Education Journal, 2022, Vol. 50 No. 1, pp. 1–30

"Why Doesn't 'Johnny' Like Mathematics?" The Voices of Senior Secondary Students in Hong Kong

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While Hong Kong students excel at international tests in mathematics, they do not display corresponding attitudes toward mathematics learning. This study examined 10 Hong Kong Secondary 6 students' perceptions of learning mathematics (experiential curriculum) and their perceived factors that limited the development of students' positive attitudes toward mathematics learning in the New Senior Secondary mathematics curriculum by content analysis of their responses in the interviews. Although the participants in this study expected to learn mathematics by "conceptual learning" and the authentic applications of mathematics, they experienced rote-and-drilling-dominated learning approaches in mathematics education, which had succeeded in developing their numerical senses and problem-solving skills but failed to develop their sense of creativity and positive attitudes toward mathematics. The practical mentality and the examination-oriented culture in Hong Kong were the perceived factors that caused such situations.

Keywords: *examination-oriented culture; marketization of education; students' attitudes toward mathematics*

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Introduction

Although Hong Kong (HK) education system has undergone radical reforms in recent years, a comparison finds that the aims of the mathematics education curriculum (senior secondary) were kept consistent. These aims include developing: (a) students' creative and critical thinking skills for problem-solving in different fields, logical communication skills in mathematical language, and abilities to manipulate mathematical objects; (b) their mathematical sense and capacity to appreciate structures and patterns; and (c) their positive attitudes toward mathematics (Curriculum Development Council [CDC], 1992, 1999, 2001, 2004, 2015a). In other words, the foci are skills, knowledge, and attitudes.

While the aim of developing HK students' mathematical skills and knowledge is concerned, HK students got outstanding international test results in past years (Mullis et al., 2016; Organisation for Economic Co-operation and Development [OECD], 2018). However, research revealed that HK students found mathematics important but did not particularly like it (Ad hoc Committee on Holistic Review of the Mathematics Curriculum, 2000).

In the current senior secondary system, students take mathematics compulsorily (CDC, 2015a, 2017), and passing the mathematics examination becomes a basic requirement for undergraduate programs. When comparing the old curriculum with the New Senior Secondary (NSS) one, one may find that the two syllabi are similar in content while the new one emphasizes the nine generic skills (CDC, 2017). The emphasis on the nine generic skills may have changed teacher's classroom practice and hence, students' learning experience, their perception of the NSS mathematics and attitudes toward mathematics learning.

It is our interest to examine the factors of discrepancy between students' excellent worldwide achievements in mathematics and their apathetic attitude toward mathematics after the implementation of the NSS mathematics education in HK. In past years, scholars conducted quantitative studies by questionnaires to investigate students' views on mathematics learning and curriculum (e.g., Leung, 2002; Liu, 2009; N. Y. Wong et al., 2001). There are, however, not many qualitative studies by interviews on the voices of HK students. In particular, researchers, teachers, and policymakers are seeking to get more useful information regarding student needs and aspiration in learning mathematics in curriculum implementation, evaluation and practice of instruction (Andersson et al., 2015; Lim, 2008; N. Y. Wong et al., 2001). Based on interviews with HK students, this article aims to explore HK students' attitudes toward mathematic learning in the NSS curriculum settings. In addition, the article will examine the factors that may promote or limit HK students' enjoyment and appreciation of mathematics learning.

This article offers interpretations for the discrepancies between the academic results and attitudes of mathematics learning of HK students. It provides concepts such as neoliberalism and empirical data for policymakers and educators to deal with those discrepancies. It fills the research gap for interpreting the factors affecting the attitudes of students' mathematics learning.

Literature Review

Attitude toward mathematics, relating to affective, cognitive and behavior components, is not easy to be defined in straightforward approach (Ayob & Yasin, 2017; Di Martino & Zan, 2011). McLeod (1992) suggested attitudes on mathematics as a relative stable positive and negative affective responses toward mathematics. Hart (1989) and Hannula (2002) stressed that attitude should be regarded as a multidimensional property being comprised of emotional response, beliefs regarding mathematics, and behavior related to the subject. With reference to International Association for the Evaluation of Educational Achievement (2019), Geesa et al. (2019) and Ayob and Yasin (2017), the authors in this study operationally define attitudes toward mathematics as students' interest, perceived abilities, and self-efficacy of studying mathematics.

Student Attitudes Toward Mathematics

As far as the aim of developing HK students' mathematical skills and knowledge is concerned, results of international studies, such as TIMSS and PISA, indicate HK students excel at mathematics tests (Mullis et al., 2016; OECD, 2018). To examine the relationship between affection and mathematics achievement in HK junior secondary schools, Cheung (1988) studied a large data set (the Second IEA Mathematics Study data, N = 5,644) of HK Grade 7 students.[1] His findings showed that the most pertinent affective dimensions in explaining students' mathematics achievement variance included their self-efficacy of doing mathematics, their perception of the importance of mathematics to society, and the concept of mathematics being creative. N. Y. Wong (1992) also used correlation and path analyses on another sample of HK secondary school students (Grades 7–13, N = 1,766), and found that mathematics achievement was closely related to self-concept, academic self-concept and attitudes toward mathematics. Other studies (e.g., N. Y. Wong & Watkins, 1998) also suggested a positive correlation between mathematics achievement and attitudes toward mathematics. It seemed to be reasonable to claim that, based on HK students' excellent

mathematics achievement, HK mathematics education enjoyed success in all aspects: skills, knowledge, and attitudes.

However, the trend of positive correlation between mathematics achievement and attitudes toward mathematics of HK secondary students might not always be consistent as mentioned in the previous paragraph or fit into the worldwide data. The Ad hoc Committee on Holistic Review of the Mathematics Curriculum (2000), by comparing the results of TIMSS, reviewed the HK mathematics education curriculum. The committee summarized that: (a) although HK students found mathematics important, they did not particularly like it; and (b) HK students did not think that they did well in mathematics in general, and girls had lower self-efficacy of their ability in mathematics than boys in particular. Leung (2002) analyzed the TIMSS questionnaire data collected from students in four East Asian countries (HK, Japan, Korea, and Singapore), and found that HK students lacked confidence in doing mathematics and displayed relatively negative attitudes toward mathematics. Leung attributed the fact that the excellently achieving HK students did not display (rate themselves at) a corresponding level of positive attitudes to the stress in the Confucian culture of HK on being humble on their academic achievement or ability. Wong and colleagues used a large sample (N = 9,696) of primary and secondary school students, and indicated that, across grade levels, students' interest in solving mathematical problems, attending mathematics classes and mathematical calculations dropped substantially although their interest in learning mathematics seemed to maintain (N. Y. Wong et al., 2001). They also interviewed fifteen groups of students (N = 60), and found that students' negative feeling about the mathematics classroom intensified across grade levels (N. Y. Wong et al., 2003). Further, Liu (2009) compared mathematics achievement, learning strategies and affect between 15-year-old students in HK (N = 4,478) and those in the United States collected from PISA 2003, and observed a clear mismatch between HK students' excellent achievement and high levels of mathematical anxiety. After the HK NSS mathematics curriculum was implemented in 2012, the mismatch still exists between mathematics achievement and attitudes toward mathematics. TIMSS 2015 identified that 46% of HK Grade 8 students (international average: 38%) did not like learning mathematics, 54% (international average: 43%) expressed they were not confident in mathematics, and 29% (international average: 13%) did not value mathematics as helpful or useful in real life (Mullis et al., 2016). PISA 2012 also recorded similar results that, comparing with the global average, HK students developed lower self-concept about mathematics, lower mathematics intention, and higher mathematical anxiety despite their excellent mathematical performance

in the test (OECD, 2013). Buckley (2013) connected students' enrollment rate of advanced mathematics classes to their anxiety in mathematics and found that the failure to develop students' positive attitudes toward mathematics might also be observed by the decrease in number of students who take the advanced mathematics examinations over years (Hong Kong Examinations and Assessment Authority, 2019) and the low enrollment and graduation rates of mathematics-related degree programs at HK universities (Tsang, 2017), not to mention the fact that HK citizens question the need for learning mathematics on online forums.

Therefore, while the results of international mathematics tests (such as TIMSS and PISA) indicate that HK students outperform their worldwide counterparts (Mullis et al., 2016; OECD, 2018), and the HK government claims that HK mathematics education enjoyed success (Government of the Hong Kong Special Administrative Region, 2016), the authors argue that current curriculum failed to develop students' positive attitudes toward mathematics.

Experiential Curriculum

In order to conceptualize various studies in the field of curriculum, Goodlad introduced a framework by identifying five perceptions of curriculum, namely ideal, formal, perceived, operational, and experiential (see Klein et al., 1975). According to their definitions, the experiential curriculum is defined by two aspects: (a) student's perception of the curriculum that is offered, and (b) student's actual learning outcomes at school (Klein et al., 1975). If education or schooling is viewed as a model of communication process, through interactions between scholars, government officers, school leaders, teachers and students, a message is transmitted from ideal curriculum to experiential curriculum accordingly, and students can receive and discover the message, namely the aims of the curriculum (learning outcomes). Hence, it is expected that noise and distortion that cause discrepancies or "gaps" between those five Goodlad's curricula exist. For example, the official curriculum developers may have to balance and consider various expectations of stakeholders (e.g., the government, employers and the public) when writing the formal documents of the mathematics curriculum, whereas mathematics teachers mainly focus on developing students' mathematical knowledge (both their learning outcomes and knowledge described in the textbooks) and how this knowledge can be instructed. After implementation of the current

mathematics curriculum in HK, students are receiving and discovering these messages and expectations from various stakeholders. However, it is reasonable to assume that some "ideal" aims may be distorted or missing.

These missing and distortions of the aims of a curriculum may be explained by the social context. The existing social context can be desirable or undesirable to students' development. For example, Cotton et al. (2013, p. 192) posited that the social inequality might be reproduced in a community with the example of Willis's study *Learning to Labour* whereas Acar (2012) argued that students' broader mind to social diversity could be developed in a mathematics classroom depending on teacher's acts as the context. Lending support from Talbert and McLaughlin (1999) and Bascia (2014), the authors argue that the social context can be not only the classroom cultures led by the teachers' acts and the school cultures, but also the "broader" HK economy and culture.

The "Market" in the HK Context

Recently, marketing approach surrounds the politics of curriculum reforms. The approach is underpinned by the concept of neoliberalism, which determines the priorities of curriculum (Rizvi, 2017). In simple terms, marketing is "a social process by which individuals and groups obtain what they need and want through creating and exchanging value with others" (Kotler & Keller, 2009, p. 4). Research findings revealed that the discourse of market had recontextualized to define particular forms of "useful knowledge" and recoded as "know-how" which valorizes procedural knowledge at the expense of more powerful forms of knowledge which can take the learner beyond their immediate experience (N. Brady & Bates, 2014; Young, 2012).

The rationale of educational reform in East Asian countries (in particular, HK) can be explained by the concept of "neo-progressivism," that the school curriculum is influenced by global and local economies (L. Brady & Kennedy, 2013; Kennedy, 2005, 2013). According to the rationale of neoliberalism, curriculum is serving the demands of society, which focus on preparing students for an ever-changing and volatile marketplace (Gautreaux, 2015). With reference to the selected views of "human capital theory," Kennedy (2005) questioned and examined how the economic constructions of education influence the school curriculum. From this perspective, the school curriculum serves to develop student's knowledge and skills that contributing to the economic, social, and political needs of society. Similar findings showed that the role of marketization appeared in higher education

in HK, aiming at coping with the needs of societal competition (Mok, 1999; S. Y. Y. Wong, 2006).

In this study, the term "market" not only refers to those economic and social needs described by Kennedy (2005), but also "marketization." The concept of marketization mainly emphasizes the interactive relationship between schools, students and parents using the model of a service provider and customer (Furedi, 2011), and describes how the preferences of customers influence the school curriculum, for example, through media (Williams, 2011), and hence influence their experienced curriculum in schools. This is even being regarded as a commodity equating knowledge and learning with "raw materials" bought and sold in market (Gautreaux, 2015). The interaction between the government, the school and the market is a dynamic process (Jongbloed, 2003). Hence, we hypothesize that there exists a close relationship between the market, the school and the students. It is also our intention to examine, in the HK context, the factors that may shape the school curriculum and students' attitudes toward mathematics by the market.

Based on the literature review, this exploratory study aims to: (a) examine HK Secondary 6 (S6, i.e., Grade 12) students' attitudes toward mathematics and their views on the current NSS mathematics curriculum (experiential curriculum); (b) identify the factors that may shape their attitudes and views; and (c) whether the "market" (the social context) influenced their attitudes. Prior studies on the experiential curriculum in mathematics focused on students' actual learning outcomes, namely mathematics achievement (e.g., Mullis et al., 2016; OECD, 2018) and attitudes toward mathematics (e.g., Leung, 2002; Liu, 2009; N. Y. Wong et al., 2001, 2003) using questionnaire. Though the use of questionnaire enables us to conduct quantitative study on students' attitudes by, for example, comparing students in different groups as well as before and after intervention, it may not provide the participants with an environment that inspires them to respond to more complex questions (compared with those in the questionnaire) with deeper reasons. On the contrary, by providing an open and pressureless environment, interviews may enable students to share freely and deeply about their perception of the current curriculum and their attitudes (experiential curriculum), and provide us with rich qualitative data to analyze the perceived factors attributing to the development of their perception and attitudes. By investigating experiential curriculum, we may examine what students would like to, and/or what they actually experience at school.

Methods

Research Questions

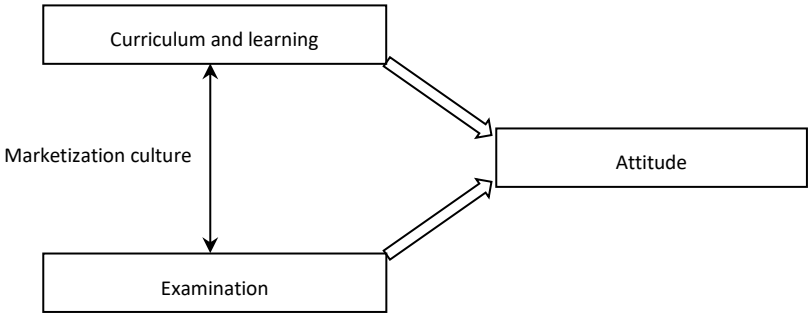
With reference to the above background and literature, the researchers formulate three research questions:

1. What are the attitudes of HK S6 students toward mathematics and how they perceive the current NSS mathematics curriculum?
2. What are the factors that may shape their attitudes and views?
3. Among those attitude-shaping factors, what is the role of "market" in influencing student attitudes toward mathematics?

Conceptual Framework

As mentioned before, the learning and assessment of mathematics in HK were embedded within the marketing-based culture (Kennedy, 2013; Lynch, 2006; Yin & White, 1994). In precise, the neoliberal approach of designing official mathematics curriculum (Kennedy, 2013) and marketization rationale of mathematics examinations impinge on the learning attitudes of students. The practical mentality of HK students has significant effects on the views of students (C. Chan & Bray, 2014; Kember & Watkins, 2010). Students' expectation of education has then been "downplayed" by the market, and the market may have affected the learning, curriculum, and examination (G. T. L. Brown et al., 2009; Kennedy, 2005; Yin & White, 1994), and hence shaped students' attitude as shown in Figure 1. In the current research, this conceptual framework will be used as a foundation for understanding the factors affecting the attitudes of HK students toward learning mathematics.

Figure 1: The Influence of the Marketization on Students' Attitudes



Participants

Data is collected from 10 S6 (similar to Grade 12 in other educational systems) students from two local secondary schools[2] in HK (see Table 1). Most students admitted to School B are higher academically achieving while most students in School A are lower achieving. Throughout three years of study, the participants have had moderate understanding of the current NSS curriculum of mathematics education, and have developed their own opinions on this curriculum. It should be pointed out that participants from the same school had various backgrounds, namely their mathematics performance and choices of elective subjects. Here, "mathematics performance" refers to in-school mathematics examination results of the students. Among the 10 participants, two enrolled in Mathematics Extended Part Module 1 (Calculus and Statistics) (M1) for enhancing and widening their knowledge and understanding of the application of mathematics, statistics in particular (CDC, 2015a). Since student attitudes toward mathematics may be associated with their mathematics performance and intention of mathematics (OECD, 2013), the participants' mathematics performance and choices of elective subjects are reported below.

Table 1: A Brief Demography of the Participants

Student participants	School	Gender	Mathematics performance*	Elective subject 1**	Elective subject 2**	Study M1
Student 1	A	M	85th	Chemistry	Physics	Yes
Student 2	A	F	95th	Geography	T&H Studies	Yes
Student 3	A	F	75th	History	Visual Arts	No
Student 4	A	M	20th	ICT	Chinese History	No
Student 5	A	M	60th	Chemistry	Biology	No
Student 6	A	M	10th	ICT	Chinese History	No
Student 7	B	F	30th	Economics	BAFS	No
Student 8	B	F	40th	Economics	Geography	No
Student 9	B	M	50th	Biology	Chemistry	No
Student 10	B	F	5th	Chinese History	History	No

* The mathematics performance refers to the percentile rank in the subject of Mathematics (Compulsory Part) with respect to the schools.

** BAFS = Business, Accounting and Financial Studies; ICT = Information and Communication Technology; T&H Studies = Tourism and Hospitality Studies.

The participants attended semi-structured interviews individually in 2017. The purpose of this study and interview was explained to the participants by the researcher before the interview. The interviews held for 20–30 minutes. In order to help create an environment

that the participants could express their opinions freely, the names of the participants were anonymous.

Semi-structured Interview

While quantitative study allows us to examine and identify any significant phenomenon by statistical analysis, qualitative research helps us gain a deeper understanding of an existing phenomenon, and in-depth investigation of factors or reasons that may cause such phenomenon. As the aim of this study is to investigate experiential curriculum of HK S6 students in mathematics, it is more appropriate to use qualitative methods (Cotton et al., 2013; Dahlin & Watkins, 2000). Qualitative methods, such as semi-structured interviews, allow interviewees to freely express their opinions guided and probed by the researcher (Morris, 2015). A set of pre-established questions were purposed for initiating and continuing the interview within the aims of this study. In order for a better understanding of students' comments, the pre-established interview questions and the overall aims of HK mathematics education are presented in Figure 2.

Each interview lasted for 20–30 minutes, whereas the difference in time taken for each interview lied mainly in probing and follow-up questions depending on participants' answers. All interviews were conducted in participants' mother tongue, Cantonese, that the participants felt comfortable to express their opinions. The interviews were audio-recorded and transcribed into written Chinese and then translated into English by the researcher. The data collected were then analyzed in order to seek any characteristics such as similarities, differences and complementarities between responses from description to explanation. Thematic analysis was then conducted across data sets. Featuring quotations were indicated based on emergent themes and representativeness of content. The analysis aimed to sort out the featuring themes and patterns from the data, and to establish those relations and connections across the data. The data analysis was anchored by the aims of this study under two key headings:

1. Students' attitudes toward mathematics learning;
2. Students' perceptions of the factors affecting the achievement of the aims of NSS mathematics.

Figure 2: The Pre-established Interview Questions

1. To you, what is mathematics? Why do you study mathematics?
2. How do you rate your mathematical abilities? (1 = lowest, 10 = highest)
3. How do you rate your enjoyment toward mathematics? And the mathematics curriculum? (1 = lowest, 10 = highest)
4. In mathematics, which chapter(s) or topic(s) do you dislike the most? Why?
5. In mathematics, which chapter(s) or topic(s) do you like the most? Why?

Questions 6–8 refer to the overall curriculum aims of the Mathematics Education Key Learning Area (CDC, 2015a, pp. 2–3), which are to develop in students:

Aim 1 *the ability to think critically and creatively, to conceptualize, inquire and reason mathematically, and to use mathematics to formulate and solve problems in daily life as well as in mathematical contexts and other disciplines;*

Aim 2 *the ability to communicate with others and express their views clearly and logically in mathematical language;*

Aim 3 *the ability to manipulate numbers, symbols and other mathematical objects;*

Aim 4 *number sense, symbol sense, spatial sense, measurement sense and the capacity to appreciate structures and patterns;*

Aim 5 *a positive attitude toward the learning of mathematics and an appreciation of the aesthetic nature and cultural aspects of mathematics.*

6. How well do you think that the aims of the NSS mathematics curriculum have achieved?
7. Referring to Q6, for those aims, what should be done to improve the situation, such that the aims may be achieved?
8. Do you have any other comment on the NSS mathematics curriculum?

Questions 1–2 were "warm-up" items that allow the participants to get familiar with the interviews. During the interviews, the time taken for answering these two questions was controlled in 2 minutes. Question 3 was related directly to enjoyment of learning mathematics. Questions 4–5 were to examine the participants' reflections on the mathematical contents that they experienced in the NSS mathematics. Questions 6–7 allowed the participants to reflect on their own experiences in class regarding the overall aims described by the official documents. Question 8 was used to capture any missing information that the participants would like to share about NSS mathematics that they received.

Data Analysis

Three items including codes, categories and themes are helpful to the understanding of the data analysis processes being used. Codes are tags for assigning units of meaning to the

descriptive or inferential information in this study. In most cases, codes are sentences or short paragraphs connecting to a specific setting (Miles & Huberman, 1994). Coding is crucial in identifying categories and finding themes and forces the researchers to make judgments about the meanings of transcripts (Ryan & Bernard, 2000).

The code list of this study, starting from what Miles and Huberman (1994, p. 58) prefer, uses the method of creating a provisional "start list" of codes. The list comes from research questions, literature review and the conceptual framework. The researchers used the concept of "curriculum and learning" and "examinations" under the marketization culture, and their influence on attitudes toward mathematics as the conceptual framework. A good coding frame is internally coherent in the sense that each code derives from an overarching analytic conception. At the end of the analysis, a coding specification was finalized. The heart of data analysis consists of finding themes and identifying categories, however (Highlen & Finley, 1996). The codes can be sorted into categories. According to Patton (1990), the data in that category hold together in a meaningful way. Finding themes is one of the main targets in all research, including the attitude toward mathematics learning. Though themes come from codes and categories, they could be extracted from different sources, such as literature review, and during and after data collection (Ryan & Bernard, 2000). Generating categories and themes is the crucial procedure in data analysis, which consists of identifying categories and recurrent themes through the grouping of pattern codes (Highlen & Finley, 1996).

To ensure the creditability of the data, the two researchers (authors) of this article individually analyzed the data and counter-checked the citations, codes, categories and themes identified by each other. After that, the researchers invited a senior research assistant to cross-checked the results. While codes and themes are illustrated in the findings, the themes are presented in discussion of this article.

Findings

From the interviews, it was found that the students with different academic achievements, whether in their school banding or in their mathematics performance, do not show different attitudes or perceptions toward mathematics. The findings are, thus, presented according to the order of the questions pre-established for the interviews, and discussed in this section under the afore-mentioned two key headings.

Students' Attitudes Toward Mathematics Learning

In this section, the researchers illustrate student attitudes toward mathematics learning and the reasons for explaining these attitudes.

Students eager to learn for application

The majority of the participants in the interviews agreed that they learned mathematics for applications. They preferred to apply their "mathematical" knowledge into daily uses, such as calculations for trading including the concepts of percentages and discounts. Yet, they believed the current NSS mathematics syllabus involved additional mathematical concepts that only science students needed to learn for studies or future career in the fields of science. While the majority perceived the emphasis on calculation and computation in learning mathematics, a few recognized the importance of mathematical reasoning and argumentation of phenomenon or theorem. One of the students stressed the importance of application in learning and explained his thoughts in detail:

> Learning mathematics is for how much to pay [for buying] and how much to be given change … for knowing [the calculation]. (Researcher: what is the purpose of learning senior secondary mathematics in your opinion?) The purpose is to understand the formulae and their applications in details. (Researcher: what do we learn them [the formulae] for?) Probably for … in the future, if you want to be a scientist, using equations for calculation. (Student 4)

This student demonstrated the pragmatic perspective of learning mathematics and emphasis on calculation of mathematics perceived by other students (N. Y. Wong et al., 2001). From students' pragmatic perspective, mathematics was learned as a tool for referencing in trades, and current and future studies or careers in science-related discourses. Student 6, for instance, said that he learned mathematics for his needs of examinations and study other subjects in school, the subject of Information and Communication Technology (ICT) in particular.

Students' preference of learning mathematics

Despite the varied mathematical abilities indicated by examination results, the participants generally liked the mathematics subject, but three (Students 3, 6 and 10)

manifested indifferent (or slightly negative) attitudes. The reasons for liking mathematics include personal interests in mathematics and mathematics problems having unique answers (though multiple methods of solutions), whereas those listed for disliking mathematics are its impracticality and non-applicability toward other disciplines. Furthermore, in response to researcher's probe about their attitude toward the curriculum, they expressed that they liked mathematics but disliked the mathematics curriculum. Three informants briefly described that they cherished the study of mathematics but did not like the current curriculum:

> In fact, I like mathematics very much, [I rated it] an "8" (like). But … [I rated] the curriculum, a "1" (dislike). (Student 3)

> A "3" (dislike), because there are many topics in mathematics that I really cannot apply, yet I am forced to learn. (Student 6)

> I like mathematics [rated "6"] but do not enjoy studying the current curriculum [rate "1"]. (Student 10)

The students distinguished between liking mathematics and mathematics curriculum. They liked mathematics but did not like the design of mathematics curriculum in HK.

Students' self-efficacy in learning mathematics

Manageability of topics was the participants' major concerns of favorite or disliked topics. Although various topics of mathematics were provided in the curriculum, the participants disliked the topics that they perceived "unmanageable." The participants thought they lacked ability to understand and apply the knowledge of those topics to examinations. For example, half of the participants disliked the topic of "the properties of circles," and found the deduction, properties and theorems involved difficult to understand, memorize and apply. On the other hand, they often liked topics that they could apply to other situations or disciplines (N. Y. Wong et al., 2002). A participant found that mathematics was useful and he used mathematical concepts to appreciate the world (Student 9). Moreover, two (Students 1 and 5) added their concerns of personal interests to the topics:

> (When interviewee is asked about any disliked topic ...) The properties of circles, [because] I think I do not quite understand. [When] calculating [finding] the angles [of a figure], [like

> using the property of] angles in alternate segments, or in the topics of Euclidean [plane] figures, I am often confused by how one step is derived to the next. And, it may involve excessive number of different steps for deduction [that confuse me]. Also, I have encountered some problems that I do not understand how solutions could be derived from the few information provided … Too complicated [for me]. (When interviewee being asked about any liked topic …) A lot, for example, [the topics of] geometric and arithmetic sequences. It may be because [I can see examples in] M1, nCr and Pascal's triangle, and even someone had applied sequences to 3-D figures! I believe I learn this topic well, and I like patterns. (Student 1)
>
> (When interviewee is being asked about any disliked topic …) Trigonometric functions and their graphs … [They are] too abstract to understand … [I cannot] apply those ideas to examinations or related situations … I may have already learned a few ideas, but I cannot apply them. I guess, I have not quite understood nor learned the topic … (When being asked about favorable topics …) [But I like the topic of] variations, because it is more useful and applicable, and easier for understanding. After learning, I know what and how [ideas of the topic] can be used, and I think I can apply [those ideas]. (Student 5)

The term "understand" frequently used by participants indicated their desire to understand mathematical ideas and they admitted the importance of understanding in mathematics (N. Y. Wong et al., 2001), yet they lost confidence and interests in those topics that they found abstract and failed to understand and manage. Also, they might have identified the correlation between the ideas of "understanding the topic" and "application of the topic knowledge to problems in tests and examinations"; in other words, they perceived that if they learned and understood the topic well, they should have applied the ideas and done well in tests of the topic.

In addition, in the mathematics class, students may develop extreme feelings due to their experience of both achievement and failure in varied topics (N. Y. Wong et al., 2003). A student can be highly motivated and enjoy learning a topic, but failed another. The response of Student 4 revealed his ambitious over challenges in mathematics, but within the range of his abilities, in particular, his memory of the ideas:

> I dislike the topic of the properties of circles the most, because there are many properties about angles in alternate segments and sectors … [in order for] finding angles and about π, that need to be remembered. I do not think I learned or remembered them well, nor I can apply them, but a little … I like the topic of statistics and probabilities, because it is

> "brain-running" [challenging] and interesting. I am motivated to learn, though I am unsure if I can solve the problems. (Student 4)

A student stressed that he had succeeded in solving problems and developing mathematical sense but failed in critical thinking and appreciating the subject:

> I have developed the sense about numbers, symbols and measurement but I am not good at thinking critically and creatively and not capable of appreciating the mathematical world. (Student 9)

Students' perceptions on Learning Mathematics

When responding to the learning of mathematics, the participants discussed about the achievement of aims, the resistance of accepting mathematics as the core subject in university admission examination, and ways to improve learning mathematics.

The achievements of aims of NSS mathematics

Regarding the five overall aims of the HK mathematics curriculum (CDC, 2015a), although recent study found lacking empirical support of the hypothesis that rote memorization may help students develop number sense (D. S. Brown & Roy, 2014), the participants in other studies believed repetition, drilling and rote learning might develop students' proficiency of computation and procedures at the initial stage (Chinn, 2017; Lai & Murray, 2015). Yet, in the present study, the participants' responses to the achievement of Aim 1 seemed to vary with their mathematical performance. Higher performing students (Students 1 and 2) tended to agree that the current curriculum could help students develop problem-solving skills. When it comes to the aim of emphasizing the applications in daily life situations, average and lower performing students (Students 3, 4 and 5) questioned such statement, as Student 3 commented:

> Only during the mathematics class, [Aim 1] can be achieved, but it fails elsewhere. For example, I have been cheated by people using simple calculation trick … Like, a doll costed 6 dollars, and two costed 15. I bought two, without noticing the trick until I went home … So, I say, only during the mathematics class, my mathematical ability [to think critically] exists, but it seems I become stupid when it comes to daily life situations without calculators. (Student 3)

Despite varied views on "developing problem-solving skills" in Aim 1, the majority of the participants agreed that, because of examinations, students learned mathematics by drilling and rote, and such learning strategies inhibited the development of creative thinking, conceptualization and inquiry (Lai & Murray, 2015). Student 1 stated:

> I see a problem caused by Education Bureau's plan, namely the HKDSE (Hong Kong Diploma of Secondary Education) examination. The examination has become the focus of senior secondary education. Students are not learning for creativity, conceptualization, or inquiry. Students are learning mathematics for scores [in the examination], no matter top scores or passing scores. Of course, the drilling strategy for examinations may have developed students' problem-solving and deductive reasoning skills … However, in general, [I believe] creativity is one, [if not the only one], of the most needed abilities in the future. (Student 1)

In addition, the participants doubted the emphasis of the HK curriculum on developing students' communication skills in mathematical language. Student 4 did not perceive any connection between mathematics and communication with others. Students 1 and 2 argued that their learning environment was examination-oriented with rote and drilling exercises, and mathematical language was not a learning focus nor could be instructed by teachers. Students 2 and 3 believed that, in order to develop communication skills in mathematical language, it required students' self-directed or interdisciplinary training:

> [Aim 2] might be achieved, but I didn't learn them [the communication skills in mathematical language] in mathematics class only, but also classes of liberal studies and history. They required using mathematics as support. Thus, [the skills mentioned in Aim 2] were not learned only in mathematics but with support of other subjects. However, to be honest, as a non-science student, [I questioned:] were those "in-depth" mathematical ideas [in secondary curriculum] necessary or applicable? For example, in liberal studies, only subtraction is needed for population change; in history, military expenditure and indemnity require basic computation. [I do not see] any need to learn those "in-depth" ideas in the current mathematics class. (Student 3)

In spite of their disagreement of the achievement of developing students' creative and logical thinking and communication with mathematical languages (Aims 1 and 2), the majority of the participants (Students 1, 2, 3, 4, 7, 8, 9 and 10) developed abilities and senses to manipulate numbers and symbols (Aims 3 and 4). They explained that rote memorizing

and repetitive drilling exercise for examinations could help them develop those capacities mentioned in Aims 3 and 4. International test results also indicated HK students' excellent achievements in mathematics in various learning stages (Mullis et al., 2016; OECD, 2018) although students could not develop positive attitudes toward mathematics, as Student 1 described:

> I think they [Aims 3 and 4] were learned quite well … through drilling exercises, [we can develop] these basic capabilities. However, because of examinations, students generally dislike [mathematics]. They may have developed some [senses of numbers and symbols], but soon after focusing on examinations and drilling exercises, they failed to develop those capabilities. However, for students who like mathematics, they could develop such capabilities, but not for those who dislike mathematics. (Student 1)

> Among those five aims, aims 1, 3 and 4 are better achieved while aims 2 and 5 are only slightly achieved. Most probably, I did not pay much attention to aims 2 and 5 but spent most time in doing exercises and seeking higher scores. I did not focus on communication, sense and positive attitude of mathematics. (Student 9)

Regarding the development of students' positive attitudes toward mathematics, all participants complained about the failure of Aim 5. Students 3 and 4 argued: in order to develop students' appreciation of the aesthetics and culture of mathematics, the contents and syllabus should align with applications in daily life. Yet, apart from questioning the needs of knowing and appreciating aesthetics and culture of mathematics, the participants attributed losing confidence in learning mathematics to the accumulation of personal failure and perceived that lack of interest in mathematics and examination-oriented learning environment lowered their attitudes toward mathematics (Students 1, 2, 3, 7, 8, 9 and 10).

Learning mathematics as the requirement of university admission

The NSS curriculum and the HKDSE examination were being implemented in 2009 and 2012 respectively. The NSS and HKDSE reforms aimed to promote positive learning outcomes and attitudes, as well as to reduce the study pressure caused by previous colonial curriculum and examination system (Chao, 2012; Education Bureau, 2008). However, various media reported the reforms did not achieve the goal of developing students' positive attitudes toward mathematics learning. Thus, HK students remained suffering from pains of study pressure and mathematics remained as one of the four hardest subjects (Ng, 2016).

Moreover, the participants complained (Students 6, 8, 9 and 10) that different from the A-level curriculum, the NSS mathematics had become a compulsory subject for university entrance. Students have no other choice but to take mathematics for examination. Students 6 and 10 commented:

> Not all [students] have positive attitudes toward mathematics. Some may "negatively" learn mathematics for examination. Also, I think [such situation] should be improved, because it [mathematics] is compulsory, from Primary 1 to Secondary 6, even in university, it seems. It is quite difficult for all students to develop positive attitudes toward mathematics, as a compulsory subject, because [the mathematical ideas] may not be applied in daily situations. For example, economists may require some related mathematical ideas but not all. (Student 6)

> I hate mathematics. I do not like the pressure and the feeling of helplessness. I keep on doing exercise, as mathematics is the core subject of university admission requirement. (Student 10)

Suggestions for improving mathematics learning

The participants were further asked for suggestions to improve the situations of failed aims. Student 1 preferred an education reform, referring to Western countries, to make some change for the current "passive" and "examination-oriented" education in HK, and wanted more inquiry-based learning activities in mathematics class for "active" learning and discovery the aesthetics of mathematics (Savery, 2006). Student 2 suggested an enhancement of connecting mathematics to applications in daily situations in classroom. Student 3 believed that reduction of "non-practical" topics could alleviate students' fear of mathematics, and they would perceive mathematics "useable." Student 4 complained about study pressure caused by society, school and the public, which lowered students' interest and motivation of learning, and about the "faulty" beliefs: "if one does not study well, achieve well [in the exams], he/she will have a dull future," and "university is a key to well-living." These beliefs narrowed students' horizons and standards of life. Student 6 wanted a systematic education reform that could divide the current mathematics curriculum and contents into "pure mathematics" and "applied topics of mathematics," where the "pure mathematics" should be an elective subject, and the "applied topics of mathematics" be taught individually in related subjects. For example, the concept of logarithm should be taught in related science (Chemistry and Physics) sections.

In sum, noticing that students might have developed negative attitudes toward mathematics compared with their counterparts from other nations, the participants believed that the current "dead-knot" situation of mathematics education might be caused by the deep-rooted examination-oriented culture in HK, which needed an urgent solution. They hoped an enhanced connection between mathematics and its applications would help to cultivate students' positive attitudes toward mathematics.

Discussion

Through the analysis of emerging themes in the interviews, we identified that: (a) the participants did not enjoy the NSS mathematics curriculum although some liked and appreciated learning mathematics; (b) "practicality" and "manageability" were the main factors affecting the participants' feelings toward the topics of mathematics; and (c) the participants complained about the "examination-oriented" culture and they attributed the failure of the aims of the NSS mathematics curriculum to its "impractical" contents and topics. Thus, the following discussion is divided under two subheadings.

Students' Preferences for Practicality and Manageability of Mathematics

While HK students are receiving rote-learning and drilling-oriented education, they prefer "conceptual" learning for better understanding of mathematical ideas (Biggs, 1991). From the responses in this research, the participants tended to like and enjoy the mathematics topics that they could manage and apply their learning to tests and examinations. The frequency that the term "practicality" appeared in the interview also indicated the desire of students to apply their learning to authentic situations, no matter in daily life or in other subjects. Also, students' mathematical abilities may vary in contexts (Nunes et al., 1993). Based on the response of Student 3, the participants may be able to perform relatively well in solving "artificially" applied mathematical tasks in tests, but they "lose" their abilities to associate problems with real-life situations mathematically. Besides, the responses also showed their practical mentality, as Student 4 commented on the public's faulty belief of equating learning to a stepping stone to university and well-living.

In addition, the participants have few chances to experience applications of mathematics in mathematics class (e.g., variation in experience with applied mathematical

tasks and pure mathematics within and between schools in HK is lower than the international average). Teachers generally provide limited information about their mathematical performances (OECD, 2013). All these might have narrowed students' views, and caused their misjudgment of mathematics being "impractical." The interview responses revealed that HK students perceived "practicality" as "direct" applications of mathematical ideas and skills to situations, but they might have missed those "indirect" applications of learned problem-solving and deductive reasoning skills, which were also highlighted in the curriculum. The message that "mathematics education aims to develop students' problem-solving and deductive reasoning skills" was not well-delivered, or simply did not meet students' expectations.

Moreover, the participants expressed their desire to understand the mathematical concepts that were taught in mathematics classes. Studies have shown that teachers also agreed to the importance of learning for "understanding mathematics" (N. Y. Wong, 2007). Yet, the participants in this study perceived that the NSS curriculum that they experienced was examination-driven, abstract, impractical and cultureless, and the mathematics classes were often filled with rote-learning and drilling activities.

In order to deepen students' understanding and gain their awareness of applications of mathematics in authentic situations, scholars have suggested various instructional approaches, such as realistic mathematics education (Van den Heuvel-Panhuizen & Drijvers, 2014) and mathematical modeling (Blum & Ferri, 2009). Currently, HK government has also promoted STEM education in order to gain students' awareness, and strengthen their integrated ability, of interdisciplinary applications of mathematics across the fields of science, technology and engineering (CDC, 2015b). Yet, the participants' responses indicated that students had not received any benefit from these instructional innovations. What are the factors that inhibited students from enjoying learning at school?

Students' Perception of the Effect of Marketization Culture on Their Experiential Curriculum

The participants in this study perceived the NSS mathematics curriculum as examination-driven. The examination-oriented culture has deeply embedded in HK over decades, and greatly affected learning and teaching (Cheng, 1997). It can be proved by the popularity of mass tutoring "franchised" schools and their emphasis on examination-oriented knowledge and skills (Kwok, 2004). Students hire private tutors and/or attend

tutoring schools, and prefer interactions with tutors to teachers at schools (Zhan et al., 2013). In this atmosphere, it is fair to say that learning is treated as a commodity and tutoring schools as a market.

Even worse, the examination-oriented culture may have also influenced teaching content (G. T. L. Brown et al., 2009) and narrowed students' experience of learning by focus on drilling. While the participants expressed their desire for various learning experiences, including activity-based tasks (Students 1 and 2), use of real objects for abstract concepts (Student 3) and use of the history of mathematics (Student 4), teachers were more concerned about students' examination results and developing students' mathematical reasoning skills and skills for solving problems that appear in examinations than the applications of mathematics in daily situations or raising students' appreciation of and interest in mathematics (P. H. Wong, 1996). The examination-oriented culture may have reproduced, if not reinforced, by education over decades.

Furthermore, the "practical" mentality of the participants is another factor that influence students' experience of mathematics education in various aspects. Apart from some mathematics topics that the students perceived "applicable" and "practical," as Student 4 commented, students are surrounded by a society which emphasizes education for university and well-living. On the other hand, under globalization, the development of HK curriculum emphasizes on sharpening student's global competitiveness (CDC, 2015a, 2015b), which seems to dominate and lead the global market (H. M. Chan et al., 2002). Thus, explaining through the concept of neo-progressivism, the school curriculum is in effect influenced by global and local economies (Kennedy, 2013). This echoed with other research findings that marketized education altered the curriculum received and changed views of students and expectations of their teachers (C. Chan & Bray, 2014). This phenomenon is even more obvious in higher education, which is expected to satisfy the needs of societal competition (S. Y. Y. Wong, 2006). From these points of view, the HK education may have shifted its focus from the students to the market.

Finally, students' expectation of education has then been "downplayed" by the market, and the market may affect the culture (Lynch, 2006), curriculum (Yin & White, 1994), and examination, shedding light on students' attitudes toward mathematics learning. In order to "survive" in HK, many students thought they had no other choice but study for examination and competitiveness (for the requirements of the market). So, the examination pressure has been perceived as "pressure for survival" by students (Kember & Watkins, 2010).

Conclusion

In this study, we examined 10 HK S6 students' perceptions of learning mathematics (experiential curriculum) and their perceived factors that inhibited the aims of the NSS mathematics curriculum by content analysis of their responses in the interviews. The participants in this study expected to learn mathematics by "conceptual learning" (compared with "rote learning", see Biggs, 1991) and understanding the authentic applications of mathematics. They experienced rote-and-drilling-dominated learning approaches in mathematics education, however. These approaches had succeeded in cultivating students' numerical senses and problem-solving skills, but failed to develop their sense of creativity and positive attitudes toward mathematics. The practical mentality and the examination-oriented culture in HK were the perceived factors that caused such failure.

The responses in the interviews also revealed that the participants had suffered from examination pressure, and struggled for surviving in the market-dominated education of HK. The "market" has become the center of education, not the students or the teachers, while examinations determined the learning outcomes of students. According to the participants' comments, the pressure triggered by examinations is so tremendous that it narrows their views to "model" answers and to solving "standard" problems that they encounter in examinations, failing to apply what they have learned to other disciplines and authentic situations. While scholars advocate student-centered learning approaches, the curriculum design has to cope with students' expectation and needs. To address students' expectation on applying mathematical knowledge to daily lives, teachers' knowledge in application of mathematics and use of mathematics history should be enhanced. Also, examination questions should be converted into more applicable to daily situations so as to create more links and strengthen associations between knowledge and real-life situations, for example, realistic mathematics education (Van den Heuvel-Panhuizen & Drijvers, 2014). All curriculum policymakers should be alerted that the ideal aims of a curriculum may be distorted, if the communication process in implementation of that curriculum is not properly handled.

Finally, it has to be pointed out that due to the small size of sample population ($N = 10$), it is not intended to generalize the findings in this study. However, it is believed that the descriptive data collected are the true "voices" of the participants about the current NSS mathematics curriculum, and the findings in this study may shed light on teacher practice of instruction and curriculum evaluation by researchers and policymakers, in particular the case of HK, in the future.

Notes

1. In HK, there are six years of schooling at primary level and six years in secondary level. Secondary 1 is similar to Grade 7 in Western education system.
2. In HK, students are often classified into three bands with respect to their academic performances: Band 1 is viewed as the "elite" and Band 3 lower achievers. Most students in school B are ranked as Band 1, while most students in school A are Band 3. Both mathematics teachers being invited in these two schools are caring the attitudes and academic performance. They are willing to participate in this research.

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高中學生眼中的香港中學數學課程

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摘 要

香港學生於不同的國際數學評測中都表現優越，但他們對學習數學並未展現出相應的態度。本研究探討 10 名香港中六學生對學習數學的看法。研究員對學生的訪問回應進行了內容分析，從中了解阻礙學生發展出對學習高中數學課程的良好態度的因素。學生雖然期望能透過概念學習和應用數學於日常環境來學習數學，但他們總是經歷死記硬背及不斷操練的方式來學習。此方式或許能有效發展學生的數感和解難能力，但未能幫助他們建立創意和良好的數學態度。務實心態和應試文化是學生最重視的因素。

關鍵詞：應試文化；教育市場化；學生數學態度

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