An International Comparative Study on the Impact of Science Teachers' Literacy on Middle School Students' STEM Career Expectations: Based on PISA 2015 Data

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A R T I C L E I N F O

A B S T R A C T

Students' STEM career expectation is a key representation of the number of would-be talents in science and technology, and teachers' literacy has a positive impact on it. In view of its complex functioning mechanism, it has become a hot topic in contemporary science education research. Based on the data of the PISA 2015 questionnaire designed for teachers, this research made an empirical analysis of the relationship between science teachers' literacy and students' STEM career expectations. The results show that within the framework of "Four Haves" Good Teachers which involves ideal and belief, moral sentiment, solid knowledge and benevolence, science teachers' literacy is closely related to students' STEM career expectations, and can help predict students' STEM career expectations to a certain extent. Different dimensions of teachers' literacy have different predicting effects on students' career expectations, and there are also differences between different countries and regions. The cultural, political, economic and educational conditions of different countries and regions affect the relationship between them, and show certain types of influence. The relationship between teachers' fair treatment of students and students' career expectations is the closest. The secondary dimensions of teachers' literacy is closely related to students' career expectations, showing that teachers' literacy plays an important role in students' career expectations in a universal sense. However, teachers' literacy in the United States, Dominica and Colombia cannot significantly help predict students' career expectations. Further research and practice to promote students' STEM career expectations should pay full attention to the functioning mechanism of teachers' literacy.

1. Career expectations within the social career cognitive framework

Career expectations refer to people's visions for future careers before they enter the labor market (Sewell & Straus，1957）Having career expectations is important, for it is a driving force for the career development of adolescents. It has been found that the career achievements of adults are significantly related to the career expectations of adolescents (Trice & McClellan, 1993). STEM career expectations of middle school students have great predictive power for their future jobs in this field (Maltese & Tai, 2011). It has been found the biggest predictor of British students' employment in natural sciences at the age of 33 is their career expectations at the age of 16 (Schoon, 2011). The number of students in eighth-grade with STEM career expectations who obtained a bachelor's degree in STEM was three times that of those who did not have STEM career expectations, and the former had a significant advantage once engaged in the STEM careers in the future (Tai, 2006). However, currently students' expectations towards scientific careers are low, and even in America and some

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European countries with high levels of science education students have not been attracted to engage in scientific research and practice (OECD, 2009). In PISA 2015, the expectations towards scientific careers of 15-year-old students were incorporated into the science literacy test framework as an important indicator of non-cognitive dimensions of scientific participation outcome. Students of more than 14 years old are at the fourth development stage of career expectations, a period of inherently unique self-direction. At this stage, adolescents are in the development stage of self-identity. In choosing future careers, they consider personal interests and practical factors, possibilities and obstacles as well as social expectations (Gottfredson, 1981). Hattie (2009), a New Zealand scholar, completed the largest meta-analysis in the field of social sciences in the world which lasted for 15 years. He synthesized the meta-analysis results of more than 800 items over 50,000 individual studies and 250 million students to explore the factors affecting academic achievement. He classified the 138 factors that affect academic achievement into six categories, and processed them through effect averaging, i.e. from the largest to the smallest, teachers, courses, teaching, students, families and schools (Hattie, 2012). It could be seen that teachers are the most important factor affecting students' academic achievement. Therefore, it is necessary to further explore the influence mechanism of teachers' literacy on the STEM career expectations of middle school students.

A large number of studies around the world have focused on the factors that influence students' career expectations at the individual, family, school, and social levels. In the context of students and family, Aschbacher (2014) found that students' scientific self-perception may specifically influence their interests and desires, the high level of which can better support and encourage them to stick to STEM careers (Aschbacher, Ing & Tsai, 2014). Kang (2017) found that the inquiry-based learning experience could positively predict students' career expectations, and this effect was mediated by the expected outcome (Kang & Keinonen, 2017). School context is an important factor that affects students' career expectations. Students' career expectations and their understanding of the education required to achieve their expectations are related to the availability of school resources. The research of DeWitt et al. (2015) shows that students' career expectations are often shaped by scientific experiences offered by their schools. Rowan-Kenyon et al. (2011) explored the new models of situational dynamics shaping career expectations and college admissions based on the multi-tier framework of college admissions and social cognitive career theory (Rowan-Kenyon, Perna & Swan, 2011). In the new models, the school environment is closely related to the development of career expectations.

2. Complex influence mechanism and connotation of teaches' literacy

Teachers play an important role in the growth of students, especially in their academic achievements and other academic-related achievements. Druva (2010) carried out the meta-analysis of K-12 science teachers in the United States which shows that there is an important relationship between the characteristics of science teachers (gender, classwork, IQ, etc.) and their behaviors in the classroom as well as students' performance (Druva , Anderson, 2010). This result is also further supported by other related meta-analysis. Coenen et al. (2018) conducted a meta-analysis of 58 studies which had been performed in different countries on teachers' characteristics and their impact on students' test scores and found that subject-related knowledge is positively correlated with students' performance, especially in mathematics and science (Coenen, Cornelisz & Groot, et al, 2018). Nevertheless, the above-mentioned meta-analysis has not revealed

that the effects of teachers on students may differ under different cultural backgrounds and different countries. Lei et al. (2018) conducted a meta-analysis of 65 studies; they specifically explored the relationship between teachers' support and students' academic emotions in different cultural backgrounds. The study found that there is a stronger correlation between teachers' support and students' positive academic attitudes in Western Europe and the United States than in some countries in East Asia, however, the correlation between teachers' support and students' negative academic attitudes is stronger in East Asia than that in Western European and Americ (Lei, Cui & Chi, 2018). The above research shows that while in discussing the influence of teachers on students, we should be fully aware of the differences in cultural, political, economic and educational conditions in different countries and regions. However, due to the difficulty in sampling, it is often impossible to compare the influencing mechanism of teachers on students across different countries or regions in one study.

The role of teachers in students' career decision-making cannot be ignored. Earlier studies have shown that high school students (especially those interested in science) are influenced to a certain extent by their high school teachers and counselors when they make plans for their high school and university (Hill , Pettus & Hedin, 1990). The research of Rowan-Kenyon et al. (2011) further supports it. They found that regardless of what resources their schools can provide and what grades they are in, teachers are always the most important factor affecting students' career expectations (Rowan-Kenyon, Perna & Swan, 2011). The difference between the teaching profession and others lies in the literacy of teachers displayed in education and instruction (Sanger & Osguthorpe, 2013). Teachers' literacy and their apparent behaviors, such as their words and deeds in and out of the classroom, will affect students subtly, and play an important role in students' moral development, academic achievement and their future profession. Although the importance of teachers' literacy has been identified by the majority of researchers, the role of teachers' literacy especially its impact on students needs to be further identified by empirical research. What does the literacy of science teachers in China's middle school involve? What conceptual framework can be used to explain it? As a representative of the fourth paradigm in teacher education, China's teacher education has trained tens of millions of elementary and middle school teachers, supporting the world's largest number of teachers. Therefore, the evaluation framework of science teachers' literacy should be based on the theory in this country. On September 9, 2014, when President Xi Jinping held a symposium with teachers and students from Beijing Normal University, he called on all teachers across the country to become qualified "Four Haves"good teachers, teachers having ideal and belief, moral sentiment, solid knowledge and benevolence (Xi Jinping, 2014). "Four Haves" good teachers are the embodiment of the new connotations and new standards in teachers' literacy construction in the new era. The "Opinions of the State Council of China on Deepening the Reform and Construction of the Teaching Staff in the New Era" also put forward the requirements of "Promoting the ethics of teachers to become "Four Haves" good teachers "(China Higher Education, 2018).

From the connotation of "Four Haves" good teachers, first of all, ideals and beliefs mean that teachers are both " teachers" responsible for imparting knowledge and " educators" responsible for educating students. On the one hand, teachers need to have correct subject concepts, good understanding of the subject as well as the origin and ontology of the research process (Quinn, 2012)and emphasize the cultivation of students' ability to observe

natural phenomena, explain problems reasonably, design experiments, conduct experiments and surveys, etc., which are closely related to life. At the same time, teachers should have scientific thinking, and personal psychological thinking characteristics to guarantee the researching and solving scientific problems and using scientific knowledge of the subject go smoothly, so that students can use scientific thinking to understand things, solve problems, and guide their behaviors (Hendrich, Licklider & Thompson, et al, 2018). On the other hand, teachers' education means that teachers should emphasize the cultivation of students' self-management, that is, the ability to organize things or the self-discipline in dealing with events (Bulla & Frieder, 2018). Students' self-control and good class habits are emphasized. At the same time, teachers are supposed to fully consider students' own situation and preferences (Brooks & Young, 2011), stimulate their learning motivation and learning potentials based on the students' choices in courses, course difficulty and the number of courses. Moral sentiment means that teachers should not only love their jobs, but also make decisions or supervise. On the one hand, loving one's job and dedication means love the job once you decide to take it, requiring teachers to have professional beliefs and firmly believe that their choice of the teaching profession is correct; at the same time, teachers must also accept, affirm and appreciate the school culture, such as being satisfied with their own teaching practice in the school and recommending the school as an ideal work unit to others; in addition, teachers can cooperate and integrate resources to achieve specific goals (such as students' learning) over a longer period of time (Vangrieken, Dochy & Raes, et al, 2015). On the other hand, decision-making or supervision is to teach by precepts and deeds, which means that teachers are required to make careful positioning, decisions and choices on issues that are highlighted in teaching, such as students' discipline, judgments or assessments on students' performance, textbooks and teaching contents. In addition, teachers' teaching practices in school are also subject to corresponding supervision, including the supervision of their testing or evaluation of students' performance, teachers' peer review of lesson plans or assessment tools and courses, principals or senior staff's observation of teachers' classrooms, as well as the observation of the classrooms from the inspectors or other personnel outside the school. Teachers should also standardize their behaviors, such as not being absent from class, resisting reforms, being too strict with students or failing to make good preparations for class. Solid knowledge means that teachers are required not only to participate in the research on teaching, but also master necessary knowledge. Teachers' research activities refer to teachers' participation in a variety of professional development activities (Darling-Hammond, 2005), such as participating in academic research activities or reading related professional literature, observing, guiding and communicating with colleagues to improve teaching, etc. in addition, teachers are supposed to have a good command of subject content knowledge, pedagogical knowledge, technology, etc (Mishra & Koehler, 2006). Benevolence means that teachers should not only treat students fairly, but also pay attention to the individual needs. On the one hand, teachers must treat every student equally, including equality among students and equality between teachers and students. On the other hand, it is necessary to respect the individual differences of students, providing encouraging feedback to individual students (Lipko-Speed, Dunlosky & Rawson, 2014). If the goal is to teach science to all types of students, then adapting science classes to students with different knowledge, abilities and needs is crucial (Hofstein & Lunetta, 2004), to achieve personal teaching by making full use of their learning opportunities. The above is the Chinese interpretation of science teachers' literacy from the perspective of "Four Haves" Good Teachers. This research focused on teachers' literacy as an important factor in influencing students' career expectations, and attempted to explore the relationship between middle school science teachers' literacy and middle school students' career expectations and its influencing mechanism, and then provide new ways and perspectives for the improvement of middle school students' STEM career expectations.

3. Research methods

The structure and positioning of science teachers' literacy under the framework of Four Haves Good Teachers have Chinese characteristics. Ideals and beliefs are closely connected with teachers' professional missions, so that good teachers have clear goals in establishing their ideals and beliefs; moral sentiment is closely connected with teachers' professional behavior, which makes teachers set up ideals and beliefs with a clear goal; solid knowledge is closely linked to the professional ability of teachers, so that good teachers have a clear direction in mastering knowledge; benevolence is closely linked with the professional responsibilities of teachers, so that good teachers are clear about the requirements for a good teacher (Zhang Jian, 2017). The connotation of "Four Haves" good teachers has been widely discussed in the field of education research and practice in China. In the future, the functioning mechanism of scientific teachers' literacy needs to be researched. Based on the data of PISA 2015, this research discussed the role of science teachers' literacy, and then explored its influencing mechanism, with the purpose of promoting students' learning effectiveness and future career development by the way of improving teachers' literacy.

Although career expectations and teachers' literacy are extremely important topics in the education field, there has not been any research on the impact of science teachers' literacy on the STEM career expectations of middle school students. Taking into account the differences in cultural, political, economic and educational conditions in different countries and regions, the influencing mechanism of teachers' literacy on students' career expectations may also be different between different countries or regions. This research is based on the adapted conceptual model of career expectations and the literacy framework of the "Four Haves" Good Teachers, using PISA2015 data for the empirical research on the possible relationship between teachers' literacy and students' career expectations. Accordingly, the research questions include: (1) Are there any correlations between the various dimensions of teachers' literacy and students' career expectations? (2) Does each dimension of teachers' literacy affect students' career expectations? (3) Are there differences in the above-mentioned correlations and influences across countries? The data in this study comes from the questionnaires designed for schools, teachers, and students in PISA 2015. Since PSIA 2015 mainly monitors scientific literacy, the status of science education was specifically examined in the questionnaires. To guarantee the integrity of the data, in this study 17 participating countries or regions with complete teacher literacy data were analyzed. The descriptive statistics of the data are shown in Table 1. All the teachers sampled in this research taught science courses during that year.

Table. 1. Questionnaire statistics of 17 countries/regions

Countries / regions	Schools		Teachers		Students	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Australia	758	14.6	3089	15.8	14530	9.8
Brazil	841	16.2	2355	12.0	23141	15.6
Chile	227	4.4	664	3.4	7053	4.7
Taipei, China	214	4.1	1344	6.9	7708	5.2
Colombia	372	7.1	1078	5.5	11795	7.9
Czech Republic	344	6.6	1401	7.1	6894	4.6
Dominica	194	3.7	280	1.4	4740	3.2
Germany	256	4.9	1060	5.4	6504	4.4
Hong Kong, China	138	2.7	646	3.3	5359	3.6
Korea	168	3.2	865	4.4	5581	3.8
Macao, China	45	.9	452	2.3	4476	3.0
Peru	281	5.4	621	3.2	6971	4.7
Portugal	246	4.7	897	4.6	7325	4.9
Spain	201	3.9	540	2.8	6736	4.5
UAE	473	9.1	1872	9.6	14167	9.5
United States	177	3.4	865	4.4	5712	3.8
Four provinces and cities in China	268	5.2	1568	8.0	9841	6.6
Total	5203	100.0	19597	100.0	148533	100.0

The data processing was divided into four stages. First, students' STEM-related career expectations (OCOD3) were regarded as the dependent variable. In PISA2015, the open-ended question-what occupation will you take at the age of thirty was presented to students and students were hoped to fill in the name of the occupation they expect to pursue. Based on the names of occupation or the descriptions filled in by students, four categories were divided according to the standards provided by ISCO-88 (OECD, 2016), specifically including scientific and engineering professionals, health professionals, information and communication technological professionals, and scientific and technical professionals and assistants. The above four STEM-related occupations were encoded as 1, and other occupations were encoded as 0. Second, in terms of control variables, this study selected the following variables: ESCS (economic, social and cultural status), OCOD1 (mother's occupation), OCOD2 (father's occupation), OCOD3 (the student's future occupation) and scientific achievements.

Among them, OCOD1 and OCOD2 were encoded again according to the classification criteria mentioned above; the scientific score was the average score in the ten topics of PV1SCIE-PV10SCIE. In terms of independent variables, the specific dimensions and data sources of teachers' literacy under the framework of "Four Haves" Good Teachers are shown in Table 2. All questions were assessed to be at five levels, with 1 point being the lowest and 5 points being the highest. The higher the score, the better it was. Finally, using the school code as a reference, the data of schools, teachers and students were matched one by one, and the average scores of all schools in the above variables were calculated. Exploratory Factor Analysis (EFA) and Confirmation Factor Analysis (CFA) were used to conduct empirical research on the structural model of the internal factors of teachers' literacy base on the PISA questionnaires from the perspective of China's "Four Haves" Good Teachers, and finally an eight-factor structure model of teachers' literacy was determined. We identified 8 specific dimensions of teachers' literacy and the two sub-dimensions of ideals and beliefs contain 8 and 7 items; the two sub-dimensions of moral sentiment contain 11 and 14 items, the two sub-dimensions of solid knowledge contain 5 and 11 items, and the two sub-dimensions of benevolence contain 6 and 13 items respectively (Table 1). According to the research purposes, SPSS was used to perform descriptive statistical analysis, correlation analysis and regression analysis on the above data.

Table. 2. The dimensions of teachers' literacy under the framework of "Four Haves" Good Teachers

First-level dimension	Secondary dimensions	
Ideals and beliefs	Teacher/teaching	Educator/educating
Moral sentiment	Love and dedication	Decision-making/Supervision
Solid knowledge	Research into teaching	Teachers' knowledge
Benevolence	Fair treatment of students	Attention to individuals

4. Research results

4.1 Descriptive analysis of the basic levels of science teachers' literacy

In terms of the overall situation of the 17 countries or regions, under the framework "Four Haves" Good Teachers, teachers scored satisfactorily in the second-level indicators: fair treatment of students(3.41), love and dedication (3.13), research into teaching (3.11), teachers' knowledge (3.01) and teachers' teaching (3.01), but not in the three dimensions teachers' education (2.49), attention to individuals (2.60) and decision-making/supervision (2.98) in which there is a great gap for teachers to improve. In terms of the four first-level dimensions of a good teacher under the "Four Haves" Good Teachers framework, teachers performed best in solid knowledge, but performed relatively the weakest in ideals and beliefs. The students' expectation score for STEM-related careers was 0.33 (SD=0.18), indicating that 33% of students are willing to engage in STEM-related careers at the age of 30. Specific to the third-level indicators, teachers reached the upper-middle level in teachers' literacy, subject concepts, school recognition, teachers' cooperation, teaching supervision, teachers' behavior, teaching and research activities, teaching knowledge, content knowledge, equality among students, teacher-student equality, support for individuals, etc. in particular in teacher-student equality, content knowledge and teaching knowledge were more prominent, but self-selection, individual feedback and technical knowledge were the weakest (Table 3).

Table. 3. Means and standard deviations of the dimensions of teachers' literacy within the framework of "Four Haves" Good Teachers

Level 1	Level 2	Mean	SD	Level 3 I	Mean	SD	Level 3 II	Mean	SD	Level 3III	Mean	SD
Ideals and beliefs	Teacher/teaching	3.01	0.47	Subject concept	3.33	0.55	Scientific thinking	2.69	0.56			
	Educator/educating	2.49	0.67	Self-management	2.88	0.75	Self-selection	2.02	1.18			
Moral sentiment	Love and dedication	3.13	0.44	Professional beliefs	3.04	0.65	School recognition	3.23	0.57	Cooperation among teachers	3.10	0.60
	Decision-making/Supervision	2.98	0.49	Curriculum decision	2.68	1.07	Teaching supervision	3.22	0.77	Teachers' behavior	3.02	0.61
Solid knowledge	Research into teaching	3.11	0.71	Teaching and research	2.95	1.07	Teaching and research activities	3.22	0.81			
	Teachers' knowledge	3.01	0.43	Technical knowledge	2.34	0.64	Teaching knowledge	3.30	0.52	Teachers' subject knowledge	3.32	0.54
Benevolence	Fair treatment of students	3.41	0.60	Equality among students	3.29	0.69	Teacher-student equality	3.67	0.66			
	Attention to individuals	2.60	0.64	Feedback to individuals	2.16	0.79	Adjustment for individuals	2.47	0.80	Individual support	3.13	0.77

Further analysis of the specific differences in the dimensions of teachers' literacy in the 17 countries or regions revealed that in the dimension "equal treatment of students" teachers had relatively higher scores, and in "teachers' education" and "attention to individuals" had the lowest scores. Teachers' level of decision-making/supervision varied greatly among the 17 countries/regions. Taken together, as far as science teachers in Dominican middle schools are concerned, "teachers' teaching" and "love and dedication to teaching" ranked the first; for Korean teachers, "teachers' education" "fair treatment of students" and "decision-making/supervision" ranked the first; for teachers from four provinces and cities of China, "research into teaching" ranked the first; for the UAE teachers, teachers' knowledge ranked the first. In comparison, middle school science teachers from China's four provinces and cities scored above the world average in most of the dimensions of science teachers' literacy and in the dimension "decision-making/supervision" got relatively lower scores, consistent with the world trend. Although they were in the forefront in terms of "teachers' teaching" and "teachers' education", but there is still a gap compared with other dimensions.

4.2 Relationship between teachers' literacy and students' STEM-related career expectations

Considering the 17 countries or regions as a whole, the factor research into teaching was not significantly correlated with students' STEM career expectations (r=0.02, p>0.05), and decision-making/supervision had a low significant negative correlation with students' STEM career expectations (r=-0.10), p<0.01). The other six dimensions, namely, educating students, teaching them, love and dedication, teachers' knowledge, treating students fairly, attention to individuals, had a low degree of significant positive correlation with students' STEM career expectations (Table 4).

In terms of the relationship between teachers' literacy and students' STEM career expectations in 17 countries/regions, treating students fairly and students' high STEM career expectations were the most connected. It was the case in Australia, Brazil, Chile, the Czech Republic, Germany, Portugal, UAE, South Korea and four provinces cities and Hong Kong of China where a significant correlation was identified between them. Teachers' educating had a low positive correlation with students' career expectations, reflected in Australia, the Czech Republic, Portugal, and the United States, and a moderate positive correlation in Germany, but a significant low negative correlation with the career expectations of students from Peru and the UAE. Teachers' love and dedication was positively correlated with the career expectations of students from 6 countries or regions including Australia, Brazil, Chile, Spain, Portugal and Hong Kong.

Table. 4. Correlation between teachers' literacy and students' career expectations

	Overall	Australia	Brazil	Chile	Peru	Czech Republic	Germany	Spain	Portugal	UAE	Korea	Macao	Four provinces	Taipei	Hong Kong	USA	Dominica	Colombia
Educating students	.041**	.277***	0.06	-0.113	-.139*	.199***	.463***	0.046	.267***	-.113*	0.074	-0.195	0.099	-0.095	0.057	.203**	0.046	0.001
Teaching	.158**	0.043	.122**	0.117	-0.031	.242***	.207**	-0.039	0.027	-0.04	0.087	.386*	0.102	0.129	.180*	0.14	0.023	0.003
Love & dedication	.146**	.104**	.111*	.251**	-0.049	0.053	0.079	.292***	.187*	0.025	0.045	0.032	0.069	0.127	.180*	0.119	0.063	0.082
Decision & supervision	-.098**	0.023	0.055	0.014	.141*	-0.031	-.217**	0.068	-0.021	0.008	-0.08	0.182	0.12	0.089	-0.056	0.057	0.067	0.008
Teaching research	0.023	0.03	0.006	-0.004	0.074	-0.052	0.013	-0.018	.314***	-0.076	-0.056	0.209	.164**	0.121	0.005	-0.041	-0.049	-0.03
Teachers' knowledge	.194**	-0.001	0.084	0.059	0.085	-0.105	.153*	0.117	0.028	-0.078	.176*	.433**	.147*	0.054	0.12	0.045	0.108	0.052
Treating students fairly	.130**	.152***	.179***	.266***	0.093	.193***	.126*	0.085	.253***	.259***	.165*	0.291	.156*	0.105	.248**	-0.085	0.08	0.084
Focusing on individuals	.225**	0.032	0.038	-0.09	-0.104	-0.04	-.139*	-0.048	-.166**	0.049	0.076	-.371*	.172**	.160*	-0.032	-0.137	-0.089	0.064

4.3 Regression analysis of the influence of teachers' literacy on students' STEM career expectations

Further regression analysis was used for the analysis of the influence of teachers' literacy on students' career expectations. The family socioeconomic status, whether the mother is engaged in a STEM occupation, whether the father is engaged in a STEM occupation, and the student's performance in science were embodied in Model 1, as the control factors; eight different secondary dimensions of middle school science teachers' literacy were embodied in

Model 2, as an independent variable; whether students choose STEM-related occupations (i.e. career expectations) as a dependent variable (Table 5). Regression analysis was performed on 17 countries/regions in turn. Generally, Model 1 and Model 2 were statistically significant correlated (p<0.001). Model 2 could effectively explain 23% of students' career expectations and had a significant predictive effect. Compared with Model 1, the predictive effect of Model 2 increased by 10%. The VIF value was between 1.09 and 2.77, indicating that multicollinearity had nothing to do with these models. The contribution of fairly treating students (β =0.17, t=11.41, p<0.001) and focusing on individual students (β =0.16, t=9.73, p<0.001) was the largest, which had a significant positive predictive effect on students' career expectations. In addition, teachers' knowledge (β =0.09, t=4.48, p<0.001) and teaching (β =0.06, t=3.19, p<0.001) also had a positive effect in predicting students' career expectations; but decision-making/supervision (β = -0.11, t=-7.27, p<0.001), teaching research (β =-0.06, t=-3.81, p<0.001) had a significant negative effect in predicting students' career expectations.

Table. 5. Regression analysis of the influence of teachers' literacy on students' career expectations

	Model/β	overall	Australia	Brazil	Chile	Peru	Czech Republic	Germany	Spain	Portugal	UAE	Korea	Macao	Four provinces	Taipei	Hong Kong	USA	Dominica	Colombia
1	ESCS	0.13***	0.14*	-0.06	-0.09	0.08	-0.06	0.27	0.14	0.17	-0.07	-0.11	0.18	-0.09	0.04	0.29*	0.03	0.01	0.15
	Occupation/Mother	0.09***	-0.03	0.02	-0.01	0.02	0.05	0.11	0.10	0.07	0.18**	0.08	0.19	0.13	0.12	-0.11	-0.09	-0.28*	0.11
	Occupation/Father	0.24***	0.20***	0.12	0.20	0.11	-0.02	-0.01	0.31**	-0.06	0.32***	0.06	0.39*	0.15*	0.05	-0.16	0.02	0.21	0.00
	Grades	-0.28***	0.28***	0.31***	0.52***	0.17	0.62***	0.32*	0.11	0.30**	0.01	0.36**	0.14	0.42***	0.33**	0.41***	0.21	-0.20	-0.14
2	ESCS	0.16***	0.14*	-0.06	-0.03	0.16	-0.08	0.28	0.15	0.17	-0.09	-0.15	0.10	-0.12	0.07	0.31*	-0.01	0.02	0.18
	Occupation/Mother	0.07***	-0.05	0.04	-0.01	0.04	0.07	0.13	0.09	0.11	0.20***	0.10	0.33	0.14	0.15*	-0.13	-0.08	-0.28*	0.09
	Occupation/Father	0.21***	0.20***	0.10	0.24	0.05	-0.04	-0.05	0.33**	-0.02	0.30***	0.06	0.36	0.14	0.03	-0.17	0.04	0.21	-0.02
	Grades	-0.23***	0.21***	0.29***	0.41**	0.29	0.58***	0.23	0.04	0.18	0.00	0.40**	-0.13	0.46***	0.30*	0.46***	0.20	-0.25	-0.12
	teachers'education	0.02	0.20***	-0.04	0.02	0.20*	0.04	0.14	0.11	0.16*	-0.19**	-0.02	0.10	0.13	0.02	0.08	-0.02	0.01	0.04
	Teachers' teaching	0.06**	-0.01	0.01	-0.08	-0.05	0.19**	-0.01	-0.10	-0.07	0.03	-0.04	-0.02	-0.03	0.10	-0.04	0.08	0.12	-0.07
	Devotion	0.03	0.06	0.04	0.15	-0.04	0.01	0.05	0.18*	0.11	0.05	-0.05	-0.27	-0.07	0.03	0.09	0.09	-0.06	0.12
	Setting examples	-0.11***	-0.03	-0.01	-0.13	0.12	-0.07	-0.13	-0.08	0.06	-0.05	-0.10	0.19	0.00	0.00	-0.09	0.06	0.16	0.03
	Teaching & research	-0.06***	-0.02	0.02	-0.11	0.04	-0.05	-0.08	-0.07	0.23**	-0.07	-0.05	0.10	0.01	0.03	0.02	-0.05	-0.04	0.01
	Knowledge	0.09**	0.01	0.04	-0.01	-0.01	-0.16**	0.01	0.07	-0.05	0.00	0.21	0.30	0.12	-0.09	0.07	0.01	0.03	0.02
	Fair treating	0.17***	0.02	0.06	0.12	-0.07	-0.02	-0.05	-0.02	0.14	0.17**	0.00	0.13	0.01	0.02	-0.09	-0.08	0.20	0.05
	focusing on individuals	0.16***	-0.07	0.05	-0.05	0.00	0.01	-0.06	0.02	0.01	0.01	0.15	-0.18	0.00	0.16*	0.05	-0.02	-0.08	0.00
1	R2	0.13***	0.26***	0.13***	0.35***	0.12***	0.34***	0.39***	0.33***	0.20***	0.14***	0.11**	0.55***	0.28***	0.17***	0.29***	0.06	0.10	0.02
2	R2	0.23***	0.30***	0.14***	0.40***	0.18**	0.38***	0.43***	0.37***	0.32***	0.21***	0.17*	0.65***	0.30***	0.21***	0.33***	0.09	0.17	0.04
	ΔR2	0.10	0.04	0.01	0.05	0.06	0.04	0.04	0.04	0.12	0.07	0.06	0.10	0.02	0.04	0.04	0.03	0.07	0.02

Specifically, Model 1 and Model 2 were significantly correlated (p<0.001 or p<0.05) of 13 countries or regions including Australia, Brazil, Chile, Peru, the Czech Republic, Germany, Spain, Portugal, the UAE, South Korea, Macau, the four provinces and cities of China, Chinese Taipei and Hong Kong. Model 2 could effectively explain 17%~43% of students' career expectations, and had a significant predictive effect. Compared with that of Model 1, the predictive power of Model 2 improved by 1%~12%, especially when Portugal and Macau were involved, with an increase of 12% and 10%, respectively. The VIF value was between 1.03 and 7.13, indicating that multicollinearity had nothing to do with these models. Teachers' education could significantly help predict the career expectations of students positively, in Australia (β =0.20, t=4.96, p<0.001), Peru (β =0.20, t=2.12, p<0.05), Portugal (β =0.16, t=2.32, p<0.05) But in the UAE, the dimension teachers' education significantly predicted in a negative way the career expectations of students (β =-0.19, t=-3.15, p<0.01). Teachers' teaching in Czech could significantly positively help predict students' career expectations (β =0.19, t=3.40, p<0.01). The teaching research from Portuguese teachers could significantly positively help predict students' career expectations (β =0.23, t=3.11, p<0.01). The teachers' knowledge of Czech teachers could significantly negatively help predict students' career expectations (β =-0.16, t=-2.93, p<0.01). The manners in treating students adopted by the UAE teachers could significantly positively predict students' career expectations (β =0.17, t=3.03, p<0.01). The focusing on individual students from Chinese Taipei teachers could significantly help predict students' career expectations (β =0.16, t=2.17, p<0.05). Only in Brazil, Chile, four provinces and cities in China, South Korea, Chinese Taipei, and Hong Kong, the sub-dimensions of high school science teachers' literacy had no significant predictive effect on students' STEM career expectations, and manifested as a predictive effect on scientific academic achievement ??   In Model 1, father's occupation in four provinces and cities in China, in Model 2, mother's occupation in Taipei, China, and family socioeconomic background in Hong Kong, China also contributed in the prediction of students' career expectations. It is worth noting that there is no statistical significance in Model 1 and Model 2

when the United States, Dominica and Colombia were involved.

5. Discussion and conclusion

We conducted an empirical study on the possible relationship between teachers' literacy and students' career expectations, trying to explore what a role teachers play in the development of students' career expectations and the possible functioning mechanism. It was found that generally within the framework of the "Four Haves" Good Teachers the literacy of science teachers in middle school was closely related to students' career expectations, and can help predict students' STEM career expectations to a certain extent. This research was based on PISA 2015 data, which provides the possibility to compare the functioning mechanism of middle school science teachers' literacy on students' STEM career expectations across different countries or regions, and reflects the differences in cultural, political, economic and educational conditions of different countries and regions.

5.1 Relationship between the inherent nature of teachers' literacy and the degree of influence

From a horizontal point of view, fair treating students had the closest relationship with the career expectations of students in different countries. Treating students fairly means that teachers fairly treat the relationship between students, between students and teachers, not favoring or bullying students. Students' sense of fairness and experience of being respected will directly affect their perceptions of teachers and courses taught by the teachers, and in turn affect their future career expectations (Gregory, Clawson & Davis, et al, 2014). However, the relationship between the research into teaching and the career expectations of students in different countries was the weakest. Relatively speaking, the research into teaching mainly refers to teachers' participation in related professional development activities, including two orientations: teaching and research. Teacher's own learning had a relatively small or no direct connection with students' career expectations. It may be that the professional developments of teachers rarely involve the contents concerning students' future career development. Our findings were consistent with those of Rowan-Kenyon et al. (2011), who recommend that although teachers are considered to be an important factor influencing students' career expectations, they should improve their ability through related professional development activities to promote students' STEM career expectations. Only for Portuguese and Chinese students, there was a significant relationship between their career expectations and teachers' research into teaching, which may be because in these countries teacher's professional training is paid more attention to. From a longitudinal point of view, on the whole, the eight secondary dimensions of the "Four Haves" Good Teachers were closely related to students' career expectations, showing that teachers' literacy plays an important role in students' career expectations generally. Teachers' literacy and its manifest behaviors, such as the words and deeds of teachers in and out of the classroom and school, social life and personal life, will subtly affect students' views on science subjects and related non-cognitive factors, and then affect their STEM career expectations.

5.2 Differences in the effects of teachers' literacy in different countries

Affected by the cultural, political, economic and educational conditions of different countries and regions, teachers' literacy plays a different role in predicting students' career expectations.

When the relevant variables were controlled, the teachers' literacy within the framework of "Four Have" Good Teachers could significantly predict students' career expectations, but the specific predicting power in different areas was different.

Among them, the predictive power of the literacy of teachers from Portugal and Macau increased by 12% and 10%, respectively. In the context of low education quality, Portugal launched a new round of reform in the evaluation system for primary and secondary school teachers in 2007, and began to attach importance to the scientific nature of the evaluation system. Based on the original concept of evaluation promoting teachers' professional development, this country proposed the development-oriented concept of promoting teachers' professional development through evaluation, an important prerequisite for the improvement of Portuguese teachers' literacy. Portugal's education system is deeply influenced by tradition. As a former colony of Portugal, Macau, China is a multicultural micro-society, with flexibility and diversity in educational development. Based on the performance in the three dimensions of PISA2015 scientific literacy, Portugal and Macao, China were higher in scientific academic achievement than the OECD average, and Portugal was higher than the OECD average in scientific understanding and career expectations[33].(OECD, 2016). These two regions both attach importance to the role of teachers in student development, so the literacy of science teachers also greatly affects students' career expectations.

5.3 Influence of teachers' literacy and the marginal effect

In the United States, Dominica and Colombia, teachers' literacy within the framework of the "Four Haves" Good Teachers cannot significantly help predict students' career expectations. These three countries were all higher than the OECD average in science career expectations, and the United States was also higher than the OECD average in scientific academic achievement and scientific epistemology (OECD, 2016). The influencing factors of students' career expectations in these countries may be more diverse, and are more closely related to their national policies, culture, and technological development level. Students' STEM career expectations in themselves are probably higher, and other influencing factors are more positive. Therefore, the marginal effects of teacher literacy may be very obvious. Take the United States as an example, its democratic and diverse culture may give students more choices. Near-end factors (such as self-efficacy, interest, etc.) and factors in a wider context (such as the science education evaluation system, relevant education policies that emphasize STEM development and even national policies that emphasize scientific and technological innovation) will comprehensively affect students' career expectations. Relatively speaking, teachers' literacy played a small role. For Brazil, Chile, the four provinces and cities of China, South Korea, Taipei, Hong Kong, science teachers' literacy had no significant predictive effect on students' STEM career expectations. The predictive effect of scientific academic achievement was the greatest, and parents' occupations and family socioeconomic backgrounds did have predictive effects. The functioning mechanism of teachers' literacy in predicting STEM career expectations in these countries/regions may be indirect, mitigated by many intermediary variables. Or maybe the academic achievements of these countries/regions weakened the role of teachers, or the role of teachers' literacy is weaker in these countries and regions, and cannot affect students' STEM career expectations.

In summary, this research focused on the influence of teachers' literacy on students' STEM career expectations, and to a certain extent our research will supplement the multi-level model of

college admissions and social cognitive career theory. The results of this study also show that future research should lay emphasis on the role of teachers, especially teachers' literacy in students' STEM career expectations as well as different influencing degrees of different teachers' literacy dimensions. Regional and cultural differences, as well as the marginal effects of teachers' literacy should also be paid attention to.

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