Self-Assessment in Mathematics Learning among Chinese Secondary School Students: Do Girls Underestimate Themselves?

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Abstract: Mathematics learning plays a significant role for high school students. Although gender differences in mathematics learning have been well documented, gender differences in mathematics learning self-assessment have not been adequately studied. The purpose of this study was to investigate whether gender differences existed in the mathematics learning self-assessment process. In this study, nine Chinese high school students answered interview questions about self-assessment (Step 1: determine/set self-assessment criteria; Step 2: seek external and internal feedback; Step 3: reflect the learning process and product with the support of feedback) in mathematics learning. The findings revealed that all high school students self-assessed their mathematics learning. Gender differences varied across the self-assessment steps. In Step 1 and Step 2, it did not show significant gender differences. However, in Step 3, gender differences were significant. This study can help educators and researchers better understand the variability and complexity of self-assessment in mathematics learning.

Keywords: Mathematics Learning, Self-Assessment, Gender Difference, Secondary School

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Introduction

Mathematics is a cornerstone subject in STEM [science, mathematics, engineering, and technology] and an important pathway to adult life and career opportunities (Wheatley, 1992). For students, mathematics is an important part of the school curriculum (Leder, 2019). Based on the importance of mathematics learning, learning strategies for mathematics learning have also been paid close attention by researchers. Self-assessment is one such learning strategy that should not be overlooked.

Self-assessment is the foundation of self-regulation learning (Mendoza & Yan, 2021). It is an essential skill that students must have when learning (Yan et al., 2020). On one hand, it has been shown that by self-assessing their performance, students can identify their advantages and disadvantages and adjust their learning accordingly (Boud, 1995; Yan & Brown, 2017). On the other hand, self-assessment has benefitical impact on student's motivation to learn (Boud, 1995; Brown & Harris, 2013; McMillan & Hearn, 2008), and autonomy in learning (Brown & Harris, 2013; Paris, S. & Paris, A., 2001).

Since the mid-1970s, gender differences in mathematics learning have been a focus of attention for researchers concerned with mathematics and those concerned with gender (Fennema, 1974; Hyde et al., 1990; Inglis & Foster, 2018). Researchers have documented gender differences in mathematics learning and explored the positive and negative factors that are evident (Fennema, 1974). However, gender differences in the self-assessment process have not been fully explored. Do gender differences exist throughout the self-assessment process? At what steps of the self-assessment process do gender differences exist and at which steps do they not exist? To examine these questions in depth, this paper first provides a preliminary theoretical conceptualization of self-assessment. Then, the existence of gender differences in each step of self-assessment in mathematics learning is investigated from the students' perspective through a case study.

Mathematics Learning

The focus on STEM (science, technology, engineering, and mathematics) is escalating in many countries and its robust role in multiple sectors is formally recognized (Honey, Pearson, & Schweingruber, 2014; Marginson et al., 2013; Royal Society Science Policy Centre, 2014). As a result, developing competence in STEM disciplines is considered an urgent goal for many educational endeavors. Mathematics is the cornerstone discipline of STEM. Many mathematics teachers and researchers have observed that mathematics is unique in the school curriculum (Damarin, 2000). High school students as teenagers are at their most active thinking period. They will either step into the society or go deeper into higher education. It is necessary to guide them at this time stage to discover their interests and lay the foundation for their future studies and life. For some students, learning mathematics can be a struggle. Efforts should be made to motivate and inspire students to learn mathematics and guide student to see the practical applications of mathematics in the real world to better help them in their journey into society (Murphy, 2016). Therefore, high school students' mindset toward mathematics learning is a topic well worth studying.

Gender differences in mathematics learning have long been a topic of exploration for researchers (Leder, 2019). The stereotype is that boys are better at math than girls. However, the study found no significant difference between boys and girls in their ability to solve math problems during junior high school and elementary school. In high school and college, gender differences would be more in favor of males (Hyde et al., 1990). Therefore, it is necessary to study the issue of gender differences in mathematics learning among high school students.

Self-Assessment

Self-assessment not only facilitates professional development (Yan, Boud, & Powell, 2020), but also is a key to lifelong learning (Papanthymou & Darra, 2018; Siegesmund, 2017; Yan & Brown, 2017). Through self-assessment learners can motivate themselves and direct their efforts, keeping them abreast of new knowledge in their professional fields (Mok et al., 2006). Research has shown that self-assessment positively affects academic achievement, self-regulation, and motivation to learn (Brown & Harris, 2013; Panadero et al., 2017). In addition, self-assessment can increase students' commitment and autonomy to learning (Brown & Harris, 2013). There are also many studies that demonstrating the ability of self-assessment to promote academic achievement. McMillan and Hearn (2008) noted that because since self-assessment enables students to control their learning process and regulate assessment criteria, it tends to positively affect students' academic performance. Due to the positive impact of self-assessment, it is imperative that researchers have a further understanding of the self-assessment process. (Panadero, Brown, & Strijbos, 2016; Yan & Brown, 2017). So, what exactly is self-assessment?

Broadly speaking, self-assessment can be defined as students reflecting on the quality of their work, judging the extent to which it reflects explicit goals or standards, and modifying it accordingly (Andrade & Valtcheva, 2009, p. 13). In many studies, self-assessment is viewed as a simple summative self-rating, but in real-world learning situations, self-assessment is clearly much more complex. A number of studies have pointed out that self-assessment is not a summative assessment, but a complex process (Mendoza & Yan 2021). Yan and Brown (2017) conceptualized self-assessment as a process through which students judge their performance based on feedback gathered from different sources (Boud, 1995; McMillan & Hearn, 2008; Yan & Brown, 2017). They proposed a "cyclical self-assessment process" that covers three sequential steps. The first step in student self-assessment is to determine self-assessment criteria. The second step is to seek feedback on one's performance from both external and internal sources. External feedback comes from explicit course requirement, others' evaluations of the student's learning, etc. Internal feedback comes from internally generated feelings about the performance of the student. The third step is to compare the feedback with their own self-assessment criteria and to reflect on the learning process and learning outcomes with the support of the feedback. This definition of self-assessment is well accepted and applied. Therefore, this definition was adopted to represent self-assessment behavior in this study.

The Case Study

To gain insight into gender differences in students' self-assessment of mathematics learning, a case study was conducted with Chinese high school students that followed Yan and Brown's (2020) self-assessment model (i.e. Step 1: determine/set self-assessment criteria; Step 2: seek external and internal feedback; Step 3: reflect the learning process and product with the support of feedback). The case study was designed to answer two research questions:

1. What is the status quo among students of self-assessment in mathematics learning?
2. Does gender differences exist in self-assessment in mathematics learning?

Method

Participants

Nine high school students from different Chinese high schools participated in this study. The participants consisted of four males and five females between the ages of 15 and 18. Female participants were labeled as S1 to S5, while male participants were labeled as S6 to S10. They came from different regions such as Guangdong and Shanghai in China (see Table 1).

Table 1. Participants Demographic

	S1	S2	S3	S4	S5	S6	S7	S8	S9
Gender	Female	Female	Female	Female	Female	Male	Male	Male	Male
Grade	2	2	2	1	3	3	2	3	2
Year	17	17	18	16	18	18	17	18	17
Region	Wuhan	Shanghai	Guangdong	Guangdong	Shandong	Liaoning	Jilin	Guangdong	Shanghai

Data Collection

With each participant's consent, an half-hour individual semi-structured interview was conducted and recorded. The nine individual interviews were conducted in Chinese and transcribed. Only responses from the participants cited in this paper were translated into English.

The first research question is about the status quo among students of self-assessment in mathematics learning. Since there are three steps of self-assessment in Yan's model(i.e. Step 1:determine/set self-assessment criteria; Step 2:seek external and internal feedback; Step 3: reflect on the learning process and product with the support of feedback.). The interview questions contained three sections. Gender differences were involved in every section.

The first section was about whether and how students determined self-assessment criteria in mathematics learning. The second section investigated the feedback students received from external and/or internal sources about the quality of their performance in mathematics learning. In the third section, students were asked whether they compared the feedback with their own self-assessment criteria and reflection based on the feedback. As the participants were high school students, the context of the study was based on high school education.

Data Analysis

Themes in the data were identified and reported according to the requirements of the thematic analysis method

(Braun & Clarke, 2006). Before analyzing the qualitative data, the accuracy of the transcriptions was double-checked by comparing the recordings to the transcribed text.

First of all, the interview data were then analyzed through a standard process of thematic coding. Three main themes were identified: determine/set self-assessment criteria, seek external and internal feedback, and reflect the learning process and product with the support of feedback. Each of the above themes includes gender differences in this theme as perceived by the students. Then the initial code was refined and categorized into the three themes (Braun & Clarke, 2006; Bryman, 2012).

Findings and Discussion

The Status Quo of Self-Assessment in Mathematics Learning and Gender Difference

According to Yan's model (2020), self-assessment is a three-step process. The first step in student self-assessment is to determine self-assessment criteria. The second step is to seek feedback on one's performance from both external and internal sources. External feedback comes from explicit course requirement, others' evaluations of the student's learning, etc. Internal feedback comes from internally generated feelings about the performance of the student. The third step is reflect on the learning process and learning outcomes with the support of the feedback.

Step 1: Determine Self-Assessment Criteria

In the first step, we investigated whether students set criteria for self-assessment. If so, how were the self-assessment criteria were set.

Most (n = 6) participants had explicit criteria for assessing their learning in mathematics as in Yan's model (2020). The other two participants indicated that they did not have explicit criteria, but had expectations for their mathematical learning (e. g. complete the study of the textbook, try to answer problems that they do not know) and the last participant indicated that she did not set criteria. Take an example of S8.

> *I set my study goals with the college entrance exams in mind. I make sure that I get all the basic questions right on my tests and assignments before working on difficult questions. ---S8*

In the response of S8, he set his criteria as getting all the basic questions right in the exams and assignments, which was a very clear criterion.

In terms of gender difference in self-assessment criteria determination, when asked whether there were gender differences in setting learning standards in mathematics learning, most participants (n=6) agreed that there were no gender differences. In addition, two participants believed that because boys didn't care about learning as much as girls did so many of them didn't even bother to set self-assessment criteria in learning. One participant

also perceived that boys were better at mathematics so they would have higher criteria for themselves. As an example, here's what S7 said.

> *I feel that girls are more eager to excel than boys, who are more casual. Girls are stricter. They may feel that their long efforts are ineffective if they don't do well in one test. ---S7*

In general, most students would set self-assessment criteria in their mathematics studies. In setting mathematics learning self-assessment criteria, most students did not believe that there were significant gender differences.

According to Leder (2019), at the high school stage, there were gender differences in solving math problems. Male students did better in solving mathematical problems. However, it is evident from our interview data that there is no significant difference between male and female students in setting self-assessment criteria for mathematics learning. Gender differences may be shown in other steps of self-assessment in mathematics learning.

Step 2: Seek Feedback from both External and Internal Sources

According to Yan (2020), the second step is to seek feedback on one's performance from both external and internal sources. Thus, the external feedback aspect investigated whether the student sought feedback from teachers and peers about the student's mathematics learning. The internal feedback aspect, on the other hand, investigated whether the student sought feedback from internal source about mathematics learning.

1.External Feedback

The majority of participants (n=8) indicated that they received feedback from their teachers about mathematics learning. Participants also reported that they received feedback from their peers, but the feedback from their peers tended to be less explicit. Take an example of S5.

> *My classmates tend not to make explicit comments about my performance in math studies. But in fact, we all have a general evaluation of everyone's performance in our minds. Students with higher grades will share their learning experiences with others, and then those with lower grades will seek help. ---S5*

From S5, peers tended to give only approximate feedback about others' learning of mathematics. Nonetheless, peers provided feedback in the form of practical actions, such as explaining math problems to students who are struggling.

Regarding the question of whether there were gender differences in external feedback, most participants (n=6) said that there were no gender differences. They believed that people around them did not treat male and female students differently. In contrast, the other three participants believed that boys would be trusted more in their

mathematical learning abilities because they were better at mathematics and logical thinking.

2.Internal Feedback

All participants reported positive or negative emotions about learning mathematics. One participant also reported getting physical feedback (e.g., dizziness). When asked if there were gender differences in seeking internal feedback, more participants (5 compared to 4) agreed that female students were more likely to experience anxiety.

> *Female students may be emotionally just a little more intense than male students.---S5*
> *I feel that female students will be relatively more anxious. because for female students, social science is their strength, science including mathematics is their weaknesses ---S7*

In sum, participants reported gender differences in terms of internal feedback. But from the interview data, it did not appear that there was a significant difference between boys and girls in terms of seeking internal feedback. The idea that women are more likely to be anxious about learning math may stem from stereotypes about women.

According to Yan (2018), a person's willingness to seek feedback is related to the cultural context in which he or she lives. Individuals of cultures characterized by individualistic self-concept (e.g., the United States) seek feedback more actively than individuals from collectivistic cultures (e.g., China). Fear of losing face was a significant barrier to feedback-seeking behavior in China. Yet, we found that the majority of Chinese high school students in our survey were positive about receiving feedback. One possible reason was that as teenagers, high school students could view the world more openly. Compared to older people who cared about their face, high school students were not bound by society's culture and rules. Another possible reason was that Chinese high school students were under pressure to pass the college entrance exam. They were more eager to receive feedback to adjust their learning style so that they could get better grades.

Step 3: Reflect on the Learning Process and Product with the Support of Feedback

According to Yan (2020), the third step is to compare the feedback with their own self-assessment criteria and to reflect on the learning process and learning outcomes with the support of the feedback.

In terms of teacher and peer evaluations, the majority of participants (n=7) felt that their teachers' and peers' feedback were generally consistent with their own self-assessment criteria.

> *The teachers at our school have special software that tallies data on students' math performance, so the teachers' feedback on students' learning in math generally matches the reality. I also have great trust in the teacher's evaluations. --S8*

My teacher has a high opinion of my learning in math and wants me to continue with my current performance. This is consistent with my self-assessment criteria. --S5

Notably, two other students, containing one male and one female student, both indicated in previous conversations that they excelled in mathematics and felt that their peers' feedback were inconsistent with their own self-assessment criteria. Here's what the two students, S3 and S7, said.

Sometimes I felt I did not do well on the test, but my classmates also thought I did well.---S3
My classmates thought I was studying hard at home, but I wasn't studying at all in my leisure time. ---S7

From S3 and S7, it can be observed that for students who do well in mathematics, their peers seem to underestimate their abilities. Overall, no significant gender differences were found in terms of seeking external feedback. In contrast, interview data showed that there were some differences between students who excel in mathematics and other students in terms of seeking external feedback.

According to the interview, most of the participants (n=6) indicated that they would consider adjusting the self-assessment criteria based on feedback from teachers. Among them, S3 and S7 both indicated that they would set self-assessment criteria with the goal of high school entrance examinations.

Because of preparing the college entrance exam, I will consider the balance between the various subjects. If I spend too much time on math, then I don't have time to study the social sciences.---S7

As for the reflections on internal feedback, most of the female students (n=4) reported that their emotions do not influence their setting of self-assessment criteria. While on the contrary, all of the male students believed that their self-assessment criteria are influenced by their internal feedback.

I think interest is the best teacher. If I am more interested in learning mathematics in this period of time, I think my learning effect will be a little bit better and my criteria may be higher accordingly.---S8

From the interviews data, it can be found that male and female students showed significant gender differences in terms of reflection on internal feedback.

From Yan (2018), there were notable gender differences in self-assessment practices. Female students showed higher levels of self-assessment practices than male students.Yan (2018) conjectured that female students engaged in more self-assessment reflections and were more willing to use self-assessment practices to check and monitor learning processes and outcomes. Our findings are consistent with Yan's (2018) conjecture. According to our data, there was a significant gender difference in reflections on feedback of mathematics learning. One possible reason is that girls are less likely to have their judgments swayed by emotions. Despite the stereotype that girls are more emotional, our research data suggest that female students are more assertive about the self-

assessment standards they set for themselves. They are less likely to be distracted by their own emotions. Compared to boys, girls are more able to make accurate reflections on their self-assessment.

Conclusion

The main findings of the paper are gender difference exists in self-assessment mathematics learning among high school students. There are three steps in self-assessment (Step 1: determine/set self-assessment criteria; Step 2: seek external and internal feedback; Step 3: reflect the learning process and product with the support of feedback) in mathematics learning. Gender differences varied across the self-assessment steps. In Step 1 and Step 2, it did not show significant gender differences. However, in Step 3, gender differences were significant. This study can help educators better understand the complexity of self-assessment in mathematics learning and the gender differences that exist within self-assessment process. It will enable teachers as well as researchers to better target their work to improve students' self-assessment of mathematics learning.

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