



# A Comparative Study of Science Teachers' Professional Ethics from the Perspective of Qualified "Four Haves" Teachers in China Based on the Data of PISA 2015

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## ABSTRACT

Teachers' ethics is the embodiment of social moral relationship and reflects the social relations and values. Starts from the perspective of qualified "Four Haves" teachers in China, this research makes an empirical analysis for a comparison of middle school science teachers' professional ethics based on the data of PISA2015. The results show that, the moral feelings are stronger, while the ideal and faith is generally weaker; conscientious and meticulous in work and equal treatment for students are stronger, while being a teacher of man/educating people and individual attention are weaker on the whole; the equality between teachers and students is obviously stronger, while the self-selection, individual feedback and technical knowledge are obviously weaker. There are four types of teachers' ethics based on the clustering results of the 17 countries, and are classified and located the common characteristics to find out the reason and promoting strategy of the "short board".

## 1. Introduction

Warnick and Silverman (2011) contended that teaching is distinct from other professions, in part because of the moral nature of the work. Campbell (2000) pointed out that increased awareness of the ethical dimensions and responsibilities of teaching is essential for both enhanced professionalism and, more significantly, improved practice. In terms of its importance, "Teachers' Ethic is the Soul of Teachers". First of all, the improvement of teachers' social status lies in the perfection of teachers' personality, the sublimity of teachers' ethics and the specialization of the profession, in which teachers' ethics plays an irreplaceable role. Secondly, teachers' loyalty to the educational cause and, their dedication and self-conscious working attitude are the basic elements which determine the prosperity and development of a school. Thirdly, the explicitness of teachers' ethics, such as teachers' behaviors, not only in and out of the classroom and school, but also in their social and personal life, will exert an imperceptible influence on the students and play an important role in the students' moral development and academic development.

In western countries, research suggests that professional ethics is currently a neglected topic in teacher education programs (Sanger & Osguthorpe, 2013; Warnick & Silverman, 2011). Serious discussion of professional ethics education in medical, law, and business schools began to occur in the 1960s. Work on professional

ethics education for teachers, however, lagged behind this development for at least two decades, with scholarly articles on the topic not appearing in substantial numbers until the mid-1980s (e.g., Howe, 1886; Soltis, 1986; Watras, 1986). However, in China, teachers' ethics has always been of great value to the national culture. Tracing back to history, it has been clearly put forward in the Period of the Warring States that "the So-called Teacher, should be a paragon of virtue and learning, so as to teach people on learning the way of the world". (The Book of Rites, The Kings Son). Nowadays, it is clearly indicated in the *Report of the 19th National Conference of CPC (Communist Party of China)* that "We should build up teachers' professional ethics" (Xi, 2017); and, a positive demand "to promote the noble teachers' ethics...", and endeavor to be a qualified Four Haves teachers" has also been proposed in the *Opinions of the State Council of the CPC on deepening the Reform and construction of teaching staff in the new Era* (State Council of the CPC central Committee, 2018). Teachers' ethics with its epochal character, is the embodiment of certain social moral relationships and reflects the social relations and values under historical conditions. Chinese government have called for teachers to be qualified "Four Haves" teachers with ideal and faith, moral sentiment, profound knowledge, and kindheartedness heart (Xi, 2014). The Qualified Four Haves Teacher is the new connotation and standard on building up teachers' ethics in the new era of China. While making strong support, response and

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expansion on the topics and tasks of teachers' ethics, it also provides people with theoretical vision and practical guidance under a thorough and accurate comprehension of the essential implication and internal logic to the construction of teachers' ethics in the new era (Shao, 2016).

Throughout the existing study of teachers' ethics it could be concluded: First of all, most of the findings and conclusions are empirically based (Shapira-Lishchinsky, 2011; Sanger & Osguthorpe, 2013; Warnick & Silverman, 2011); Whereas in China, the research not only on teachers' ethics in early time but also on qualified "Four Haves" teacher in recent years are mainly theoretic discussions, but in deficiency of empirical research or systematic study based on quantitative method, which does little in promoting further development to meet the real needs in practical fields. Secondly, considering research context, teachers' ethics is influenced by the cultural context to a large extent (Ha & Que, 2006). Most of them just study the present situation and training of teachers' ethics within national context, and less do comparative study on the East-West teachers' Ethics, which is not conducive to the promotion and sharing of research results, nor to the in-depth understanding of the differences and gaps of the teachers' ethics between China and other countries in the world. Lastly, as far as the object of study is concerned, most of the research both in China and Western countries started from teaching profession, but seldom made discussion on teachers' ethics from the disciplinary point of view, although some of them has began to investigate teachers' ethics of the teachers in different grades (i.e., kindergarten, primary and middle school, university etc.). The professional ethics will vary with different professions, therefore, local circumstances should be taken into account for relevant moral education (Warnick & Silverman, 2011).

The synthesis of science education is in demand of the teachers' knowledge structure to be professional and extensive. For purpose of cultivation, science education in junior middle school is mainly in assisting students in building up their scientific spirit, attitude and values, and starting learning scientific knowledge, skills and methods systematically, so as to form the ability of scientific exploration and acquire scientific behavior and habits basically. Higher standard is put forward on teaching strategies and teaching methods according to the characteristics of science curriculum. With the data of PISA 2015 from the perspective of the qualified "Four Haves" teacher in China, this paper makes an empirical analysis on science teachers' professional ethics in middle schools of various countries, and is in an effort to investigate its present situation, similarities or differences and strong or weak points.

## 2. Theoretical Framework

From the connotation of qualified Four Haves teacher: First of all, ideal and faith means that the teacher should be a teacher of classics/teaching (i.e., to transmit wisdom and impart knowledge, including both the subject conception and the scientific thinking); and also be a teacher of man/educating (i.e., to teach the students on how to be an upright person, including both self-management and self-selection). Of which, the subject conception refers to the original and noumenon opinion or consciousness on the research object and the process of the subject, which has lasting and transferring value beyond the classroom instruction (Quinn, Schweingruber, & Keller, 2012). It specially refers to whether the teachers make much account of students' abilities which are closely related to livelihood, i.e., observing natural phenomena, explaining problems rationally, getting involved in and programming experiments, implementing experiments and surveys etc in this study. Scientific thinking refers to the individual mental characteristics that the students are in capable of think smoothly during the process of studying and solving scientific problems and academic scientific knowledge. So as to enable the students to comprehend things, solve problems and direct their behaviors in a scientific mode of thinking (Hendrich, Licklider,

Thompson, Thompson, Haynes, & Wiersema, 2018). In this study, it refers to the students' abilities in advocating genuine knowledge, thinking independently, exploring problems and solving problems; such as clear and logical reasoning, drawing reasonable conclusions, expressing their own ideas, completing the experiment report independently, etc. Self-management refers to the students' organizing ability or self-discipline in dealing with events, which also includes the whole process of setting, realizing and monitoring the learning objectives, and the ways to accomplish the learning objectives (Bulla & Frieder, 2018; Liu, Hu, Liu, et al., 2016). It mainly relates to the students' self-discipline and good habits in class circumstances; e.g. to be a good listener, getting into the learning state in time, and observing the discipline in classroom etc. Offering students choices in a classroom may enhance their feelings of self-determination and intrinsic motivation to participate in class activities (Brooks & Young, 2011). The self-selection refers to whether students have opportunities to choose courses from categories, levels and quantity according to their learning state and preferences, so as to stimulate their learning motivation and potential.

Secondly, moral sentiment refers to that teachers should be conscientious and meticulous in work (including professional belief, school acknowledgement and teacher collaboration); and also to set a good example (including curriculum decision-making, teaching supervision, teacher behavior). Of which professional belief refers to teachers' firm belief in the value of labor power based on certain acknowledge by their profession, such as job satisfaction, self-efficacy, etc. (OECD, 2016). Here, it refers to teacher's view on the pros and cons of teacher profession and whether they regret making the career choice. School identification refers to the teachers' acceptance, affirmation and appreciation of school culture psychologically (Poole, 2018), specially including whether the teacher is satisfied with the school or recommend it as a ideal work place for others in this study. Teacher collaboration generally refers to a way of working where teachers combine their resources to achieve specific goals over an extended period of time (Vangrieken, Dochy, Rae, & Kyndt, 2015; Yuan, Zhang, & Yu, 2018), specially here which means that teachers make discussions together on teaching content, teaching strategies, students' interests and examinations etc., so as to improve teaching efficiency. Curriculum decision-making refers to the orientation, decision and choice of relevant issues highlighted in the course made by the whole decision-making of an individual decision-maker or group in designated field and situation on the basis of collecting and integrating information (Ho, 2010), and here it relates to teachers' judgment and choice on the discipline and assessment of students, textbook and teaching content. The teaching supervision refers to whether the schools adopt the following methods which were used to monitor the practice of science teachers in their schools during the previous academic year: tests or assessments of student achievement; teacher peer review of lessons plans, assessment instruments, and lessons; principal or senior staff observations of lessons; and observation of classes by inspectors or other persons external to the school (OECD, 2016). Here, it refers to learning in schools is hindered by such teacher behaviour as: teachers not meeting individual students' needs; teacher absenteeism; school staff resisting change; teachers being too strict with students; and teachers not being well-prepared for classes.

Thirdly, profound knowledge means that teachers should not only participate in teaching research (including academic teaching research and activity-based research), but also master the necessary knowledge (including technical knowledge, teaching knowledge and content knowledge). Of which, the teaching and research activities refer to a kind of practical and reflective professional development activity for the purpose of promoting teacher development; during the process teachers in primary and middle schools are confronted with all kinds of specific problems on education and teaching for analyzing and implementing school curriculum and educating work purposefully, methodically and systematically (Darling-Hammond, 2005). The academic pedagogical research in this paper refers to whether the teacher has participated in academic research activities

or consult relevant professional literature; however, the activity-based pedagogical research refers to whether the teachers have joined professional development groups to improve teaching quality by means of mutual observing, directing and discussing with colleagues. Knowledge of subject content is the premise for teachers on engaging in a particular subject, including not only specific subject knowledge, but also the teachers' profound understanding of the subject being taught and the relationship of the subjects, which is a kind of knowledge that "beyond facts and concepts". Pedagogic knowledge usually refers to general pedagogic knowledge which is a general teaching method shared by all academic subjects. Technical knowledge includes traditional technology and digital technology, and it lays emphasis on technical elements (Mishra & Koehler, 2006). The content knowledge refers to whether the students can explain the complex scientific concepts, clarify the ethical issues relative to science, and be able to explain the relationship among biophysical chemistry, etc.. Teaching knowledge refers to whether the teacher can design experiments or handle operation interactively, and use various evaluation strategies to promote the conceptual understanding of students through discussion. Technical knowledge refers to whether the teacher is able to use interactive whiteboard, and allow the students to watch videos or surf the Internet etc.

Finally, kindheartedness means that teachers should treat every student equally (including equality of students and equality between teachers and students), as well as focus attention on individual (including individual feedback, individual adjustment and individual support). The equality among students means that teachers should treat all the students equally, that is to say, teachers should not neglect a student or treat a student harshly, and do not despise a student etc. Equality between teachers and students refers to the relations between teachers and students, their personality is equal. In this study, the equality between teachers and students means that teachers should not sneer at or insult students. Providing informative and encouraging feedback is essential for improving student outcomes (Lipko-Speed, Dunlosky & Rawson, 2014). The individual feedback refers to that teachers should tell students about their classroom behaviors, their advantages and disadvantages, and offer progressive suggestions to them. Adapting science lessons to students with different knowledge, abilities and needs is crucial if the goal is to teach science to all types of students (Hofstein & Lunetta, 2004). The individual adjustment means that teachers should adjust the content and structure of the curriculum according to students' existing needs and knowledge, and support them in need. Students need support from school staff, particularly from their teachers, if they are to make the most of the learning opportunities available to them (Klem & Connell, 2004). Individual support refers to teachers' extra assistance for students, i.e., help students on learning, explain relevant concept patiently until the students' fully understanding of it, and help students to express their viewpoints etc. From the perspective of structure and orientation, ideal and faith is closely related to teachers' professional mission, so as to provide qualified teachers with a specific goal on establishing their ideal and faith; the close connection between moral sentiment and teachers' professional behaviors offers a clear handhold on the self-cultivation of moral sentiment to qualified teachers; profound knowledge and teachers' professional ability combined closely, which shows a clear direction for qualified teachers on mastering profound knowledge; the combination of Kindheartedness and teachers' professional responsibility, shows a positive demand to the qualified teachers with kindheartedness (Zhang, 2017). These four aspects complement each other with respective roles and functions, none of them is indispensable.

Liebig (1843), a German chemurgist, raised "Liebig's Law of the Minimum" for the first time, in the *Chemistry in its application to agriculture and physiology*. Liebig's Barrel refers that, the capability of a barrel depends on the shortest plank, rather than the highest piece or the average length of all planks, since the surface of water is flat with the shortest plank. If you want to improve the overall effect of the barrel, you should work harder on making up the shortest plank, rather than to lengthen those longer ones. According to

Liebig's Barrel, Hausmann, Klinger & Wagner (2008) advanced the theory of two different types of wooden barrel models. One of the barrel is hooped with horizontal wooden planks, the capacity of it depending on the width of each plank, and the water will be increased when widening any plank of the barrel. In such a case, any effort would be effective. Another barrel is made of vertical planks, the capacity of such a barrel depending on the length of each plank, but the only method for increasing its capacity is to lengthen the shortest plank; namely the *typical Liebig's Barrel*. However, both of the barrel models could be extreme, since the fact often lies between the two barrels. Combined with the qualified "Four Haves" Teacher, we compare teachers' ethics to a wooden barrel. The four big planks of this barrel are not just a whole in-block horizontally or vertically, instead, each big plank is made up of two vertical planks, which is assembled horizontally by two or three small blocks (Fig. 1).

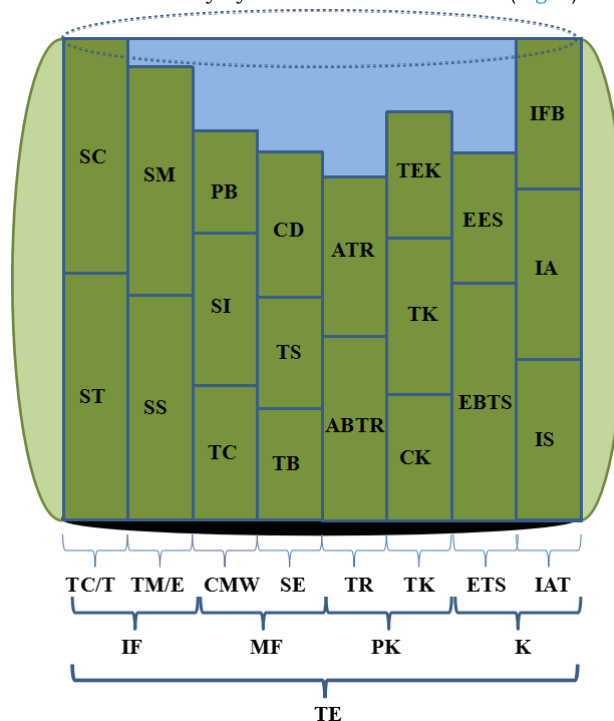


Fig. 1. Plank Effect of the theoretical model in the thesis

Abbreviations, IF: Ideal and Faith, MF: Moral Feelings, PK: Profound Knowledge, K: Kindheartedness, TC/T: Teacher of Classics/Teaching, TM/E: Teacher of Man/Educating, CMW: Conscientious and Meticulous in Work, SE: Set an Example, TR: Teaching Research, TK: Teacher Knowledge, ETS: Equal Treatment for Students, IA: Individual Attention, SC: Scientific Concept, ST: Scientific Thinking, SM: Self-Management, SS: Self-Selection, PB: Professional Belief, SI: School Identification, TC: Teacher Collaboration, CD: Curriculum Decision-making, TS: Teaching Supervision, TB: Teacher Behavior, ATR: Academic Teaching Research, ABTR: Activity-Based Teaching Research, TEK: Technical Knowledge, TK: Teaching Knowledge, CK: Content Knowledge, EES: Equality of Every Student, EBTS: Equality Between Teachers and Students, IFB: Individual Feedback, IA: Individual Adjustments, IS: Individual Support.

### 3. Research Methodology

#### 3.1 Research questions and Data collection

There are research questions of this study: (1) What is the current situation of teacher's ethics of the 17 countries on the basis of the presentation in every third-grade dimension? And, what is the "short board"? (2) How many types are there of teacher's ethics of the 17 countries based on the presentation in every second-grade dimension? What are the characteristics of each type? Data of this research are from school questionnaires, teacher questionnaires and

student questionnaires of PISA 2015. Considering the completeness of the data, only 17 countries with complete data were analyzed, the

basic statistics shown in table 1. All the teachers in this study were teaching science subjects in the current school year at that time.

**Table 1** Basic information of the data for 17 countries.

	School		Teacher		Student	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
AUS(Australia)	758	14.6	3089	15.8	14530	9.8
BRA(Brazil)	841	16.2	2355	12.0	23141	15.6
CHL(Chile)	227	4.4	664	3.4	7053	4.7
TAP(Taipei)	214	4.1	1344	6.9	7708	5.2
COL(Columbia)	372	7.1	1078	5.5	11795	7.9
CZE(Czech)	344	6.6	1401	7.1	6894	4.6
DOM(Dominica)	194	3.7	280	1.4	4740	3.2
DEU(Germany)	256	4.9	1060	5.4	6504	4.4
KHG(Hong Kong)	138	2.7	646	3.3	5359	3.6
KOR(South Korea)	168	3.2	865	4.4	5581	3.8
MAC(Macao)	45	.9	452	2.3	4476	3.0
PER(Peru)	281	5.4	621	3.2	6971	4.7
PRT(Portugal)	246	4.7	897	4.6	7325	4.9
ESP(Spain)	201	3.9	540	2.8	6736	4.5
ARE(United Arab Emirates)	473	9.1	1872	9.6	14167	9.5
USA(United States)	177	3.4	865	4.4	5712	3.8
QCH(China)	268	5.2	1568	8.0	9841	6.6
Total	5203	100.0	19597	100.0	148533	100.0

### 3.2 Data analysis

Table 2 is the theoretical framework and data analysis source of this study. The data firstly is transformed, and then the average scores of the three dimensions is calculated. A single-sample-t test of SPSS is used to compare whether there were significant differences in the average scores between each country and the 17 countries in a given dimension. (In the table, deep shading represents no significant difference, light shading represents the difference is significantly higher, blank shading represent the difference is significantly lower). The averages of each country and the 17

countries in the third dimension were imported into Origin, and made the corresponding scatter diagram. Hierarchical cluster analysis was conducted on the average scores of the third dimension adopting SPSS. Because the four research dimensions at the first class index differ greatly, this study does not adopt a unified clustering method, but proceeds step by step: In the first step, cluster analysis was carried out on the third-grade indexes under each first-grade index, and the second-grade index was assigned value according to the results of clustering; in the second step, clustered the second-grade index and drew the final results from classification according to the assignment of the previous step.

**Table 1.** Theoretical analysis framework and corresponding data.

Barrel	Big Plank	Small Plank	Small Block	Data source
TE	IF	TC/T	SC	TC041Q02NA, TC041Q03NA, TC041Q04NA, TC041Q05NA
			ST	TC037Q01NA, TC037Q02NA, TC037Q07NA, TC037Q12NA
		TM/E	SM	ST097Q01TA, ST097Q02TA, ST097Q03TA, ST097Q05TA
			SS	ST064Q01NA to 4-point, ST064Q02NA to 4-point, ST064Q03NA to 4-point
	MF	CMW	PB	TC026Q01NA, TC026Q02NA, TC026Q04NA reverse scoring, TC026Q06NA reverse scoring
			SI	TC026Q05NA, TC026Q07NA, TC026Q09NA
			TC	TC031Q14NA, TC031Q15NA, TC031Q18NA, TC031Q20NA
		SE	CD	SC010Q07TB 4-point scoring, SC010Q08TB 4-point scoring, SC010Q10TB 4-point scoring, SC010Q11TB 4-point scoring, SC010Q12TB 4-point scoring
			TS	SC032Q01TA 4-point scoring, SC032Q02TA 4-point scoring, SC032Q03TA 4-point scoring, SC032Q04TA 4-point scoring
			TB	SC061Q06TA, SC061Q07TA, SC061Q08TA, SC061Q09TA, SC061Q10TA
	PK	TR	ATR	TC020Q03NA to 4-point, C020Q05NA to 4-point
			ABTR	C020Q02NA to 4-point, C020Q04NA to 4-point, C020Q06NA to 4-point
		TK	TEK	TC037Q08NA, TC037Q18NA, TC037Q19NA
			TK	TC033Q04NA, TC033Q05NA, TC033Q06NA, TC033Q08NA
	K	ETS	CK	TC034Q01NA, TC034Q02NA, TC034Q04NA, TC034Q06NA
			EES	ST039Q01NA reverse scoring, ST039Q02NA reverse scoring, ST039Q03NA reverse scoring, ST039Q04NA reverse scoring
			EBTS	ST039Q05NA reverse scoring, ST039Q06NA reverse scoring
		IAT	IFB	ST104Q01NA, ST104Q02NA, ST104Q03NA, ST104Q04NA, ST104Q05NA
			IA	ST107Q01NA, ST107Q02NA, ST107Q03NA
		IS	IS	ST100Q01TA reverse scoring, ST100Q02TA reverse scoring, ST100Q03TA reverse scoring, ST100Q04TA reverse scoring, ST100Q05TA reverse scoring

## 4. Results

### 4.1 Ideal and Faith

In the dimension of teacher of classics/teaching, the scores on curriculum concept of various countries are higher on a whole, range from 2.88 to 3.71, while the world average score is 3.33. Of which, Dominica got the highest scores(M=3.71), followed by Portugal (M=3.67) and China (M=3.65); only Chile scored below 3 (M=2.88) and was at a slightly lower level. In general, 41.18% of the countries or regions scored significantly higher than the world average, 11.76% without significant difference, while 47.06% scored significantly lower than the world average level. The scores on

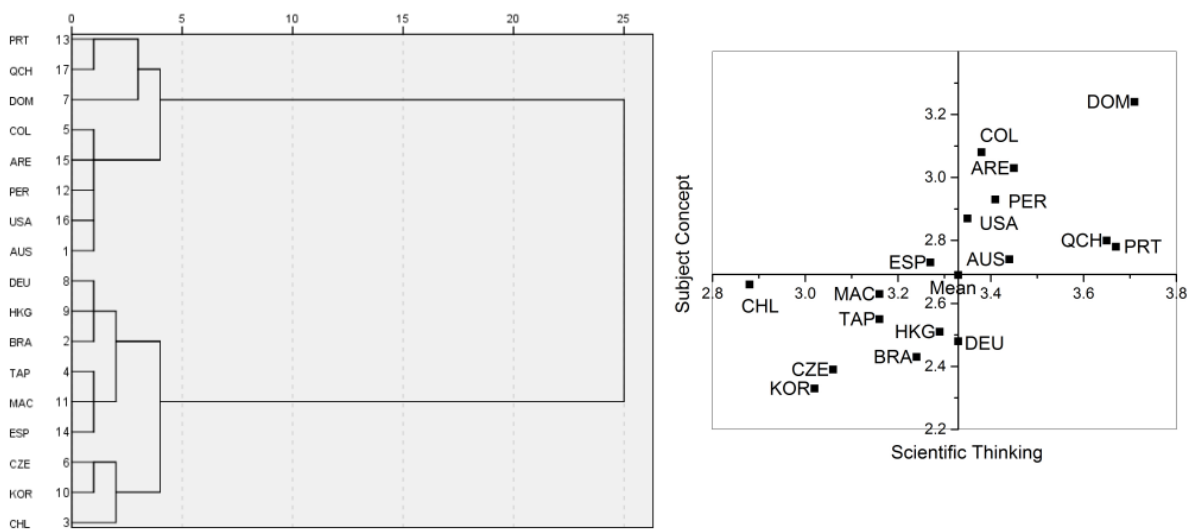
scientific thinking of various countries are all on the low side, range from 2.33 to 3.24, and the average score worldwide is 2.69. Only three countries scored higher than 3, of which, Dominican got the highest score(M=3.24), followed by Colombia (M=3.08) and the United Arab Emirates (M=3.03); South Korea (M=2.33) scored the lowest, followed by the Czech Republic (M=2.39) and Paris (M=2.43). In general, 47.6% of the countries or regions scored higher than the world average, 11.76% without significant difference, while 41.18% scored significantly lower than the world average level.

**Table 3** Comparison of subject concept and scientific thinking in the dimension of teacher of classics/teaching with ideal and faith.

Country	Subject Concept					Scientific Thinking				
	M	SD	T	df	p	M	SD	t	df	p
AUS	3.44	0.45	12.475	2690	0	2.74	0.45	5.534	2406	0
BRA	3.24	0.60	-5.821	1624	0	2.43	0.56	-19.864	1811	0
CHL	2.88	0.59	-18.371	578	0	2.66	0.52	-1.365	613	0.173
TAP	3.16	0.56	-10.22	1094	0	2.55	0.47	-10.197	1184	0
COL	3.38	0.50	2.699	780	0.007	3.08	0.53	20.598	787	0
CZE	3.06	0.50	-18.969	1247	0	2.39	0.44	-24.259	1267	0
DOM	3.71	0.44	11.71	183	0	3.24	0.51	16.094	220	0
DEU	3.33	0.51	0.197	911	0.844	2.48	0.51	-12.95	960	0
KHG	3.29	0.44	-2.407	611	0.016	2.51	0.41	-10.796	621	0
KOR	3.02	0.52	-16.109	722	0	2.33	0.46	-21.565	728	0
MAC	3.16	0.53	-5.503	287	0	2.63	0.45	-2.22	303	0.027
PER	3.41	0.52	3.209	385	0.001	2.93	0.55	9.37	476	0
PRT	3.67	0.38	23.672	719	0	2.78	0.47	5.335	773	0
ESP	3.27	0.56	-2.514	487	0.012	2.73	0.55	1.463	494	0.144
ARE	3.45	0.53	9.282	1652	0	3.03	0.55	25.628	1728	0
USA	3.35	0.50	1.059	677	0.29	2.87	0.55	8.963	753	0
QCH	3.65	0.47	23.424	1239	0	2.80	0.55	7.582	1321	0
Mean	3.33	0.55				2.69	0.56			

Based on the results of the cluster analysis, 17 countries were divided into two types from the teacher of classics/teaching division. The first type includes eight countries: i.e., PRT(Portugal), QCH(China), DOM(Dominica), COL(Colombia), ARE(United Arab Emirates), PER(Peru), USA(United States of America), and AUS(Australia). These countries scored significantly higher than the world average in terms of curriculum concept and scientific thinking in general. On the whole, these countries are at a higher level from

teacher of classics/teaching division. The second type includes nine countries: i.e., DEU(Germany), KHG(Hong Kong), BRA(Brazil), TAP(Taipei), MAC(Macao), ESP(Spain), CZE(Czech), KOR(Korea), CHL(Chile). These countries scored significantly higher than the world average in terms of curriculum concept and scientific thinking in general. On the whole, these countries are at a lower level from teacher of classics/teaching division.



**Fig. 2** Clustering and distribution of 17 countries on the teacher of classics/teaching.

In the aspect of the teacher of man/educating, the scores of various countries on self-management are on the low side in general, range from 2.66 to 3.14, while the world average is 2.88. Of which, Korea got the highest score ( $M=3.30$ ), followed by Hong Kong ( $M=3.14$ ) and China ( $M=3.13$ ); Australia and Brazil ( $M=2.66$ ) had the lowest scores, followed by Czech Republic ( $M=2.67$ ), and Spain ( $M=2.77$ ). On the whole, 52.94% of the countries or regions scored significantly higher than the world average, 5.88% without significant difference, while 41.18% scored significantly lower than the world average level. The scores of various countries on self-selection are all on the low side, range from 1.30 to 3.24, and the world average score is 2.02. These countries all scored below 3, with the United States scoring the highest ( $M=2.83$ ), followed by Korea ( $M=2.53$ ) and Peru ( $M=2.46$ ); seven countries even scored below 2, with the Czech Republic ( $M=1.30$ ) scoring the lowest, followed by Chile ( $M=1.44$ ) and Brazil ( $M=1.52$ ). On the whole, 58.82% of the countries or regions scored significantly higher than the world average level, while 41.18% scored significantly lower than the world average level. Based on the results of the cluster analysis, we divided the 17 countries into two types in the teacher of man/educating division. The first type includes PRT (Portugal), ARE (United Arab Emirates), DOM (Dominica), PER (Peru), USA (United States of America), AUS (Australia), ESP (Spain), KHG (Hong Kong), QCH (China), KOR (Korea), ten countries. With the exception of AUS (Australia), DOM (Dominica), and ESP (Spain), the other seven countries were significantly above the world average in self-selection. These 10 countries are significantly above the world average in self-selection. On the whole, these countries are at a high level of the teacher of classics/teaching division. The second type includes seven countries or regions: i.e. BRA (Brazil), CZE (Czech), CHL (Chile), COL (Colombia), DEU (Germany), TAP (Taipei), and MAC (Macau). With the exception of TAP (Taipei), DEU (Germany), and MAC (Macau), the other four countries are significantly below the world average in self-selection. The seven countries are also significantly below the world average in self-selection. On the whole, these countries are at a low level in the teacher of classics/teaching division.

## 4.2 Moral Feelings

In terms of conscientious and meticulous in work, the overall scores on professional belief of various countries are on the high side, range from 2.76 to 3.64, while the world average is 3.04. Among them, Dominica ( $M=3.64$ ) scored the highest, followed by Germany ( $M=3.44$ ), Colombia and Spain ( $M=3.41$ ); Brazil ( $M=2.76$ ) scored the lowest, followed by China ( $M=2.84$ ) and the Czech Republic ( $M=2.88$ ).

On the whole, 35.29% of the countries or regions scored significantly higher than the world average; 17.65% without significant difference; 52.94% scored significantly lower than the world average. The overall scores of school identification in each country are on the high side, range from 2.90 to 3.70, while the world average is 3.23. Among them, Dominica ( $M=3.70$ ) scored the highest, followed by Colombia ( $M=3.57$ ), Peru ( $M=3.38$ ); only three countries or regions scored below 3, Hong Kong and Macao with the lowest scores ( $M=2.90$ ), followed by Korea ( $M=2.92$ ). On the whole, 52.94% of the countries or regions scored significantly higher than the world average; 11.76% without significant difference; 35.29% scored significantly lower than the world average. The scores on teacher collaboration of each country are on the high side overall, range from 2.64 to 3.45, while the world average is 3.10. Among them, China ( $M=3.45$ ) scored the highest, followed by Dominica ( $M=3.44$ ), United Arab Emirates ( $M=3.43$ ); Germany ( $M=2.64$ ) scored the lowest, followed by the Czech Republic ( $M=2.87$ ), and Brazil ( $M=2.91$ ). In general, 35.29% of the countries or regions scored significantly above the world average; 17.65% of them without significant difference; 47.06% scored significantly below the world average.

According to the results of the cluster analysis, the 17 countries can be divided into two types in terms of conscientious and meticulous in work. The first type includes KOR(Korea), MAC(Macau) TAP(Taipei), KHG(Hong Kong), BRA(Brazil), CZE(Czech Republic), ARE (United Arab Emirates), QCH(China) eight countries. These countries are obviously below the world average in terms of their professional beliefs. In addition to BRA (Brazil), seven other countries are also obviously below the world average in terms of school identification. In addition to KOR(South Korea), ARE(United Arab Emirates) and QCH(China), five other countries are also obviously below the world average or without significant differences in terms of teacher collaboration. In general, these countries are at a lower level regarding conscientious and meticulous in work. The second type includes nine countries: COL(Colombia), ESP(Spain), AUS(Australia), USA(United States), PER(Peru), CHL(Chile), PRT(Portugal), DEU(Germany) and DOM(Dominica). With the exception of PRT(Portugal), the other eight countries scored obviously above the world average or had no significant differences in terms of professional belief. These nine countries are obviously above the world average in terms of school identification in general. With the exception of CHL(Chile), DEU(Germany), ESP(Spain) and USA(United States), the other five countries are above the world average or without significant differences in terms of teacher collaboration. On the whole, these countries are at a higher level regarding conscientious and meticulous in work.

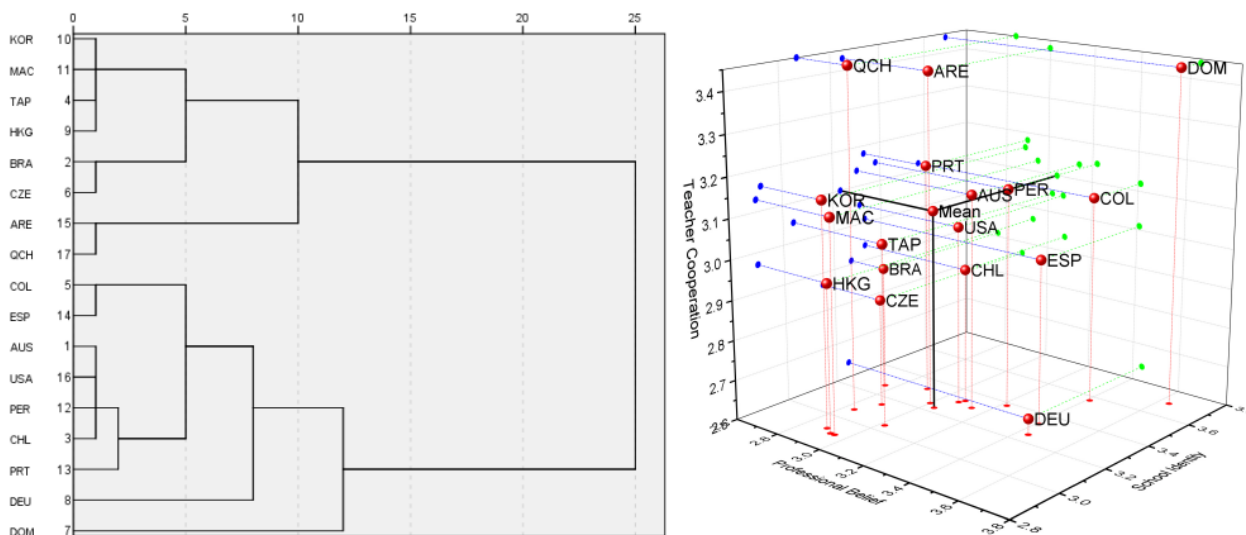


Fig. 3. Clustering and distribution of the 17 countries of conscientious and meticulous in work.

In terms of setting an example, the score on curriculum decision-making of each country was on the low side in general, range from 1.76 to 3.63, while the world average was 2.68. Of which, Hong Kong (M=3.63) scored the highest, followed by Macao (M=3.44) and the Czech Republic (M=3.23); two countries scored below 2, with Dominica (M=1.76) scoring the lowest, followed by China (M=1.90). On the whole, 41.18% of the countries or regions scored significantly above the world average; 23.53% had no significant difference; 35.29% scored significantly below the world average. The scores on teaching supervision of each country are on the high side in general, range from 2.28 to 3.87, while the world average is 3.22. Of which, the United Arab Emirates (M=3.87) scored the highest, followed by China (M=3.86) and Korea (M=3.79); Spain (M=2.28) scored the lowest, followed by Portugal (M=2.76) and Colombia (M=2.79). In general, 52.94% of the countries or regions scored significantly above the world average; while 47.06% scored obviously below the world average. The scores on teacher behavior of each country are on the high side in general, range from 2.64 to 3.34, while the world average is 3.02. Of which, Korea (M=3.34) scored the highest, followed by the Czech Republic (M=3.25) and Spain (M=3.18); China (M=2.64) scored the lowest, followed by Macau (M=2.75) and Chile (M=2.85). On the whole, 29.41% of the countries or regions scored significantly above the world average; 35.29% had no significant difference; 35.29% scored significantly below the world average. According to the results of the cluster analysis, the 17 countries can be divided into two types in terms of setting an example. The first type includes five countries, COL(Colombia), PRT(Portugal), BRA(Brazil), CHL(Chile), and ESP(Spain). The curriculum decision-making and teaching supervision of these countries are obviously below the world average in general. With the exception of ESP(Spain), the other four countries did not differ from or below the world average significantly in terms of teacher behavior. On the whole, these countries are at a low level in terms of setting an example. The second type includes twelve countries, CZE(Czech), KOR(Republic of Korea), KHG(Hong Kong), MAC(Macau), PER(Peru), USA (United States), AUS(Australia), DEU(Germany), TAP(Taipei), DOM(Dominica), ARE(United Arab Emirates), and QCH(China). In terms of curriculum decision-making, with the exception of DOM(Dominica), ARE(United Arab Emirates) and QCH(China), the other nine countries are obviously above the world average or without significant difference. In regard of teaching supervision, with the exception of AUS(Australia), TAP (Taipei) and DEU(Germany), the other nine countries or regions are significantly above the world average. In regard of teacher behavior, with the exception of AUS(Australia), DEU(Germany), MAC(Macau) and QCH(China), the other eight countries or regions are obviously above the world average, or without significant difference. On the whole, these countries are at a high level of setting an example.

#### 4.3 Profound knowledge

In terms of teaching research, each country scored slightly lower in academic teaching research, range from 1.97 to 3.60, while the world average is 2.94. Only four countries scored higher than 3, with Germany (M=3.60) scoring the highest, followed by China and Dominica (M=3.38); Hong Kong scored the lowest (M=1.97), below 2. On the whole, 23.53% of the countries or regions scored significantly above the world average; 35.29% had no significant difference; 41.18% scored significantly below the world average. The overall scores of each country in activity-based teaching research are on the high side in general, range from 2.58 to 3.71, while the world average is 3.22. Of which, China (M=3.71) scored the highest, followed by the United Arab Emirates (M=3.62) and Australia (M=3.51); Germany scored the lowest (M=2.58), followed by Portugal (M=2.68) and the Czech Republic (M=2.73). On the whole, 47.06% of the countries or regions scored obviously above the world average; 11.76% had no significant difference; 41.18% scored below the world average obviously.

According to the results of cluster analysis, the 17 countries or regions can be divided into two types from teaching research: The first type includes KOR(Korea), MAC(Macau), USA(United States), TAP(Taipei), PER(PER), BRA(Brazil), AUS (Australia), ARE (United Arab Emirates), DOM (Dominica) and QCH (China). In regard of the academic teaching research, with the exception of KOR (South Korea), MAC (Macau), ARE (United Arab Emirates) and USA (United States), the other six countries have no significant differences from or above the world average. In terms of activity-based teaching research, the other nine countries or regions are significantly above the world average or without significant differences except BRA (Brazil). In general, these countries are at a high level in teaching research. The second type includes KHG (Hong Kong), COL (Colombia), ESP (Spain), CHL (Chile), PRT (Portugal), CZE (Czech Republic) and DEU (Germany). In regard of academic teaching research, with the exception of DEU (Germany) and PRT (Portugal), the other five countries were all obviously below the world average or without significant difference. All the seven countries are obviously below the world average in terms of the activity-based teaching research generally, and they are at a low level in teaching research on the whole.

In terms of teacher knowledge, the scores on technical knowledge of each country are at a lower level in general, range from 1.80 to 2.84, while the world average is 2.23. Of which, the United Arab Emirates (M=2.84) scored the highest, followed by the United States (M=2.47), Dominica and Spain (M=2.35); Korea scored the lowest (M=1.80), followed by Germany (M=1.92) and Taipei (M=1.96). On the whole, 41.18% of the countries or regions scored obviously above the world average; 11.76% without significant difference; 47.06% scored below the world average obviously. In terms of teaching knowledge, every country scored higher generally, range from 2.71 to 3.71, while the world average is 3.28. Of which, Dominica (M=3.71) scored the highest, followed by the United Arab Emirates (M=3.60) and Colombia (M=3.53); only four countries scored below 3, of which Hong Kong scored the lowest (M=2.71), followed by South Korea and Macau (M=2.96). On the whole, 41.18% of the countries or regions scored obviously above the world average; 17.65% had no significant difference; 41.18% scored below the world average obviously. The overall scores on content knowledge of each country are on the high side in general, range from 2.57 to 3.69, while the world average is 3.31. Of which, Dominica (M=3.69) scored the highest, followed by Colombia (M=3.56) and Chile (M=3.54); only three countries scored below 3, of which Hong Kong scored the lowest (M=2.57), followed by Taipei (M=2.92) and Macau (M=2.94). On the whole, 58.82% of the countries or regions scored obviously above the world average; 11.76% had no significant difference; 29.41% scored below the world average obviously. According to the results of the cluster analysis, we can divide the 17 countries into five types in terms of teacher knowledge. The first type includes seven countries: AUS (Australia), PER (Peru), ESP (Spain), USA (United States), COL (Colombia), DOM (Dominica) and ARE (United Arab Emirates). The seven countries are significantly above the world average in terms of technical knowledge, teaching knowledge and content knowledge in general. These countries are at a high level of teacher knowledge, and the assignment is 2. The second type includes ten countries, CHL(Chile), DEU(Germany), BRA(Brazil), CZE(Czech Republic), PRT (Portugal), MAC (Macao), QCH (China), TAP (Taipei), KOR (Korea) and KHG (Hong Kong). In terms of technical knowledge, with the exception of QCH(China), the other nine countries or regions are all obviously below the world average or without significant difference. In terms of teaching knowledge, with the exception of CHL(Chile), the other nine countries or regions are all obviously below the world average or without significant difference. In terms of content knowledge, with the exception of BRA(Brazil), CHL(Chile) and DEU(Germany), the other seven countries or regions are all obviously below the world average or without significant difference. On the whole, these countries are at a low level of teacher knowledge.

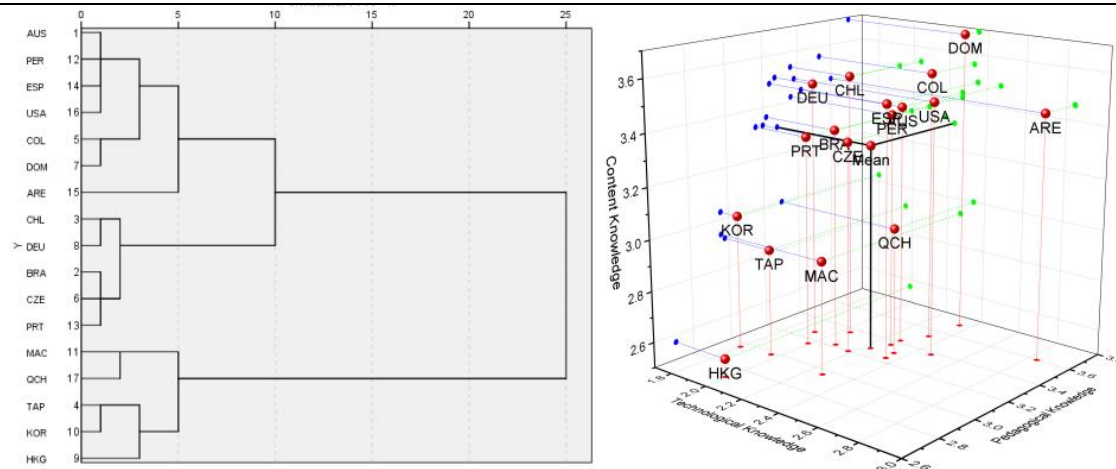


Fig. 4 Clustering and distribution of teacher knowledge in 17 countries.

#### 4.4 Kindheartedness

In terms of equal treatment of students, the scores of various countries are higher on the whole, range from 3.03 to 3.50, while the world average is 3.26. Of which, Korea ( $M=3.50$ ) scored the highest, followed by Taipei ( $M=3.49$ ) and Colombia ( $M=3.40$ ); Hong Kong had the lowest score ( $M=3.03$ ), followed by Macau ( $M=3.07$ ) and China ( $M=3.10$ ). In general, 52.94% of the countries or regions scored significantly higher than the world average; 47.06% of them are obviously below the world average. In regard of equal treatment of students, the scores of each country are much higher on the whole, range from 3.40 to 3.83, while the world average is 3.63. Of which, Taipei ( $M=3.83$ ) scored the highest, followed by Korea ( $M=3.81$ ), Peru ( $M=3.79$ ); the United Arab Emirates scored the lowest ( $M=3.40$ ), followed by Australia ( $M=3.45$ ), and the Czech Republic ( $M=3.51$ ). In general, 52.94% of the countries or regions scored obviously above the world average; 17.65% without significant differences; 29.41% scored below the world average obviously. According to the results of cluster analysis, the 17 countries can be divided into two types in terms of equal treatment of students. The first type includes 9 countries, i.e. TAP (Taipei), KOR (South Korea), BRA (Brazil), ESP (Spain), CHL (Chile), DOM (Dominica), USA (United States), COL (Colombia), CZE (Czech). In regard of equality of every student, these nine countries are all significantly above the world average. In regard of equality between teachers and students, with the exception of CZE (Czech) and USA (United States), the other seven countries are obviously above the world average or without significant difference. On the whole, these countries are at a relatively high level with equal treatment of students. The second type includes 8 countries, AUS (Australia), ARE (United Arab Emirates), HKG (Hong Kong), MAC (Macao), DEU (Germany), PRT (Portugal), PER (Peru), and QCH (China). In terms of equality of every student, these countries are all significantly below the world average. In regard of equality between teachers and students, with the exception of DEU (Germany), PER (Peru), PRT (Portugal), and QCH (China), the other four countries are obviously below the world average or without significant difference. In general, these countries are at a lower level of equal treatment of students.

In terms of attention on individuals, the scores of each country are generally lower regarding individual feedback, range from 1.78 to 2.51, while the world average is 2.20. Of which, Dominican Republic ( $M=2.58$ ) scored the highest, followed by the United Arab Emirates ( $M=2.45$ ), and Peru ( $M=2.36$ ); four countries scored below 2, with Korea scoring the lowest ( $M=1.78$ ), followed by Germany ( $M=1.83$ ), and the Czech Republic ( $M=1.94$ ). On the whole, 41.18% of the countries or regions scored obviously higher than the world average, 5.88% without significant difference; 52.94% are below the world

average obviously. The scores of each country on individual adjustments are lower in general, range from 2.21 to 2.83, while the world average is 2.47. Of which, Portugal ( $M=2.83$ ) scored the highest, followed by the United States ( $M=2.58$ ), and Chile ( $M=2.57$ ); Germany scored the lowest ( $M=2.21$ ), followed by Macau ( $M=2.32$ ), and Korea ( $M=2.35$ ). On the whole, 41.18% of the countries or regions scored obviously higher than the world average; 5.88% without significant differences; 52.94% are below the world average obviously. The scores of each country on individual support are higher as a whole, range from 2.71 to 3.49, while the world average is 3.16. Of which, Dominica ( $M=3.49$ ) scored the highest, followed by Portugal ( $M=3.36$ ), and Peru ( $M=3.29$ ); only four countries scored below 3, with Germany scoring the lowest ( $M=2.71$ ), followed by the Czech Republic ( $M=2.76$ ), and Korea ( $M=2.91$ ). On the whole, 52.94% of the countries or regions scored obviously higher than the world average; 5.88% without significant differences; 41.18% are below the world average obviously.

According to the results of the cluster analysis, the 17 countries can be divided into two types from the individual attention. The first type includes 13 countries or regions, COL (Colombia), PER (Peru), QCH (China), BRA (Brazil), ARE (United Arab Emirates), USA (United States), DOM (Dominica), AUS (Australia), CHL (Chile), TAP (Taipei), KHG (Hong Kong), ESP (Spain), and PRT (Portugal). Regarding individual feedback, with the exception of AUS (Australia), BRA (Brazil), CHL (Chile), PRT (Portugal), and ESP (Spain), the other eight countries were all obviously above the world average or without significant differences. Regarding the individual adjustments, with the exception of BRA (Brazil), TAP (Taipei), COL (Colombia), and PER (Peru), the other eight countries were obviously above the world average or without significant differences. Regarding the individual support, with the exception of TAP (Taipei), KHG (Hong Kong), ESP (Spain), the other 10 countries were obviously higher than the world average or without significant differences. On the whole, these countries are at a higher level of individual attention. The second type includes CZE (Czech), DEU (Germany), KOR (Korea), and MAC (Macao). These four countries were significantly below the world average in terms of individual adjustments, individual adjustments and individual support, and they are at a lower level of individual attention.

## 5. Discussion

According to the clustering results of the second dimension, the 17 countries can be classified into the following four types: The first type includes four countries, DOM (Dominica), USA (United States), AUS (Australia), and PER (Peru). All the eight dimensions of these countries are with high consistency under the four first-grade dimensions. The second type consists of three countries, ARE (United

Arab Emirates), QCH(China), and KHG(Hong Kong). Countries of this type are in a higher level only on the first-grade dimension of ideal and faith, while two second-grade dimensions under all the other first-grade dimensions are in "one high and one low" staggered distribution. This shows that great disparity exists in the first-grade dimensions, but there is more consistency in the second-grade dimensions. The third type includes four countries, COL(Colombia), ESP(Spain), CHL (Chile), and PRT(Portugal). Countries of this type are all in higher level within the two second-grade dimensions which are under the first-grade dimension of kindheartedness, however, great disparity exists within the other three first-grade dimensions. The "one high and one low" staggered distribution of the two second-grade dimensions under the first dimension of ethical feelings shows

great disparity in the first-grade dimension and consistency in the second-grade dimension. The three second-grade dimensions under the first dimension of ideal and faith and profound knowledge are mixed, which shows great disparity existing in these second-grade dimensions. The fourth type includes BRA(Brazil), TAP(Taipei), KOR(Korea), MAC(Macau), CZE(Czech), and DEU(Germany). These countries are on the low side of the two second-grade dimensions under the first dimension of ideal and faith, but in the "one high and one low" staggered distribution of the two second-grade dimension under all the other first dimension. This shows great disparity in the first dimension and consistency in the second dimension. The fourth type and the second type are typical.

**Table.4** Four types of 17 countries science teachers' ethics.

	IF		MF		PK		K	
	TC/T	TM/E	CMW	SE	TR	TK	ETS	IAT
DOM, USA, AUS, PER	high	high	high	high	high	high	higher	high
	high		high		high		high	
ARE, QCH, KHG	higher	high	low	high	higher	low	low	high
	high		mixed		mixed		mixed	
COL, ESP, CHL, PRT	mixed	mixed	high	low	low	mixed	higher	high
	mixed		mixed		mixed		high	
BRA, TAP, KOR, MAC, CZE, DEU	low	lower	lower	higher	higher	low	higher	lower
	low		mixed		mixed		mixed	

Type I is to be maintained including DOM(Dominica), USA(United States), AUS(Australia), PER(Peru). Australia attaches great importance to the quality of teachers' professional development and has formulated applicable standards on this, which have played an important role in promoting its education reform (Goodrum & Rennie, 2007). The *National Professional Standards for Excellent Science Teachers* has been formalized in 2002, by the *Australian Science Teachers Association, ASTA*, for guiding the professional development of their science teachers. The professional development system of science teachers in the United States is comparatively mature. Different standards of science teachers' professional development for the pre-service and in-service training stages have been set by the federal and state governments, which provide institutional guarantee for the professional development of science teachers. At the same time, the United States has implemented a diversified training mode for science teachers, which provides a wealth of choices for their professional development, and a professional development assessment system for science teachers based on the certification of teacher's qualification, in order to improve the professional standards of science teachers. Dominica is similar to Peru, weak in Education and economic base, but develop rapidly in recent years. Both of them have participated in the *One Laptop Per Child project (One Laptop Per Child)*. The Dominican economy is among the best of Caribbean countries, but it is still a relatively backward country belonging to the third world. Peru's economic level is on the high side of Latin America, but the fruits of its economic development failed to benefit ordinary people of the lower classes. Problems of polarization between the rich and the poor remain distinctly. The two countries are retained in the first type for intensive study in the future.

The second type, includes ARE(United Arab Emirates), QCH(China), and KHG (Hong Kong), needs to be strengthened in terms of being conscientious and meticulous in work, teacher knowledge and equal treatment of students. The training system of science teachers in Hong Kong is similar to that of Euro-American countries: on paying attention to practice and emphasizing the application of case teaching and cooperation inquiry in the process of pre-service development; the curriculum design is relatively flexible with high selectivity for students. Compared with the students majoring in science education in Hong Kong, the normal school students in mainland China still have some advantages. For example, students with a sound disciplinary foundation often have superiority on single-subject studying; normal school students are in a high degree on unified training with positive learning initiative and strong sense of discipline (Huang, Su, Xiao, & Zhang, 2009). The third type, including COL(Colombia), ESP(Spain), CHL(Chile), and PRT(Portugal)), needs to be strengthened in terms of setting an example and teaching research. The fourth type, include BRA(Brazil), TAP(Taipei), KOR(Korea), MAC(Macau), CZE(Czech), and DEU(Germany), needs to be strengthened in terms of teacher of classics/teaching, teacher knowledge etc. The pre-service training model of science teachers in Taiwan has strict standards, rigorous procedures, plentiful courses and reasonable practice. The verification standards for science teachers in Taiwan place emphasis on teachers' Chinese language ability, knowledge of teaching discipline, knowledge of teaching practice, and students' development and tutorial knowledge (Konig, Blomeke, Paine, Schmidt, & Hsieh, 2011). The post-service professional development of science teachers in Taiwan consists of two parts, namely, the tutorial system of novice teacher and in-service training, of which, the in-service training is in multi-form and covers a wide range of subjects.

## 6. Conclusion

With the concept of qualified "Four Haves" teachers in China as

a point of departure, this research conduct an empirical analysis based on the data of PISA 2015, which is propitious for the systematic and in-depth comparison of science teacher ethics in middle school. The findings in this study contribute to further research and development so as to meet the real needs in the practice field. It turned out that the moral feelings is stronger in the first dimension, while the ideal and faith is weaker on the whole; from the second dimension, be conscientious and meticulous in work and the equal treatment of students are stronger, while the teacher of man/educating and the attention to individual are weaker on the whole; from the third dimension, the equality between teachers and students is obviously stronger, while the self-selection, the individual feedback and the technical knowledge are weaker evidently. Regarding the types of teachers' ethics in various countries, DOM(Dominica), USA(United States), AUS(Australia), and PER(Peru) fall under the "consistent higher" type; ARE(United Arab Emirates), QCH(China), and KHG(Hong Kong) fall under the "overall higher - high and low disparity" type; COL(Colombia), ESP(Spain), CHL(Chile), and PRT(Portugal) fall under the "High and Low mixed" type; BRA(Brazil), TAP(Taipei), KOR(South Korea), MAC(Macau), CZE(Czech Republic), and DEU(Germany) fall under the "overall lower- high and low disparity" type.

Science teachers in middle school are chosen as our study object, for a thorough understanding and further development of science teachers' professional ethics; so as to promote teachers' professional development and upgrade the quality of science education. Therefore, they should tamp the base of being a teacher of man/educating, and individual attention in teachers' ethics dimension; so as to meet all kinds of challenges of science curriculum in middle school, and adapt to the requirements of science education in middle school. Specifically, we should begin with self-selection, individual feedback and technical knowledge. First of all, teachers should offer opportunities to students for learning relevant contents freely, but the degree of freedom should remain to be discussed. Regarding the degree, it is not the higher the better. The prerequisite for students to make their own choices on learning content according to their interests and capability is that these options can guarantee the students for mastering the basic academic aptitude and be conducive to their further study, career and life in the future. How to grasp the freedom should be the embodiment of the adaptive educational ability of schools and teachers. Secondly, teachers should improve the quality and the frequency of feedback. In the study, the data of this part comes from students' questionnaires, so the scores might be relatively lower. Compared to students, teachers usually say they provide more feedback than what students perceive (Carless, 2006), which shows that there is still great improving space for teachers on individual feedback. Teacher feedback plays a very important role in students' development. Providing informative and encouraging feedback is essential for improving student outcomes (Lipko-Speed, Dunlosky, & Rawson, 2014). Especially for low-performing students, feedback is more important. More perceived feedback is also associated with poorer performance in science, probably because low-performing students need and receive more feedback than better-performing students (OECD, 2016). In addition, the more students perceive that their teachers frequently provide feedback, the more likely they are to expect to work in science-related careers and the stronger their epistemic beliefs. Finally, teachers also need further study for mastering technical knowledge. The mode of teaching and learning in classroom has been greatly changed by the technological development. The new technology can provide representations, analogies, samples etc. of teaching content, thereby promoting the teachers' teaching work and students' understanding of the learning content.

Therefore, it is a necessary accomplishment for the contemporary teachers to use educational technology and master the basic technical knowledge. This is a comparative study on the current situation of teachers' ethics within a cross-cultural background, which is conducive to exploit the differences and gaps of teachers'

ethics in different countries. According to the performance of each country in every dimension of teachers' ethics, these countries are classified and the common traits of each type are found out; thus providing the possibility in searching the reasons of the "short board" of teachers' ethics and the promotion strategy of each type in different countries.

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## References

- Brooks, C. F., & Young, S. L. (2011). Are choice-making opportunities needed in the classroom? using self-determination theory to consider student motivation and learner empowerment. *International Journal of Teaching & Learning in Higher Education*, 23(1), 48-59.
- Bulla, A. J., & Frieder, J. E. (2018). Self - management as a class - wide intervention: An evaluation of the "Self & Match" system embedded within a dependent group contingency. *Psychology in the Schools*, 55(3), 305-322.
- Campbell, E. (2000). Professional ethics in teaching: Towards the development of a code of practice. *Cambridge Journal of Education*, 30(2), 203-221.
- Carless, D. (2006). Differing perceptions in the feedback process. *Studies in higher education*, 31(2), 219-233.
- Darling-Hammond, L. (2005). Teaching as a profession: Lessons in teacher preparation and professional development. *Phi delta kappan*, 87(3), 237-240.
- Goodrum, D., & Rennie, L. (2007). *Australian School Science Education—National Action Plan 2008–2012—volume 1*. Canberra: Commonwealth of Australia.
- Hausmann, R., Klinger, B., & Wagner, R. (2008, September). *Doing growth diagnostics in practice: a Mindbook* (Issue Brief No. 177). Cambridge, MA: Center for International Development, Harvard University.
- Hendrich, S., Licklider, B., Thompson, K., Thompson, J., Haynes, C., & Wiersema, J. (2018). Development of scientific thinking facilitated by reflective self - assessment in a communication - intensive food science and human nutrition course. *Journal of Food Science Education*, 17(1), 8-13.
- Ho, D. C. W. (2010). Teacher participation in curriculum and pedagogical decisions: Insights into curriculum leadership. *Educational Management Administration & Leadership*, 38(5), 613-624.
- Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: foundations for the twenty-first century. *Science Education*, 88(1), 28-54.
- Howe, K. R. (1986). A conceptual basis for ethics in teacher education. *Journal of Teacher Education*, 37(3), 5-12.
- Huang, D., Su, Y., Xiao, H., & Zhang, J. (2009). 内地与香港科学教师职前专业发展比较研究[The comparative research on professional development of pre-service science teacher between China-mainland and Hong Kong]. Paper presented at the 5th Chinese symposium on science education development, Hunan, China.
- König, L., Blomeke, S., Paine, L., Schmidt, W. H., & Hsieh, F. J. (2011). General Pedagogical Knowledge of Future Middle School Teachers: On the Complex Ecology of Teacher Education in the United States, Germany, and Taiwan. *Journal of Teacher Education*, 62(2), 188-201.
- Klem, A. M., & Connell, J. P. (2004). Relationships matter: linking teacher support to student engagement and achievement. *Journal of School Health*, 74(7), 262-273.
- Lipko-Speed, A., Dunlosky, J., & Rawson, K. A. (2014). Does testing with feedback help grade-school children learn key concepts in science?. *Journal of Applied Research in Memory & Cognition*, 3(3), 171-176.
- Le Ha, P., & Van Que, P. (2006). Vietnamese educational morality and the discursive construction of English language teacher identity. *Journal of Multicultural Discourses*, 1(2), 136-151.
- Liebig J. (1843). *Chemistry in its application to agriculture and physiology*. London, UK: Taylor and Walton.
- Liu, X., Hu, Q., Liu, Y., Fang, X., Cheng, Y., Mo, Lei., ... Lin, C. (2016). 我国学生发展核心素养的实证调查[An empirical investigation of core competencies development in China]. *Journal of the Chinese Society of Education*, 29(7), 15-22.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record*, 108(6), 1017-1054.
- OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. Paris: OECD Publishing.
- Poole, A. (2018). "We Are a Chinese School": Constructing School Identity from the Lived Experiences of Expatriate and Chinese Teaching Faculty in a Type C International School in Shanghai, China. *International Journal of Progressive Education*, 14(1), 105-121.
- Quinn, H., Schweingruber, H., & Keller, T. (2012). *A framework for k-12 science education: practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.
- Sanger, M. N., & Osguthorpe, R. D. (2013). Modeling as moral education: documenting, analyzing, and addressing a central belief of preservice teachers. *Teaching & Teacher Education*, 29(1), 167-176.
- Shapira-Lishchinsky, O. (2011). Teachers' critical incidents: ethical dilemmas in teaching practice. *Teaching & Teacher Education*, 27(3), 648-656.
- Shao, Z. (2016). 新时期师德建设本质意涵论析[Essence analysis of teachers' ethics construction in new period]. *Curriculum, Teaching Material and Method*, 36(9), 102-106.
- Soltis, J. F. (1986). Teaching professional ethics. *Journal of Teacher Education*, 37(3), 2-4.
- State Council of the CPC central Committee. (2018, January 20). 中共中央国务院关于全面深化新时代教师队伍建设改革的意见[Opinions of the State Council of the CPC on deepening the Reform and construction of teaching staff in the new Era]. Retrieved from [http://www.gov.cn/zhengce/2018-01/31/content\\_5262659.html](http://www.gov.cn/zhengce/2018-01/31/content_5262659.html)
- Vangrieken, K., Dochy, F., Raes, E., & Kyndt, E. (2015). Teacher collaboration: a systematic review. *Educational Research Review*, 15, 17-40.
- Warnick, B. R., & Silverman, S. K. (2011). A framework for professional ethics courses in teacher education: *Journal of Teacher Education*, 62(3), 273-285.
- Watras, J. (1986). Will teaching applied ethics improve schools of education?. *Journal of teacher education*, 37(3), 13-16.
- Xi, J. (2017, October 18). 决胜全面建成小康社会，夺取新时代中国特色社会主义伟大胜利——在中国共产党第十九次全国代表大会上的报告[Secure a decisive victory in building a moderately prosperous society in all respects and strive for the great success of socialism with Chinese Characteristics for a new era -- Delivered at the 19th National Congress of the Communist Party of China]. Retrieved from <http://cpc.people.com.cn/19th/n1/2017/1027/c414395-29613458.html>
- Yuan, R., Zhang, J., & Yu, S. (2018). Understanding teacher collaboration processes from a complexity theory perspective: a case study of a Chinese secondary school. *Teachers and Teaching*, 24(5), 1-18.
- Zhang, J. (2017). 教师工作价值理论的重大创新——学习习近平总书记关于教师工作的重要论述[Theory innovation of the value of teachers' work—Study of the significant discourse on the value of teachers' work by President Xi Jinping]. *Journal of National Academy of Education Administration*, 6, 3-7.