

Analysis of “Trap Questions” in Chinese Primary Mathematics Education

Meiyu Lu^{1, a}

¹Faculty of Education, The University of Hong Kong, China

^aEmail address: u3584625@connect.hku.hk

Abstract: As a critical component of China’s school education, math is a heavy-weight subject in decisive nation-level examinations. To improve students’ performance in those high-stakes tests, various strategies have been adopted in the realm of mathematics when young learners embark on their primary education. Amid those practical methods for enhancing students’ math scores, a type of test item - “trap question” is designed to hone students’ sensitivity and ability to address easily-confused mathematical issues, which may involve traps on the conceptual, cognitive and lexical level. Drawing on these three dimensions for designing trap questions, three types of trap questions are often adopted in China’s primary education, including conceptual, cognitive and reading traps. This article focuses on, among others, the adoption of trap questions in China’s primary mathematics education, gleaning a comprehensive analysis of the Chinese stylized pedagogical tool for math subject. Invoking a philosophical account of constructivism, this analysis suggests that trap questions can be harnessed to shape students’ rigorous thinking patterns. However, this article argues that the popularity of trap questions vis-à-vis China’s mathematics teaching reflects an intention of nurturing young learners’ sensitivity towards particular test items in examinations as a test-taker rather than rigorousness as a mathematician. The pedagogical implication of the trap questions is also discussed.

Keywords: Trap questions, Mathematics education, Primary education, China.

1. Introduction

Mathematics is often viewed as a rigorous discipline which involves shrewd calculation, reasoned argument and close examination. Nowadays, many education systems in the world foreground math subject as an essential component of school education. China’s education system is not an exception. Over the past few decades, Chinese students have consistently excelled in international mathematic competitions. Such salient achievements may be associated with the emphasis on developing students’ rigorousness in China’s (Here and in the rest of this paper, China refers to the Chinese mainland) mathematics education (MoE, 2011). To this end, various teaching strategies have been adopted. For example, the “trap questions” (“陷阱题” in Chinese) are designed to improve and examine students’ rigorous reasoning ability. While reasoning is an essential element in China’s mathematics education, domestic researchers and practitioners have made immense effort to reveal the characteristics and effect of trap questions in teaching practice.

With the intensive investigation trap questions have become a site for scholarly debate in the realm of China’s mathematics education. Many teachers and researchers see trap questions as an effective tool by which the instructor can improve students’ motivation for learning (e.g., Ni, 2018; Zhou, 2019), prompt them to reflect on their mistakes (Wang, 2019; Zhang & Shi, 2003) and shape students’ rigorous characteristics (Zhou, 2019; Zhang, 2019). In contrast, some researchers argue that artificial trap questions deviate from the nature of mathematics, which require students to adapt to the trap patterns rather than develop their own thinking styles (Wen, 2006). Since trap questions have been widely used in China’s examinations, education practice and classroom teaching, we should closely observe trap questions and their potential impact on China’s students.

Before narrowing down this discussion to the effect of trap

questions in primary mathematics education in China, I begin by inquiring about primary teachers’ perception and practice of trap questions from both a philosophical and a socio-cultural perspective, aiming to reveal why trap questions are valued in China’s socio-educational context. Drawing on results found in the existing literature, this article moves to discuss the potential impact of trap questions on primary students in China.

2. Philosophical Perspective

As noted in previous sections, some scholars argued that trap questions deviate from the kernel of mathematics. From a post-constructivism perspective, trap questions can be seen as a fallacious construction designed to present ambiguity, hidden and/or interferential information. Yet, they are frequently adopted as an instructional technique in China’s math examination and classroom teaching. While artificial trap questions are valued in China’s class, those “authentic” mathematical issues may be neglected. Thus, it is not surprising that many researchers and teachers would stand against the adoption of trap questions in China’s math class. Nonetheless, under China’s test-driven education system, the popularity of trap questions is not unaccountable.

Constructivism may view trap questions as an effective way to garner students’ attention to improving their rigorousness in tests and honing their skills in identifying various traps and learning trap patterns. In doing so, students will hopefully improve their performance in China’s high-stakes tests. On the other hand, trap questions help students develop their rigorous mathematics thinking, constructing a stringent scholarship in a long term. While rigor is prioritized in mathematics subjects, Chinese math teachers often value trap questions.

Trap questions serve to disclose and then solve common mathematical misconceptions to students (Tu & Zheng, 2008).

In addition, many primary students tend to think stereotypically, applying formulas regardless of the conditions (Wu, 1998; Zhou, 2019). As a result, many math teachers would put great effort into nurturing students' rigorous character and scientific reasoning.

3. Three Types of Trap Questions

In general, trap questions can be categorized into three types, including conceptions traps, mindset traps and reading traps. Most of the trap questions found in the literature were presented in close-ended formats. These designed traps are mainly derived from concepts that students easily overlook. Nonetheless, these traps may be viewed as important components in the teaching units. In what follows, I present an analysis of each type of trap questions.

Q1. 下列属于整除的算式是()。

Which formula is integer division?

A. $17 \div 3 = 5 \dots 2$ B. $24 \div 3 = 8$
 C. $2.8 \div 0.4 = 7$ D. $7 \div 2 = 3.5$

Q2. 一个数除以真分数, 所得到的商() 这个数。

If a number is divided by a proper fraction, the quotient will be () this number.

A. 大于 (greater than) B. 等于 (equal to)
 C. 大于或等于 (greater than or equal to)

Figure 1. Conceptional traps

Although deductive reasoning is a critical element in mathematics (Ayalon & Even, 2008), teachers should be cautious while designing deductive reasoning in close-ended questions with many hidden rules or conditions because the traps may affect the detection of students' acquisition of relevant concepts. For example in Q2, if students do not realize that zero can be applied in the division, even those who have comprehended the proper fraction division may end up choosing the wrong answers. Alternatively, students may spend considerable time verifying all the options.

Q3. 判断对错: 路程和时间成正比例。 ()

The statement that distance is in direct proportion to time, is true or false?

Q4. 比较 $\frac{1996}{1997}$ 和 $\frac{1995}{1996}$ 的大小。

Figure 2. Cognitive traps

As seen in Figure 2, Yang (2002) demonstrated a cognitive trap where students may judge it as a true statement due to its seemingly rational reasoning. Meanwhile, students may resort to their stereotypical thinking patterns, leading them to propose an untenable judgment. In this regard, this trap question can work to remind students of the conditionality – the speed must remain unchanged. Unlike Q3, Q4 is another item exemplified by Wu (1998), who showcased how cognitive traps can elicit students' innovative solutions. When students find that the reduction of the given fractions is highly complex, some students may utilize the whole unit "1" to perform a comparison between the two fractions, as presented below:

3.1. Conceptional Traps

Conceptional traps are designed to assess students' comprehensive understandings of basic concepts. This type of traps often takes two forms. The first form mixes easily confused mathematical concepts for students to differentiate them, whereas the second one examines whether students can include conditionality while analyzing the test items. As seen in Figure 1, Yang (2002) illustrated two examples of the conceptional traps, which reflect the teacher's latent intention to guide students to follow a strict deductive reasoning method. For Q1, students must know that the rule - "整除" means the divisible division between integers. Then, students are expected to infer the result step by step (24 and 8 are integers, and "divisible" means no remainder left in the result), reasoning that equation B is the answer.

3.2. Cognitive Traps

Given limited mathematical knowledge and life experience, young learners often identify and choose solutions based on the external characteristics of problems, such as words, symbols and structures. And they readily form, and rely on, a fixed thinking pattern (Zhou, 2019). Being used to challenge students' thinking patterns, cognitive traps often contain plausible expressions, requiring students to identify unstated assumptions and deliberate ambiguity.

$$1 - \frac{1996}{1997} = \frac{1}{1997} \text{ and } 1 - \frac{1995}{1996} = \frac{1}{1996}, \frac{1}{1996} > \frac{1}{1997}, \text{ and } \frac{1996}{1997} > \frac{1995}{1996}$$

Additionally, some students may apply the analogical method to compare two fractions (i.e., $\frac{1}{2} < \frac{2}{3} < \frac{3}{4} < \frac{4}{5} \dots$). In this way, they may capture that the fraction with greater numerators and denominators possesses greater value in the above deductive sequences.

4. Reading Traps

The third and final category of trap questions is reading traps. This type of trap questions is constructed based on the assumption that some students may make mistakes because of

their cursory reading. Thus, instructors leverage such common characteristics to examine students' rigorousness in mathematics reading during the examination. Figure 3 illustrates a sample reading trap discussed by Zhou (2019),

which can trap students who may be slapdash and thus fail to distinguish “把/元” (unit/yuan) and “元/把” (yuan/unit) in the text.

Q5. 乐器店新购了 9 把小提琴，共花了 3600 元。售价合理的是()。			
A. 400 元/把	B. 400 把/元	C. 498 把/元	D. 498 元/把
The musical instrument store purchased 9 new violins, costing a total of 3,600 yuan.			
Which price is rational for sale? ()			
A. 400 yuan/unit	B. 400 units/yuan	C. 498 units/yuan	D. 498 yuan/unit

Figure 3. Reading traps

As a result, inattentive students may feel frustrated when they realize the test item lured them. Nonetheless, the aims of reading traps and other types of trap questions are not to disturb students. Instead, these trap questions can stimulate students' cognition development with the teacher's guidance. As Beatty et al. (2006) pinpointed, solving a trap question can trigger students' pondering of the question, opening up opportunities for them to see an alternative mathematical discourse. In addition, students may struggle to articulate and defend their previous thinking patterns, attempting to challenge the teacher's reasoning and perceptions. In this way, trap questions can inform the teacher students' cognitive processes and intrinsic construction of particular issues, offering explicit guidance to them.

5. Pedagogical Application of Trap Questions

As discussed above, trap questions can contribute to constructing an effective math class, nurturing students' rigorousness as a mathematician. Unsurprisingly, many Chinese math teachers seek to incorporate trap questions into their teaching practice. The most frequently reported strategy is adopting conceptual and cognitive traps immediately after instructing mathematical concepts. For instance, Zhang (2019) illustrated a trap question that merely presents the lengths of two sides of a right triangle (i.e., $a=3$, $b=4$) and requires students to calculate the length of the third side (c). In Zhang's (2019) scenario, students were just instructed the Pythagorean theorem. Thus, this test item challenged students' current schemata (i.e., $a^2+b^2=c^2$). After students made a common error, the teachers guided students to re-examine the question from another perspective (c can be a hypotenuse or a right-angle side).

The rationale of the above strategy lies in cognitive conflict and constructivism. In the view of constructivism, Limón (2001) argued that learners are active builders of their knowledge and seek to connect “the new knowledge to be acquired with the existing knowledge that students have, in order to promote meaningful learning” (p. 358). At the surface level, posting a trap question confronts students' prior knowledge. Yet, the students' re-examination of the given problem allows them to (re)construct a critical understanding of the Pythagorean theorem. As Chinn and Brewer (1993) suggested, conceptual progress occurs when students identify inconsistencies between old and new information, seek connections among new knowledge and develop conflicting hypotheses to reconcile cognitive conflicts. In this way, students would realize the importance of rigorousness in tackling mathematical problems, improving their thinking

patterns as active learners.

6. Potential Impacts on Students by Trap Questions

While math subject is often featured as a “plain” subject, the cognitive trap questions that are characterized with inherent suspense and thinking zigzag can raise students' attention to, and stimulate their interests in, math learning. The desire to mitigate the conflict between prior knowledge and new information stimulates students' intrinsic learning motivation. Such a cognitive process touches upon Piaget's (1985) conceptualization of cognitive conflict. Specifically, students must pass through a series of cognitive conflicts before meaningful learning occurs. In other words, cognitive conflict is a pre-condition of the occurrence of effective conceptual change (Lee & Kwon, 2003). Very often, trap questions are designed to disguise ill-founded statements, creating conflicts between students' current knowledge and new information. In light of the foregoing, trap questions as a teaching strategy pave the way for students' conceptual development by creating meaningful conflict in class.

However, teachers' excessive adoption of trap questions does not consistently and necessarily lead to students' conceptual change. Teachers who alert students to be rigorous via frequently adopting trap questions may force students to memorize the trap patterns by rote rather than hone their cognitive skills. For example, “高考数学状元” (the top scorers in the national college entrance examination) are often students who excel in tackling all the test items and traps. Thus, this article argues that those top scorers perhaps rely more on their mechanical operations of various test items rather than rigorous and logical characteristics per se.

As Kleiner (1991) suggested, “too much rigor may lead to rigor mortis” (p. 294). From the perspective of cognition development, cognitive conflict triggered by trap questions may negatively affect students' response behavior. Kwon et al. (2000) revealed that cognitive conflict also causes anxiety among students, which decreases some students' motivation to perceive new information in the class. In Kleiner (1991)'s parlance, “mathematical rigor is like clothing. Its style it ought to suit the occasion, and it diminishes comfort and restricts freedom of movement if it is either too loose or too tight” (p. 291). Thus, if trap questions are inevitable, balancing the impact of trap questions must be incorporated into teachers' training to soften the negative effects of traps.

7. Socio-cultural Aspects

7.1. Goals of Mathematics Education in China

The latest version of Mathematics Curriculum Standards (MCS) issued by the Ministry of Education (MoE) in China changed the teaching goals of mathematics education from “double-base” to “four-base”, including knowledge and skills, mathematical thinking, problem-solving, and emotions and attitudes. Despite immense effort by China’s education authorities, Lin et al. (2009) reported that the MCS and Chinese math teachers’ practice overwhelmingly focus on achieving goals at “understanding” and “proficiency” levels. In contrast, other cognitive skills (e.g., analysis, evaluation and creation) received less attention. Additionally, the objectives at emotions and attitudes dimensions encourage students to form conscientious characteristics and scientific attitudes such as fixing mistakes (“修正错误”, MoE, 2011, p.9) and seeking truth and being rigorous (“严谨求实”, MoE, 2011, p.9). While the above characteristics have been foregrounded in MCS, it is not uncommon for teachers to apply trap questions to eliminate students’ slapdashery in math learning.

8. Test-driven Education System in China

China’s education system is well-known for its test-driven nature in the world. Most Chinese students receive admission

from renowned institutions because of their outstanding performance in tests. For instance, if a pupil hopes to enroll in the best middle schools in local for better education resources, s/he should pass the entrance examination in the first instance. Once embarked on tier-1 middle schools, she will hopefully be admitted into tier-1 high schools, and then top tier universities. Unsurprisingly, Chinese parents and students are likely to associate top-notch universities with a “top-notch” life hereafter. In other words, students’ performance in high-stakes examinations from elementary school to high school seems to determine students’ fate, especially for those from rural areas. As a bridge between primary education and higher education, the college entrance examination is inexplicitly associated with the development of primary education (Zuo & Tang, 2020).

Within such a context, since the college entrance examination prioritizes students who obtained good marks (Huang, 2019), primary school teachers would pay more attention to students’ performance in tests in their early school education stages. If most students can achieve good marks, further categorizing students’ grades become necessary. Thus, one strategy to further differentiate students’ grades and performance is designing trap questions. For example in Figure 4, if the question setter did not trap students with differentiated length units, most students perhaps can correctly respond to the question. However, students who are not rigorous in reading the text will fall into the length unit trap and lose points in the test.

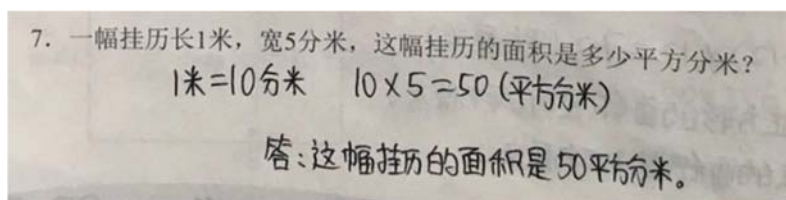


Figure 4. A reading trap question in the official workbook that come with the math textbook. (Third-grade workbooks published by Beijing Normal University, 2018)

While the high-stakes tests such as college entrance examination predominate China’s education system, teaching-learning activities are often designed to prepare students for those examinations only, training both teachers and students a mater who can function well in various tests. Without denying that other extant socio-culture factors can contribute to the education state quo, test scores should not be employed as the only measurement in the education system.

9. Conclusion

This article presented a preliminary analysis on what and how trap questions were adopted by Chinese primary mathematics teachers. While my intention was not purely on introducing this type of test items in China, I identified potential factors that contribute to the education state quo, including the benefits of raising cognitive conflict, test-driven education system and the development of students’ rigorousness. Despite the positive impact of trap questions, it may argue that the popularity of trap questions in mathematics teaching practice perhaps mirrors the state quo of China’s mathematics education. While the promotion of trap questions foregrounds the cultivation of students’ rigorousness, they may disguise an intention of nurturing students’ sensitivity towards designed test items in examinations.

References

- [1] Ayalon, M., & Even, R. (2008). Deductive reasoning: In the eye of the beholder. *Educational Studies in Mathematics*, 69(3), 235-247.
- [2] Beatty, I., Gerace, W., Leonard, W., & Dufresne, R. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics*, 74(1), 31-39. <https://doi.org/10.1119/1.2121753>
- [3] Chinn, C. A., & Brewer, W. F. (1993). The role of anomalous data in knowledge acquisition: A theoretical framework and implications for science instruction. *Review of educational research*, 63(1), 1-49.
- [4] Group of primary mathematics. (2018). *Knowledge and skills workbook (3B)*. Shenzhen: Haitian Publishing House.
- [5] Huang, J. (2019). A study on college entrance examination reform trend: a screening theory perspective. *Education Theory and Practice*, 20, 16-18.
- [6] Kleiner, I. (1991). Rigor and proof in mathematics: A historical perspective. *Mathematics magazine*, 64(5), 291-314.
- [7] Kwon, J., Park, H., Kim, J., Lee, Y., & Lee, G. (2000). The analysis of the relationship between cognitive conflict characteristics (levels and patterns) and response patterns of students confronted with anomalous situation in learning

- science. Research report on subject education. Ministry of Education in Korea.
- [8] Lee, G., & Kwon, J. (2003). Toward an understanding and use of cognitive conflict in Science instruction: Definition and model. *Journal of Korean Association for Research in Science Education*, 23 (4), 360 – 374.
- [9] Limón, M. (2001). On the cognitive conflict as an instructional strategy for conceptual change: A critical appraisal. *Learning and instruction*, 11(4-5), 357-380.
- [10] Lin, J., Zhou, Y., & Lu, M. (2019). Consistency analysis on teachers' books and curriculum standards with different versions – using Jiangsu edition and Beijing Normal University edition senior secondary school mathematics compulsory (teacher's book) as example. *Teaching and Management*, 12.
- [11] Ministry of Education. (2011). Guidelines for mathematics curriculum for compulsory education. Retrieve from <http://www.moe.gov.cn/srcsite/A26/s8001/201112/W020220418401382030426.pdf>
- [12] Ni, Q. (2018). Trap question design in primary mathematics teaching. *Primary school Teaching Reference*, 32, 63.
- [13] Piaget, J. (1985). *The equilibration of cognitive structures: The central problem of intellectual development*. Chicago: University of Chicago Press.
- [14] Tu, R., & Zheng, Q. (2008). Discussion and thinking on trap questions in mathematics. *Teaching and Management*, 19, 49-51.
- [15] Wang, X., (2019). Application of trap questions in primary mathematics teaching. *Gansu Education*, 15, 163.
- [16] Wu, B. (1998). Developing thinking skills via practicing trap questions. *Teachers' Friend*, 4, 17.
- [17] Wen, J. (2006). Do not “trap” students in mathematics learning. *Secondary Mathematics Teaching Reference*, 21, 9-10+20.
- [18] Yang, S. (2002). Discussion on designing knowledge trap in conceptual math test items. *Teaching and Management*, 5, 76-77.
- [19] Zuo, C., & Tang, F. (2020). Motion, motivation and envisagement of new college entrance examination reform. *Guangxi Social Science*, 2, 178–184.
- [20] Zhou, Q. (2019). Trap question design in primary mathematics teaching. *Mathematics Learning and Research*, 24, 131.
- [21] Zhang, F., & Shi, Y. (2003). Functions of trap question in mathematics teaching. *Contemporary Educational Science*, 3, 56-57.
- [22] Zhang, Z. (2019). Trap question design in primary mathematics teaching. *Western All- round Education*, 4, 236.