive teaching approach can reduce the achievement gap between culturally and linguistically diverse students in rural settings and their peers in urban districts.

INTRODUCTION

The number of ethnic minority (hereafter, "EM") students across all levels of public schooling in Hong Kong has increased by 10% between 2015 and 2020 (Legislative Council of Hong Kong Special Administrative Region, 2020). As such, mathematics classrooms are becoming more culturally diverse in a society which has remained hitherto culturally homogenous, and mathematics pedagogy has become more complex. In particular, EM students in Hong Kong have encountered many difficulties when learning mathematics (Tse & Hui, 2012). After all, for example, they value different aspects of mathematics learning compared to their ethnic Chinese peers (Sum et al., submitted). For Hong Kong, this is an emerging issue not just for the EM students but also for their ethnic Chinese peers in their classrooms. The quality of mathematics learning notwithstanding, a student's performance in mathematics assessments is also a function of this learning in class, and such performance has important implications on a student's future in Hong Kong, such as for entry to universities.

Fractions is one of the most difficult topics in school mathematics (Lortie-Forguesa et al., 2015). For instance, the part-whole concept is conceptualised differently in different languages, with the Asian analytic conceptualisation (thinking from whole to part) being different from Western synthetic conceptualisation (thinking from part to whole) (Leung, 2016). The differences concern not only the reading order, but also the articulation corresponding to the analytical way of thinking from whole to part, in which the part-whole relation is an integral part of the linguistic term. Constructing

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meanings of fraction concepts requires the use of concise language as a thinking tool for expressing the abstract relation. In this paper, we report the preliminary results of an ongoing study investigating the effectiveness of employing storytelling as a pedagogical strategy to support students' development of fraction concepts.

LITERATURE REVIEW & THEORETICAL BACKGROUND

Storytelling

Storytelling can build vocabulary, conceptual/content knowledge and improve comprehensions of English-language learners (Hickman et al., 2004) while fostering cultural awareness in multilingual educational settings (Hernández-Castillo & Pujol-Valls, 2018). Storytelling improves students' mathematics achievement (Orr, 1997), and promotes high level thinking and problem solving skills (Hong, 1996). Storytelling as a pedagogical strategy in mathematics can be adopted in several ways, such as providing a meaningful context that is experientially appropriate for students, preparing and developing concept and skill, and posing problems to foster thinking and reasoning (Welchman-Tischler, 1992). It remains unknown, however, if storytelling will be useful in multilingual settings involving Asian analytic and Western synthetic conceptualisations.

Culturally responsive teaching

Culturally responsive teaching (CRT) attempts to boost the academic achievement of students from diverse cultural and linguistic backgrounds by "using the cultural knowledge, prior experiences, frames of references and performances styles of ethnically diverse students to making learning encounters more relevant and effective for them" (Gay, 2018, p. 36). In the context of mathematics education, "all students can be successful in mathematics when their understanding of it is linked to meaningful cultural referents, and when the instruction assumes that all students are capable of mastering the subject matter" (Ladson-Billings, 1995, p. 141). CRT aims to make mathematics learning more relevant to students' cultural backgrounds and experiences, including their respective frames of references. Our study is largely guided (theoretically and practically) by the work of Gay (2018) and others who have developed the ideas of CRT (e.g., Aguirre & Zavala, 2013). The following research questions have thus guided our study:

RQ1: Does storytelling intervention support students to develop language-related conceptualisations of fraction in ways which lead to improvement in achievement?

RQ2: How does such intervention develop students' fraction language and concept in a classroom oriented towards culturally responsive teaching?

Due to space constraints in this paper, the results of the qualitative analysis will not be reported here. As such, only RQ1 will be responded to in this paper.

METHOD

Participants

The research design comprised a pre-test, an intervention, and a post-test. A total of 186 Primary three students from three schools in Hong Kong participated in this study, of whom 60 were involved in the intervention. The language of instruction (English) was not the first language for both the teachers and their students. The intervention was conducted in two classrooms at a village school in Hong Kong, located in a catchment area for EM communities with lower socioeconomic status. Among the 60 students, there were 28 ethnic Chinese (n=23 were born in Hong Kong, n=4 were born in Mainland China, n=1 was born in Korea) and 32 EM students (n=19 were born in Hong Kong, and of which 9 were second generation, whom was born in HK with at least one of the parents also born in HK). The ethnicities of the EM students include Black, Filipino, Korean, Nepalese, and Pakistani. The students in the intervention group speak different languages at home, namely, Cantonese (n=29), English (n=8), Nepali (n=17), Urdu (n=6).

Storytelling intervention and data collection

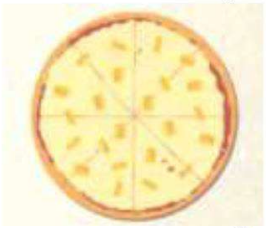
Two teachers worked collaboratively with the research team, whereby the designed reading activities and mathematical tasks were enacted with students. As such, data consisted of classroom observations, teacher-developed artefacts, teacher interviews, field notes, students' products and other artefacts. Two picture books were selected: *Breakfast Around the World* written by Ye-shil Kim, and *Charlie Piechart and the Case of the Missing Pizza Slice* by Marilyn Sadler. Both stories were set on everyday context situations with rich mathematics vocabulary that provokes students to consider partitioning, fair share and iterating. Our focus was on developing students' understanding and use of fraction vocabulary (e.g., half, quarter, one-fourth, equal share, numerator, denominator), and their associated fractional representations and symbols. The intervention took place in two classrooms each encompassing six 20-minute class sessions. All lessons were video-recorded and transcribed. As each story was read aloud, teachers stopped at pre-planned points and posed questions for discussion, which was built on the theory of CRT. This provided opportunities for conversational interaction, which in turn developed students' mathematical language and content knowledge. Teachers also highlighted how fraction language was used in the story and explained their meaning using illustrations. Students were also asked to repeat the fraction words in English to provide a phonological representation of the words, and to respond to questions in other contexts to make the words a part of their working vocabulary.

Data analysis

We assessed the students' mathematical performance prior to the intervention in early March 2021, and after the intervention two months later. Both the 13-item pre- and

post-tests had the same content, although the context or presentation may be different (see Figure 1), and the numbers used in 7 items were modified (see Figure 2). Items include reading and writing fractions representing a part of one whole and one group/set, dividing the whole into a number of equal parts, specifying and/or drawing fractions in part-whole and part-group models, recognising the concept of equivalent

Pre-test: I ate $\frac{3}{8}$ of a pizza. My sister ate $\frac{5}{8}$. Who ate more?



Post-test: I ate $\frac{5}{8}$ of a pizza. My sister ate $\frac{3}{8}$. Who ate more?

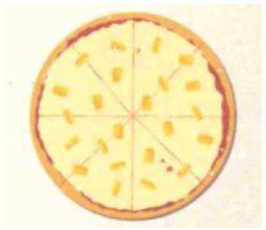
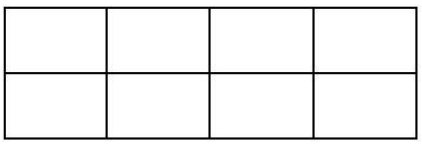


Figure 1: Changing the context of the same question for the pre- and post-tests.

Pre-test: Shade $\frac{3}{8}$ of the whole figure.



Post-test: Shade $\frac{3}{12}$ of the whole figure.

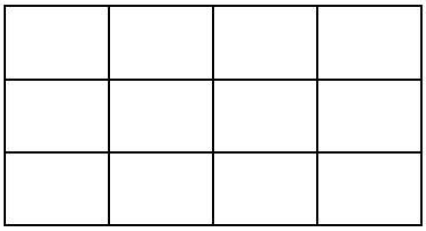


Figure 2: Modifying the numerals used in pre-test and post-test items.

fractions, comparing fractions with the same denominator, and solving problems represented in diagrams. Students were told that they could provide their answers in any language. With Cronbach's alphas at .823 and .803 in the pre- and post-tests respectively, the tests showed a satisfactory internal consistency.

A series of paired-samples *t*-tests were conducted to compare the pre- and post-test scores for intervention and control groups at a significance level of .05. The effect size (ES) of the difference in group means were measured by Cohen's *d* for *t* tests to show the extent to which students improved their achievement in the fraction test across time. In general, $d < 0.2$ counts as small effect size, and $d > 0.8$ counts as large effect size. A 2×2×2 repeated measures ANOVA was conducted to investigate the effectiveness of intervention across time between Chinese and EM students, with Time (pre-test, post-test) as the within-subject independent variable and Group (Intervention, Control) and Ethnicity (Chinese, EM) as the between-subject independent variables, and response accuracy rate as dependent variable.

FINDINGS AND DISCUSSION

As shown in Table 1, results of the paired-samples *t*-tests revealed a significant difference in response accuracy rate for all students between pre- and post-tests (*ps* < .001). In addition, the effect sizes (larger than 1) indicate students' huge progression in the fraction test from pre-test to post-test.

	Pre-test		Post-test			
School	Mean	SD	Mean	SD	*t*	Cohen's *d*
Total (n=186)	35.65%	24.08%	68.28%	21.18%	17.50***	1.28
Intervention (n=60)	25.38%	17.76%	68.46%	21.97%	16.33***	2.11
Chinese (n=28)	29.95%	20.33%	74.73%	21.94%	11.55***	2.18
EM (n=32)	21.39%	14.32%	62.98%	20.81%	11.44***	2.02
Control (n=126)	40.54%	25.19%	68.19%	20.88%	11.88***	1.06
Chinese (n=67)	44.55%	27.56%	71.76%	21.27%	8.08***	.99
EM (n=59)	35.98%	21.54%	64.15%	19.82%	8.79***	1.15

Table 1: Comparisons between Pre-test and Post-test scores.

Since all students, with or without intervention received, demonstrated significant improvement, we further investigated the effectiveness of intervention in relation to time and ethnicity in a repeated measures ANOVA. The analysis showed significant main effect for Time, $F(1, 182) = 336.90$, $p < .001$, $\eta_p^2 = .65$, suggesting that all students had a higher response accuracy rate in the post-test (M = 68.28%, SD = 21.18%) than in the pre-test (M = 35.65%, SD = 24.08%). Significant main effects were also found for Group, $F(1, 182) = 5.82$, $p = .017$, $\eta_p^2 = .03$, in which students in the Control group (M = 54.37%, SD = 19.09%) generally had a higher response accuracy rate than those in the Intervention group (M = 46.92%, SD = 17.17%), and for Ethnicity, $F(1, 182) = 10.31$, $p = .002$, $\eta_p^2 = .05$, in which the overall response accuracy rate of ethnic Chinese students (M = 56.44%, SD = 19.93%) was higher than that of

EM students (M = 47.30%, SD = 16.32%). The significant main effect for Group where students in the Control group scored higher than those in the Intervention group might be counterintuitive because we expected that students who received intervention would perform better in the fraction test than those who were taught in traditional classrooms. It is possible that the overall higher response accuracy rate of students in the Control group is attributed to the obvious discrepancy between both groups' prior knowledge and experiences as demonstrated in the pre-test. It is also plausible that the ratios of ethnic Chinese to EM students in both groups were different, i.e., more ethnic Chinese in the Control group while more EM students in the Intervention group, thereby the achievement gap between ethnic Chinese and EM students masked the intervention effect.

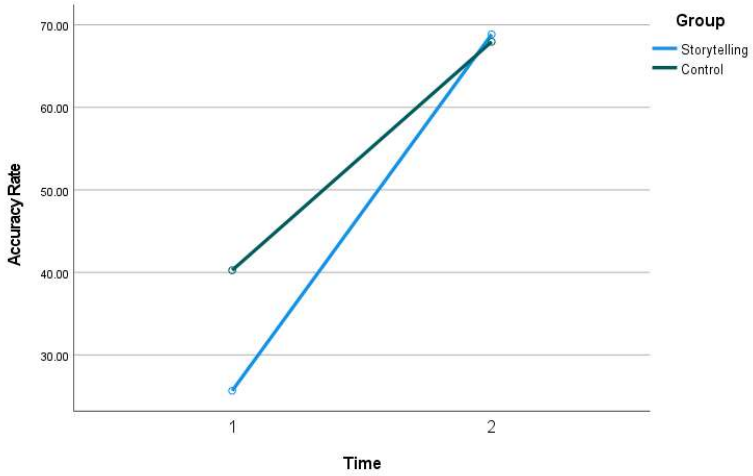


Figure 3: Comparison of students' response accuracy rate between the Intervention (storytelling) and Control Groups at pre-test and post-test.

Given these possibilities, the interaction effects of Time × Group, Time × Ethnicity, and Group × Ethnicity were examined. Among these, only the interaction effect of Time × Group was statistically significant, $F(1, 182) = 16.11$, $p < .001$, $\eta_p^2 = .08$. The response accuracy rate of students in the Intervention group at pre-test (M = 25.38%, SD = 17.76%) was significantly lower than that of students in the Control group at pre-test (M = 40.54%, SD = 25.19%), $p < .001$, while the response accuracy rates of both groups at post-test were comparable (Intervention: M = 68.46%, SD = 21.97%; Control: M = 68.19%, SD = 20.88%), $p = ns$. This result indicates that even though students in the Intervention group might have less prior knowledge and background in comparison to those students in the Control group, they had caught up to similar knowledge levels as students in the Control group, reducing the achievement gap after experiencing the intervention (Figure 3). In addition, the non-significant interaction effects of Time × Ethnicity, $F(1, 182) = .08$, $p = .772$, $\eta_p^2 < .001$, and Group × Ethnicity, $F(1, 182) = .13$, $p = .717$, $\eta_p^2 = .001$, both suggested that Ethnicity did not moderate the associations between Time and accuracy rate and between Group and

accuracy rate. In other words, ethnic Chinese students performed better than EM students in the fraction tests across time and group.

The intervention has several prominent aspects: CRT embraces diversity and allows students to connect mathematics with relevant/authentic situations in their respective lives, making learning meaningful and memorable. Storytelling provides language support for English language learners. While textbook language consists of academic language, usually with fragmented single word utterances, the language used in the stories is presented in relevant context of conversational language. Fraction language and concepts are developed through extensive listening and language scaffold (such as gestures, revoicing, and facial/oral expressions), with additional support including illustrations and images in the picture books. The multimodality of picture books provides better access for students to engage more fully in the mathematical meanings they encountered, and serves as resources in supporting students' understanding, and fills the gaps of missing prior knowledge and experiences. In our study, teachers posed contextual problems based on the stories to engage students in authentic communication, and created opportunities for them to use fraction words and phrases to communicate their reasoning. Teachers also used problem situations to make explicit connections with students' cultural frames of references, making teaching more culturally responsive.

CONCLUSIONS

Culturally and linguistically diverse students in Hong Kong rural areas with lower socioeconomic status face many barriers to realising their (mathematics) learning potential. Our initial findings here suggest that integrating storytelling with culturally responsive teaching could be a useful intervention, helping the EM students to at least not fall further behind in their mathematics learning. Further qualitative analysis of data collected from artefacts, observations and interviews is currently being conducted to confirm, interpret further, and extend these initial findings.

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