How might values in mathematics learning affect the development of beliefs: An exploratory study with Chinese elementary students

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Abstract
258 Grade 3 students in a suburban primary school located in Chengdu, China responded to an open-ended questionnaire item regarding their beliefs about mathematics. The traditional beliefs attracted the most number of students, followed by integral, feeling good, and constructivist beliefs. Since the questionnaire also identified the students’ values in relation to positive mathematical well-being, it was additionally found that students who valued engagement highly were more likely to hold constructivist beliefs and less likely to hold traditional beliefs, compared to peers who did not value engagement as highly. Also, students who valued perseverance highly were more likely to hold integral beliefs.

Keywords
primary mathematics education, engagement, perseverance, wellbeing

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1. Introduction
In OECD’s latest conception of school education learning framework, the OECD Learning Compass 2030 (OECD, 2019b), collective well-being is a shared destination and objective. The global disruptions to schooling due to the COVID19 pandemic, with the associated introduction of remote education, have only highlighted the importance of wellbeing in ensuring that students, teachers and principals continue to thrive and to function well in learning and teaching. This is no less important in mathematics pedagogy, in which the notion of mathematical wellbeing [MWB] – a measure of

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students “feeling good and functioning well” (Huppert & So, 2013, p. 839) – is an expression of the extent to which phenomena such as mathematics anxiety, lack of efficacy, and disengagement are threatening the quality of mathematics learning.

Tiberius’ (2018) values-fulfillment theory of wellbeing established an important link between wellbeing and values, in that “well-being is served by the successful pursuit of a relatively stable set of values that are emotionally, motivationally, and cognitively suited to the person” (p. 13). Our preliminary research work in Chengdu, China in 2021 revealed that amongst Year 3 students, positive MWB is associated with the valuing of relationship, engagement, bliss, accomplishment, perseverance, meaningfulness, and learning (Pan et al., in press).

While values express what are important (or not) to individuals, they are also related to beliefs (e.g. Clarkson et al., 2010; Hannula, 2012; Ponizovskiy et al., 2019; Stern et al., 1999) which express what individuals consider to be correct or incorrect. These constructs will be teased out separately in the Literature Review section below. Thus, one may value practice in mathematics learning, with the belief that practice makes perfect. As such, we have also been interested to explore how the values associated with MWB might be related to student beliefs about mathematics. In particular, we focus in this paper on the two most valued attributes of engagement and perseverance amongst the Chinese students. This knowledge will have implications for how the development of these two values can be more effectively monitored through observing the beliefs which the students hold, since valuing can be implicit and difficult to assess, whereas beliefs can be more visible and observable. Moreover, values are subjective and may not be as easy to be taught in some cultures, unlike beliefs which are statements of truth and which are thus easier to be explained and/or defended.

In this context, this paper reports our findings in response to the following research questions:

1. What belief categories do Grade 3 students in Chengdu, China hold about mathematics?
2. How are these belief categories related to the students’ valuing of engagement and perseverance, which are associated with positive MWB?

We begin with a review of prior research that had informed our understanding of values and beliefs. The paper will then outline the methodology that was used to collect and analyse the data for this research. The analysed data will be reported, which then leads to a discussion of our interpretation and sense-making of what these might mean for responding to the research questions posed.

2. Literature review

This section outlines what is known about values and beliefs in mathematics education. These two constructs have been investigated by many researchers across different cultures, and thus it is not the intention here to provide a detailed review. For these, the reader may like to refer to such extensive reviews as Bishop et al. (2003), Goldin et al. (2016) and Seah (2019). Rather, current research literature will be selected to help us understand how values and beliefs are similar to and different from each other, and what is currently known about the interdependence that accompanies the development of any of them.

2.1 Values

Values are expressions of what are important to a culture, society, institution or individual. They are conative variables which are motivational in nature (Boer & Fischer, 2013; Seah, 2019). Our values, shaped by different contexts in our respective life experiences, identify for us what are important and worth pursuing, and provide the driving force and motivation to try to attain whatever are being valued. Due to the potential for place-based differences, values might be classified as being personal, social, societal or human “to acknowledge local differences” (OECD, 2019a, p. 4).
Since values, once acquired, are very much internalized within each person, interactions between people (whether personally or via institutions/policies) invariably convey what each person values. As such, the different aspects of school curriculum – intended, implemented, and attained – are never value-free.

Even if a formal, intended curriculum may not articulate explicitly the teaching of attitudes and values, attitudes and values may still inform and govern the experiences in schools, including how expectations about desirable behaviour are communicated; how conflict and consensus-making between and amongst young people and adults in schools are managed; how student voice and choice matter or do not matter in schools; and how young people experience and act in their school cultures and learning environments. (OECD, 2019a, p. 7)

In the context of mathematics education,

valuing is defined as an individual’s embracing of convictions in mathematics pedagogy which are of importance and worth personally. It shapes the individual’s willpower to embody the convictions in the choice of actions, contributing to the individual’s thriveability in ethical mathematics pedagogy. In the process, the conative variable also regulates the individual’s activation of cognitive skills and affective dispositions in complementary ways. (Seah, 2019, p. 107)

Students’ achievement in mathematics learning has been associated with what they value with regards to mathematics and its pedagogy. Eccles et al.’s (1983) application of the Expectancy–Value Theory to education, for example, considers student achievement as being determined primarily by two factors, namely, students’ expectancies for success, and the subjective task values they possess. Here, subjective task values refer to the extent to which a task (such as learning mathematics) is important. Weidinger et al. (2020) examined the three components of task values in mathematics education with German secondary school students, and found that all three components, that is, “intrinsic, attainment and utility values have incremental value to explain differences in math grades above each other and other important achievement predictors” (p. 420). New Zealand Ministry of Education (n.d.) found that “students had higher mathematics achievement, on average, if they were confident in their mathematics ability, liked mathematics, or valued mathematics” (p. 14).

Abin et al.’s (2020) study in Spain examined the roles of cognitive, emotional and motivational variables in predicting secondary school students’ performance in mathematics. Unfortunately, values was not any of the four motivational variables chosen (i.e. perceived utility, perceived competence, intrinsic and success motivation, and causal attributions), so it was an opportunity lost to investigate the predictive power of values compared to these motivational and other variables.

Given the increase in interest in students’ wellbeing in school education, not least due to the COVID-19 pandemic, the close links between values and (mathematical) wellbeing (e.g. Tiberius, 2018) have been investigated in Australia, led by Julia Hill (Hill et al., 2021), and more recently in China (Pan et al., in press), further highlighting the significance of values and valuing in helping students learn mathematics more effectively and positively. Yet, we have not fully developed efficient means of inculcating specific values amongst students. Explicit teaching may not be effective, whereas implicit teaching may take a while before we can see the results. Assessing values and valuing can also be challenging, since any action or behaviour observed cannot confirm the presence of any particular value. Given that positive mathematical wellbeing is derived from values that are fulfilled, then what seems to be relatively easy would be the facilitation of opportunities for students to successfully experience the relevant valuing. Indeed, even though values might be an internalised and relatively stable conative
variable, the difficulties with teaching/developing and assessing them have been barriers to more extensive harnessing of values in (mathematics) teaching.

One approach to addressing these barriers would be to consider constructs which are closely related to values, so that interventions involving the manipulation of these constructs might stimulate desired changes to and/or assessment of the related values. Here we have been reminded of the many associations that have been made between the constructs of values and beliefs (e.g. Clarkson et al., 2000; Hannula, 2012; Ponizovskiy et al., 2019; Stern et al., 1999). The value-belief-norm (VBN) theory of Stern et al. (1999) sees values as impacting on beliefs. Clarkson et al. (2000) referred to values as beliefs in action. More recently, Hannula’s (2012) conception of the dimensions of affect conceived the relationship between beliefs and values as one of coemergence, which also emphasises the close relationship between them. Yet, none of these were empirically-based. As such, it might be useful to understand this relationship a bit more with data, to explore means of supporting the teaching/inculcation and fulfilment of values to students.

2.2 Beliefs

Whereas values express what are important, beliefs are commonly associated with what are correct or right (versus wrong). A belief “makes an assertion about some matter of fact or some principle or law” (Dewey, 1933, p. 6). For Richardson (1996), beliefs in teaching and elsewhere are “psychologically held understandings, premises, or propositions about the world that are felt to be true” (p. 103). In mathematics education, Beswick (2007) defined beliefs as “anything that an individual regards as true” (p. 96). While this perspective of beliefs as referring to correct/incorrect might be prevalent, other definitions also exist. A recent example in mathematics education research is a generic view of beliefs as “an individual’s understandings that shape the ways that the individual conceptualizes and engages in mathematical behaviour generating and appearing as thoughts in mind” (Sumpter, 2013, p. 1118). These assessments of what are correct/incorrect or right/wrong are often made in context, and as such, beliefs are often expressed in the form of statements. Examples include ‘encouraging students to produce multiple solution approaches to the same answer cultivates creativity’, and ‘teachers can intentionally structure their questions with the aim of cultivating student creativity’. This then is another difference between values and beliefs: being transcendental, values are often expressed in the form of single words (e.g. creativity, practice, and relationships) instead.

The value-belief-norm (VBN) theory of environmentalism (Stern et al., 1999) has received empirical support across different cultures over the years (e.g. Hiratsuka et al., 2018). According to this theory (and the data which support it), values influence behaviour (such as norms) either directly or indirectly. The latter happens when values affect relevant beliefs and worldviews, which in turn govern norms, actions and behaviour. This again reflects the deeply internalised nature of values within individuals, a main reason why it deserves to be understood and made use of more in school (mathematics) education.

Prior research of students’ beliefs often resulted in seemingly unrelated lists of individual beliefs. Markovits and Forgasz’s (2017) work with Israeli grades 4 and 6 students found that “more than a quarter of the students (26%) conceived of the need to be smart or wise to work and succeed at mathematics” (p. 57), “conceptions of mathematics – difficulty and elegance – and related expectations of how the subject is taught or learnt – speed, effort/diligence, and persistence – were expressed by 10% of the students” (p. 58), “10% of students … [related] to the importance of mathematics to humanity, and the need and the capability of humans to learn mathematics” (p. 58), and “a small group of students (6%)… [believed] that there is possibly some innate human capability for mathematics” (p. 59). On the other hand, House’s (2006) large-scale study of Japanese and United States students’ beliefs with regards to mathematics achievement focused on attribution of success.
Given the huge possibilities of individual belief statements, it is usually more useful to consider belief categories instead. So, for example, while beliefs in mathematics education may be about the nature of the discipline, mathematics teaching, and mathematics learning (Beswick, 2012), there are infinite possible beliefs in each of these three considerations. After all, there are infinitely many ways to consider mathematics and its pedagogy, and each of these can be associated with a belief. Take for example, if we consider the phenomenon of private tuitions, there are related beliefs such as ‘private tuitions is a waste of parents’ money’, ‘private tuitions represent money well-spent’, ‘it is not clear how much money parents in country X contribute to private tuitions annually’, etc. The thing is, across a population, different individuals possess their own belief(s) about private tuitions, and while some of these may be the same across multiple people, the possibilities are endless.

Thus, turning our focus to belief categories, these categories and sub-categories potentially allow us to develop organised perceptions of mathematics, mathematics teaching and mathematics learning. Beliefs about the nature of mathematics, for example, can be sub-categorised as being instrumentalist, Platonist, and problem-solving. More recently, Belbase (2019) proposed the alternative belief sub-categories about the nature of mathematics, namely traditional, constructivist and integral:

The traditional belief about mathematics considers that it is an objective and absolute knowledge that is independent of human experience and cognition…. Another belief related to constructivism contemplates mathematics as a corrigible, changeable, and challengeable body of knowledge through human (individual or social) construction…. The integral beliefs about mathematics … observe teacher beliefs as an interrelated construct of different beliefs which cannot be strictly isolated as this or that kind. It is more related to cultural-historical-political agenda of mathematics. (Belbase, 2019, p. 7)

This is similar to Nisbet and Warren’s (2000) findings about teachers’ beliefs reflecting either a static view of mathematics or a mechanistic view. Belbase’s (2019) categorisation has thus been adopted in the current study, given that the relatively limited belief research with primary school aged students has only identified individual beliefs, and also given that the categories provide a useful range of ideas about what mathematics is relative to self.

The dearth of empirical studies investigating the relationship between values and beliefs in mathematics education – and in particular, how values impact on the beliefs that are developed – thus represents a research gap which motivated the design and conduct of this current research study. As discussed above, addressing this research gap will allow us to make use of our knowledge of beliefs to support the development and assessment of values, which in turn facilitates ongoing work on improving mathematics teaching and learning, an example of which is related to the key roles played by values in promoting students’ mathematical wellbeing.

3. Methodology

3.1 Data Sources

Data for this exploratory study were collected in Chengdu, the capital city of Sichuan province, southwestern China. With an urban population size that is in excess of 9 million, Chengdu is one of the 8 largest cities in China.

As an exploratory study, only one school was chosen as data source. The volunteer school is a popular mid-size government school located in suburban Chengdu serving the local community.
Data were collected from a convenience sample of 258 Grade 3 students from six different classes taught by three mathematics teachers from the school.

3.2 Data collection

Data were collected via a two-page anonymous student survey which was completed during class time in 2021. On the front page, student respondents selected learning moments which they associated with the times when they were feeling good and functioning well in mathematics lessons. The values underlying these learning moments were teased out by the research team, with engagement and perseverance representing the most valued, followed by relationship, accomplishment, meaningfulness, bliss, and learning (Panet al., in press).

The focus of this paper is on the students’ beliefs, and how they might relate (or not) to what they valued. These information was collected in page 2 of the questionnaire through the following item:

2. In your opinion, what do you think is mathematics?

Thus, students provided qualitative, open-ended textual responses to this item, which were expected to reveal the beliefs about mathematics that were held by the Grade 3 students. The belief here is that this is a question to which every child can write/say something about, and that it would be possible to classify these thoughts into Belbase’s (2019) categories of traditional, constructivist and integral beliefs. We were not concerned with the possibility that most student beliefs might fall into any one particular category; if that were to happen, it would still reflect what Grade 3 students’ beliefs about mathematics were, and the findings would be equally meaningful and valued.

The students filled in the questionnaire during their mathematics lessons. The third author administered the questionnaire to all the six classes personally, stayed in the relevant classrooms so that she could address students’ queries on-the-spot, and collected the questionnaire responses after the students had finished them.

3.3 Data analysis

After the questionnaires were collected, student data were recorded digitally on a Microsoft Excel spreadsheet. Since Item 2 is open-ended, there was an infinite possibility of what a textual response representing beliefs might look like. To condense and categorize the data collected for Item 2, an additional column was created in the spreadsheet to allow for the classification of the student responses. We were guided by Belbase’s (2019) three categories of beliefs about mathematics (i.e. traditional, constructivist, integral). We visualize the three types of beliefs portraying the mathematics discipline as being increasingly less absolute as a body of knowledge, and being increasingly shaped by people as we move from traditional through constructivist to integral beliefs.

In coding the beliefs, the numeral ‘99’ has been used to represent student responses which refer to beliefs which are not about mathematics (e.g., beliefs about mathematics learning or teaching), irrelevant responses such as ‘I do not know’, or no-response.

4. Results

4.1 Categories of student beliefs about mathematics

The student participants responded to the open-ended item in the questionnaire: ‘In your opinion, what do you think is mathematics?’. These qualitative responses were entered into the data spreadsheet, and the first two named researchers read then categorised the student responses into one of three belief categories about the mathematics discipline (i.e. traditional, constructivist, integral),
The purpose of the in-person discussion was to clarify the few instances when there was disagreement in categorisation, and the instances when students’ responses did not appear to be meaningful or relevant (e.g. ‘I have forgotten’), or that they could not be categorised into one of the three labels (i.e. traditional, constructivist, integral).

To this end, for the latter, it was noticed that there were quite a number of belief responses which associated mathematics with affective qualities, such as ‘mathematics is interesting’ and ‘mathematics is like a happiness heaven’. While these beliefs could not be classified as one of Belbase’s (2019) three categories, they still respond to the stimulus question (i.e. ‘what do you think is mathematics?’) and equally importantly, they also represent a form of relationship between mathematics and self. So, if the constructivist family of beliefs reflects a person’s interpretation and construction of mathematical knowledge, then this group of beliefs here would be reflecting the person’s (positive) emotional interaction with regards to this knowledge. In this context, a fourth belief category is being proposed here, which we call ‘feeling good’ to emphasise the positive slant to the affective beliefs.

67 students had provided responses which were irrelevant, meaningless, or illegible, and an additional 8 did not provide any response to this questionnaire item. Thus, 75 questionnaires could not be used for this item, leaving a remainder of 183 responses to be analysed.

As shown in Figure 1, amongst these 183 students, about a third each held the traditional and integral beliefs, with the last third holding either the constructivist or feeling good beliefs. Specifically, 68 of the 183 eligible respondents (i.e. 37.16%) held traditional beliefs of mathematics as a discipline ‘out there’ waiting to be discovered, understood, and learnt/mastered. Mathematics is a fixed entity which does not evolve or change over time or as a result of interacting with human civilisations. Student responses corresponding to this belief category include ‘mathematics is computation’, ‘mathematics is numbers’, and ‘mathematics is plus, minus, multiply, divide’. On the other hand, nearly as many students (59, or 32.24%) had beliefs which are considered as integral, in that their beliefs about mathematics were integrative of different perspectives, recognising the sociocultural basis of

![Figure 1. Distribution of students’ beliefs regarding mathematics.](image-url)
mathematical knowledge and structure. Student responses corresponding to this category included ‘mathematics is about applying mathematical knowledge to life’ and ‘mathematics is something very useful which was invented by human beings’.

The constructivist and feeling good beliefs reflect a focus on how mathematics is constructed by students cognitively and experienced affectively respectively. In the Chengdu student sample, 21.5 (i.e. 11.75%) students held constructivist beliefs while 34.5 (i.e. 18.85%) of their peers held feeling good beliefs. The numbers of students holding these beliefs are not whole numbers since three students had beliefs which combined both cognitive and affective components, so each of them was regarded as having half constructivist and half feeling good beliefs.

A chi-square goodness of fit test was used to determine whether the four belief categories (i.e. traditional, constructivist, feeling good, integral) were equally embraced by the 183 students. Preference for particular belief categories was not equally distributed, \( \chi^2 (3, N = 183) = 30.28, p < .001 \). In other words, the Chengdu students’ beliefs about mathematics were predominantly of the traditional and integral categories, while only 11.75% of these students held beliefs which reflect constructivist notions.

### 4.2 Belief categories amongst students with high or low mean valuing scores

The extent to which each student valued the seven value dimensions associated with positive MWB was quantified. Since each student indicated if a particular lesson moment was not important, important, and very important to them, a score of 0, 1 and 2 points could be allocated for each student for each value. A mean valuing score ranging from 0 to 2 (inclusive) was computed for each student, representing the extent to which they valued the seven value dimensions of engagement, perseverance, relationship, accomplishment, meaningfulness, bliss, and learning.

For the 258 students, the mean valuing score ranged from 0 (n = 1) to 1.92 (n = 1). Those with mean valuing scores greater than 1.5 (n = 90) was regarded as the group of students possessing high mean valuing of the seven value dimensions, whereas those with mean valuing scores less than 1 (n = 44) made up the group with low mean valuing.

A z-test for proportions was conducted comparing the proportion of students with high mean valuing scores holding traditional beliefs (0.14) to that of students with low mean valuing scores (0.23). The result was not statistically significant (z = -1.19, p = .23, two-tailed). Thus, there was no difference in the proportion of students holding traditional beliefs, whether they valued the seven value dimensions highly, or lowly.

A z-test for proportions was conducted comparing the proportion of students with high mean valuing scores holding constructivist beliefs (0.11) to that of students with low mean valuing scores (0.07). The result was not statistically significant (z = 0.79, p = .43, two-tailed). Thus, there was no difference in the proportion of students holding constructivist beliefs, whether they valued the seven value dimensions highly, or lowly.

A z-test for proportions was conducted comparing the proportion of students with high mean valuing scores holding feeling good beliefs (0.16) to that of students with low mean valuing scores (0.16). The result was not statistically significant (z = -0.05, p = .96, two-tailed). Thus, there was no difference in the proportion of students holding feeling good beliefs, whether they valued the seven value dimensions highly, or lowly.

Another z-test for proportions was conducted comparing the proportion of students with high mean valuing scores holding integral beliefs (0.3) to that of students with low mean valuing scores (0.16). The result was not statistically significant (z = 1.76, p = .08, two-tailed). Thus, there was no difference in the proportion of students holding integral beliefs, whether they valued the seven value dimensions highly, or lowly.
4.3 Belief categories amongst students with high or low valuing of engagement

Given that the 258 students valued engagement and perseverance the most (Pan et al., in press), we were interested to find out if those students who valued any or both of these two value dimensions might hold particular beliefs about mathematics. Specifically, for those students who valued engagement the most (i.e. 2 points) (n = 57), what sort(s) of beliefs would they be inclined to hold? As a comparison, we were also interested to find out what beliefs were held by students who did not value engagement (as much). Given that only two students claimed that they did not value it (i.e. 0 point), we expanded the criteria to students with scores of 1 point or below in relation to valuing engagement. This resulted in 34 students.

A z-test for proportions was conducted comparing the proportion of students valuing engagement highly holding traditional beliefs (0.18) to that of students who did not value engagement much (0.38). The result was statistically significant (z = −2.20, p = .03, two-tailed). In other words, the students who valued engagement highly were less likely to hold traditional beliefs about mathematics, compared to their peers who valued engagement less.

Another z-test for proportions was conducted comparing the proportion of students valuing engagement highly holding constructivist beliefs (0.16) to that of students who did not value engagement much (0.00). The result was statistically significant (z = 2.44, p = .01, two-tailed). In other words, the students who valued engagement highly were more likely to hold constructivist beliefs about mathematics, compared to their peers who valued engagement less.

A z-test for proportions was conducted comparing the proportion of students valuing engagement highly holding feeling good beliefs (0.16) to that of students who did not value engagement much (0.09). The result was not statistically significant (z = 0.95, p = .34, two-tailed). In other words, the students who valued engagement highly and those who valued it lowly were equally likely to hold feeling good beliefs about mathematics.

A z-test for proportions was conducted comparing the proportion of students valuing engagement highly holding integral beliefs (0.25) to that of students who did not value engagement much (0.18). The result was not statistically significant (z = 0.77, p = .44, two-tailed). In other words, the students who valued engagement highly and those who valued it lowly were equally likely to hold integral beliefs about mathematics.

4.4 Belief categories amongst students with high or low valuing of perseverance

The same criteria were applied to identify students who valued perseverance highly (2 points) and those who were considered to be valuing perseverance lowly (0–1 point, inclusive). This resulted in the former group having 143 students, and the latter group made up of 63 students.

A z-test for proportions was conducted comparing the proportion of students valuing perseverance highly holding traditional beliefs (0.22) to that of students who did not value perseverance much (0.30). The result was not statistically significant (z = −1.19, p = .23, two-tailed). In other words, the students who valued perseverance highly and their peers who valued it lowly were equally likely to hold traditional beliefs about mathematics.

A z-test for proportions was conducted comparing the proportion of students valuing perseverance highly holding constructivist beliefs (0.10) to that of students who did not value perseverance much (0.08). The result was not statistically significant (z = .57, p = .57, two-tailed). In other words, the students who valued perseverance highly and their peers who valued it lowly were equally likely to hold constructivist beliefs about mathematics.

A z-test for proportions was conducted comparing the proportion of students valuing perseverance highly holding feeling good beliefs (0.14) to that of students who did not value perseverance much (0.13). The result was not statistically significant (z = 0.25, p = .80, two-tailed). In other words,
the students who valued perseverance highly and their peers who valued it lowly were equally likely to hold feeling good beliefs about mathematics.

A z-test for proportions was conducted comparing the proportion of students valuing perseverance highly holding integral beliefs (0.29) to that of students who did not value perseverance much (0.11). The result was statistically significant ($z = 2.75$, $p = .01$, two-tailed). In other words, the students who valued perseverance highly were more likely to hold integral beliefs about mathematics when compared to their peers who valued it lowly.

5. Discussion

The beliefs about mathematics that were held by Year 3 students in Chengdu, China could be categorized across all the three categories proposed by Belbase (2019) – that is, traditional constructivist, and integral – plus an additional one suggested by our data, which is named ‘feeling good’. 37.16% of the eligible responses held traditional beliefs, followed by 32.24% holding integral beliefs. 18.85% of the eligible responses belong to the feeling good beliefs, while only 11.75% held constructivist beliefs. This knowledge provides an affective perspective to deepening our understanding of Chinese students’ performance in school mathematics, one which we will seek to confirm in relevant follow-up studies. After all, a full understanding of Chinese students’ mathematics performance can only be achieved when we consider not just the cognitive aspects of (mathematics) pedagogy, but the affective and conative aspects as well (Seah, 2019). Beliefs as an affective variable assumes a greater significance too given that they are susceptible to sociocultural influences, not least from the values that characterize the communities and cultures within which the beliefs are inculcated.

Even though preference in our Chengdu sample for particular belief categories was not equally distributed, the 37.16% of students holding traditional beliefs of mathematics and who made up the largest belief group should be considered in the context that all the rest of the belief categories perceive mathematics as a cultural product with which learners interact. Although the young age of the students mean that their beliefs may still evolve as they mature, it does indicate that at least in the foundational childhood years, Chinese students were more likely to hold constructivist, feeling good, or integral beliefs with regards to what they think mathematics is.

Of course, there is always the concern that the relatively young age of the students means that they might not yet developed the full capacity to be aware of what they believed in, nor to be able to express these beliefs in words. The research design had attempted to stimulate students’ awareness and expression by posing the question in an open-ended and generic manner. Nevertheless, it is useful to keep this limitation in mind as the results are understood and interpreted.

In fact, our results above contrast with Jin et al. (2008), whose surveying of Chinese middle school students revealed that they held traditional beliefs about mathematics, while their teachers’ beliefs were more constructivist or integral in nature. In the apparent absence of other empirically derived information about Chinese students’ (specific) beliefs about mathematics, the research team’s sense-making of this difference – based on our collective experience of the Chinese primary mathematics classrooms – is that beliefs are relatively easy to teach and mould with students, especially when they are young and more impressionable. By drawing our data from just one school, our study has probably demonstrated how the school’s relatively progressive worldviews regarding mathematics might have instilled in the Grade 3 students constructive, feeling good and integral beliefs about the mathematics discipline. The school’s teaching staff is also generally open to new ideas about knowledge and its pedagogy, and is likely to have contributed to how the students’ beliefs turned out. Of course, these students’ beliefs would have also been shaped and influenced by their parents and other significant adults, and even by their peers in their friendship groups. Perhaps this is why the students’ beliefs can differ from their teachers’ when they are older, such as in their teenage years, as reported in Jin et al. (2008).
Nevertheless, the discussion above supports the assumption with which we designed this research study, which is that the nature of beliefs implies that they might be easier to inculcate and teach, compared to the inculcation of values. Indeed, as suggested by the findings of An et al.’s (2008) research with a group of Grade 6 Chinese students, the young students’ beliefs about mathematics can improve (change) just after two sessions! This underlies the powerful influence of how teaching activities are planned for, as is the case in An et al.’s (2008) research. Indirectly, too, this demonstrates the power of values in motivating the introduction into the mathematics lessons of novel teaching approaches, and thus, how values influence the formation of beliefs. Our next-stage research with students in the upper grades of the school would help us deepen our understanding of these relationships.

So, turning our attention now to values influencing beliefs, students who valued engagement highly were observed to be more likely than those who did not value it highly to hold constructivist beliefs about mathematics. As we saw above, such beliefs regard mathematics learning as involving active meaning-construction by students. Mathematics is not an objective, absolute body of knowledge waiting to be understood and learnt. Students holding constructivist beliefs would thus tend to be committed to personal active engagement with mathematics learning. As such, students valuing engagement highly were more likely to hold constructivist beliefs. Perhaps, too, this is also why these students were also observed to be less likely than their peers who did not value engagement much to hold traditional beliefs about mathematics (such as the belief that mathematics is an objective, absolute body of facts and truths).

Amongst the four categories of beliefs about mathematics, the integral category of beliefs might be considered to be the most complex. Learning mathematics with the recognition that it shapes and is shaped by the world around it, and that human cognition and affect further mediate our understanding and learning of mathematical knowledge and skills, reflect the essential features of integral beliefs about mathematics. Holding these beliefs imply a willingness and commitment to keep trying to understand what mathematics is with all the subjectivities around it. Such beliefs include those relating to the application of mathematical knowledge and skills to solving daily life problems, or problems which are found in our lives. Thus, it is fair to argue that for a student to cultivate these integral beliefs about mathematics, there needs to be the embracing and valuing of perseverance. As such, students who embraced perseverance have been observed to more likely hold integral beliefs about the mathematics discipline.

What our data are telling us, we propose, is that there is no evidence that values do not affect the development of beliefs. In fact, this study has also found that different values (e.g. engagement and perseverance) subscribed to by any student – and any individual for that matter – stimulate the formation of different types of beliefs. While a valuing of engagement is likely to stimulate constructivist beliefs which reflect the importance of engaging in mathematics learning, any student who also values perseverance might hold beliefs relating to this value which are integral in nature.

6. Conclusion

The design and conduct of this study have been governed by the following two research questions:

1. What belief categories do Grade 3 students in Chengdu, China hold about mathematics?
2. How are these belief categories related to the students’ valuing of engagement and perseverance, which are associated with positive MWB?

Our analyzed data suggested that all four belief categories were observed, with the traditional beliefs being the most popular, followed by the integral, feeling good, and constructivist beliefs. However, it should also be noted that if we are to consider traditional beliefs against the other three beliefs which
acknowledge/emphasize the subjectivity of mathematical knowledge, then this category of beliefs (at 37.16%) was not held by the majority of the students surveyed.

As our data indicate, the full range of belief categories relating to the nature of mathematics was documented across the students. This is probably due to the fact that students subscribe to different values, and these values stimulate the development of different beliefs belonging to the range of belief categories. Thus, as the analyzed data showed, students who valued engagement were more likely to hold related beliefs about mathematics which were constructivist in nature, and less likely to hold traditional beliefs, when compared to their peers who did not value engagement as much. On the other hand, those who embraced perseverance strongly were found to hold related beliefs about mathematics that were integral in nature, compared to their peers who did not value perseverance as much.

We began this paper with a reference to the promotion of (students’) mathematical wellbeing through the fulfilment of seven values, namely, engagement, perseverance, relationship, accomplishment, meaningfulness, bliss, and learning. We were interested in investigating how these values might be best developed and their development, assessed. Our analyzed data suggest that with multiple values involved, different value categories would be stimulated such that holding integral beliefs about mathematics and its pedagogy might be the best indicator that different values are being embraced and fulfilled, since this belief category acknowledges the most open perspective, integrating the traditional, constructivist and feeling good beliefs at the same time.

The discussion thus far has been guided by current theories (e.g. the VBN Theory) which adopt the view that our values, being such an internalized part of who we are, influence the beliefs we learn to hold. Thus, in our analysis here, the beliefs of students who valued engagement and perseverance were compared with the beliefs held by their peers who did not value similar attributes as much, so that we can examine how particular values might influence the formation of beliefs. Yet, theoretically, one might argue that beliefs can also affect the embracing of the values which cultivate them, or more significantly, of other values. The acknowledgement of what is considered true or factual by a belief should also contribute to the extent that associated values are internalised. For example, a valuing of efficiency might lead to a high school student holding the belief (rightfully or otherwise) that ‘all mathematics workings should be able to be laid out within one page’, and in turn, this belief might strengthen the student’s valuing of (mathematical) lexicon and/or of neatness. Here we are reminded of the reciprocal relationship that has been found to exist between beliefs, self-efficacy and students’ mathematics achievement (Williams & Williams, 2010). If indeed beliefs also influence the internalisation of particular values, it would open the doors to researching how values can be better developed and monitored. This possibility is being tested during the next phase of the study, involving interviews with students to better understand the interaction between what they value and what they believe.

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