

# Research on Education Effect for Chinese Medical Students' Learning Style Based on Kirkpatrick Model and Structural Equation Model

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## Research article

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# Abstract

**Background:** The recognition of learning style was not optimistic in China. The evaluating indices of education effect were vague and adopted some ready-made indices such as teaching satisfaction or academic achievement. Those indices have their own basis and significance, but one mere index can not reflect education effect comprehensively.

**Methods:** We used Kirkpatrick model to appraise Chinese medical education effect by selecting appropriate indices for the four levels and structural equation model (SEM) to explore the correlation among those indices after a survey on 17460 medical students.

**Results:** 1) Kirkpatrick model: Level 1 students' satisfaction scored  $4.19 \pm 0.993$ ; Level 2 learning motivation  $1.95 \pm 0.568$ ; Level 3 the Visual  $0.227 \pm 0.131$ , Aural  $0.300 \pm 0.138$ , Read/Write  $0.273 \pm 0.138$  and Kinesthetic  $0.324 \pm 0.144$  for sensory learning style, Extroversion  $0.531 \pm 0.207$ , Sensing  $0.597 \pm 0.186$ , Thinking  $0.585 \pm 0.207$ , Judging  $0.662 \pm 0.225$  for personality type and Concrete Experience  $32.03 \pm 6.394$ , Reflective Observation  $33.41 \pm 6.486$ , Abstract Conceptualization  $34.13 \pm 6.650$ , Active Experimentation  $34.00 \pm 6.600$  for empirical learning style; Level 4 learning attitude  $2.68 \pm 0.781$ , learning expectation  $2.14 \pm 0.953$  and academic achievement  $2.43 \pm 0.793$ . 2) SEM: the fitting indices were 0.687-0.581. Most of the paths were valid except for VARK, T and J parts ( $t < 2$ ,  $P > 0.05$ ).

**Conclusions:** Kirkpatrick model with selected indices evaluated comprehensively the education effect (learning style was one important index); there were actually relations among those indices; based on the importance tested by SEM and students' satisfaction obtained from the survey, we sorted the college cultivating works into four types, among which type B (important but unsatisfactory work) urge most to be strengthened.

## Background

Learning style is a learner's persistent individual learning method and tendency<sup>□</sup>. Studying learning style is both helpful for students to improve learning ability and efficiency and for teachers to promote teaching effectiveness and pertinence. Among those different categorizations of learning style the five taxonomy system invented by Rebecca Oxford was more authoritative: the first type focused on sensory preference and belonged to the physiological element<sup>□</sup> with Fleming's VARK (the Visual, Aural, Read/Write, Kinesthetic) as a representative; the second focused on personality traits and belonged to psychological element<sup>□</sup> with MBTI (Myers Briggs Type Indicator) as a representative; the third, fourth and fifth were related to the way of information processing, reception and thinking mode and belonged to the psychological element<sup>□</sup> with KLSI (Kolb Learning Style Inventory) as a representative.

The quality of medical education is an eternal topic, while most papers studied it only from a certain aspect, such as students' satisfaction, academic achievement and learning motivation etc., those indices

have their own basis, but one mere index was too weak to comprehensively evaluate the education effect. Besides, the relations among those indices were rarely reported.

Kirkpatrick model (K model), the most widely-used evaluation model previously mainly used to evaluate training effect, was proposed by Donald L. Kirkpatrick in 1976<sup>[1]</sup>. It divided the evaluation into four progressive levels: Reaction, Learning, Behavior and Result (Level 1–4), respectively to survey on participants' opinion on the training, their acquirement of knowledge and skills, their ability of practicing mastered knowledge and their concrete contributions to the company operation<sup>[1]</sup>, but it only worked well in the first two levels, the latter two levels, which revealed the training effect more profoundly, were seldom used for lack of practical indices. In recent years, K model has begun to be applied in education, such as evaluating employment guidance training in colleges, principal training in primary and secondary schools<sup>[1]</sup> and MBA courses,<sup>[1]</sup> etc., while its application in evaluating education effect for Chinese medical students' learning style has not been reported.

Theoretically, causal relationship cannot be drawn from any statistical model; still Structural Equation Model (SEM) has the strongest similarity to causal relationship, it can test the presupposed causality<sup>[1]</sup> and obtain the influence of independent variables on dependent variables<sup>[1]</sup>. SEM, synthesizing the idea and method of path analysis and CFA (confirmatory factor analysis), realized the measurement of effect that multiple observed variables had on latent variables through measurement model and established the internal quantitative causality between latent variables through structural model. SEM was widely used in studying correlation, constructing evaluation index system, evaluating and analyzing satisfaction and competitiveness in psychology, management, sociology, medicine etc., but seldom in education. Relevant softwares include LISREL, SAS, AMOS, EQS and Mplus, etc.

Regarding the cultivating of medical students as a training, we selected alternative evaluation indices for the four levels of K model on the basis of experts' repeated demonstration to comprehensively assess the education effect of Chinese medical students for their learning style: students' satisfaction with college cultivating works obtained by self-compiled satisfaction questionnaire (Level 1); students' mastery of professional knowledge and skills represented by their academic achievement of theoretical and clinical skills collected from the administrative department (Level 2); the change of students' learning behavior and attitude with learning style and motivation as the main body gained by surveying with questionnaires of VARK, MBTI, KLSI and learning motivation, learning expectation, as well as symposium and individual interview of teachers, educational managers and students (Level 3); and finally students' contribution to economical and social development demonstrated through their comprehensive quality which represented by participation in the second classroom, quality and quantity of publications, self-management ability and lifelong learning consciousness (Level 4). Based on the information collected at those four levels, the education effect of Chinese medical students concerning learning style was comprehensively evaluated.

On the other hand, since satisfaction, learning motivation, learning style and comprehensive quality are all abstract concepts<sup>[1]</sup>; they have the character of latent variables with measuring difficulty. Considering

SEM's technical characteristic of allowing independent and dependent variables to contain measurement errors, this study, after investigating 17460 students from 11 medical colleges covering different regions of China, constructed SEMs containing multiple latent variables to explore relations among the indices of four levels in K model, namely, the correlation among students' satisfaction with college cultivating works, their learning motivation, learning style and comprehensive quality (including academic achievement) and then the cultivating works tested by SEM with good fit and great contribution were selected and further sorted to provide a reference for medical colleges to improve the education.

## Methods

Firstly, a comprehensive questionnaire was compiled, it contained three widely-used, authoritative learning style inventories (VARK, MBTI and KLSI), which have high reliability and validity, as well as scales to measure students' satisfaction, learning motivation, learning attitude and learning expectation, etc., specifically it included the following parts:

1. basic information.
2. questionnaire on students' satisfaction with cultivating works: based on the 39 observation points of *Evaluation Index System for Qualification of Undergraduate Teaching Work in General Colleges and Universities* issued by China's Ministry of Education (No. 2, 2011), the questionnaire was finally compiled after experts consultation. The satisfaction degree was scored by 5-level Likert method, increasing gradually from 1 to 5.
3. questionnaire on three types of learning style: 1) **VARK** (the Visual, Aural, Read/Write and Kinesthetic) Questionnaire Version 7.0 (2006), it consisted of 16 multiple-choice questions, students' learning style was defined as one or more of type V, A, R and K according to the scores, its alpha reliability coefficient of internal consistency test was 0.86,[12] it was widely used especially in TAFE vocational education in Australia; 2) **MBTI** (Myers Briggs Type Indicator) Chinese Form G, it contained 94 items with 21 in E-I (Extroversion-Introversion) dimension, 26 S-N (Sensing-Intuition), 23 T-F (Thinking-Feeling) and 24 J-P (Judging-Perception), each dimension had two opposite endpoints, representing one of the two preferences, the higher the score, the more extreme it was, according to the eight endpoints (preferences) corresponding to the four dimensions, 16 personality types were shaped, each was represented by four abbreviated letters; 3) **KLSI** (Kolb Learning Styles Inventory) Version 3.1 (2005), it consisted of 12 questions, each described a learning situation with 4 options randomly representing four links of learning process, scores of those links were summarized, and four main variables of CE (Concrete Experience), AC (Abstract Conceptualization), RO (Reflective Observation), AE (Abstract Conceptualization) and two combined variables of AC-CE, AE-RO were calculated, after contrasted with the attached learning style grid, corresponding point in the coordinate of the model was found, then the quadrant was defined to determine whether students' preference during learning process was Converging, Diverging, Assimilating or Accommodating, its alpha reliability coefficient was 0.70 and the reliability coefficient of test-retest for those six variables was 0.54.

4. simple assessment inventory for students' learning motivation: it consisted of 12 items and had high reliability and validity, based on the scores, the intensity of learning motivation was divided into three types, i.e. the weak, intermediate and strong, accordingly recorded 1-3 points.

Others: including students' learning expectation and learning attitude, etc., self-assessment was adopted to streamline the questionnaire, 1-4 points were recorded accordingly from naturalness to excellence in learning expectation and slothful to extremely hardworking in learning attitude.

Cronbach's alpha reliability coefficient was applied in this study and KMO factor analysis was adopted as the structural validity index. The reliability and validity of each scale were shown in **Table 1**. The alpha coefficient of internal consistency test of the whole questionnaire was 0.696, proving good internal consistency, reliability and validity of the questionnaire.

Then, indices of the presupposed K model were slightly adjusted. Considering academic achievement (Level 2) belong to comprehensive quality (part of Level 4), it was incorporated into Level 4, and learning motivation was taken as the index of Level 2 since studies had showed that learning motivation was closely related to academic achievement, and since it was difficult to unify statistical standards of students' participate in the second classroom, besides, times or numbers couldn't truly measure the learning effect and comprehensive quality, thus we finally took students' academic achievement, learning attitude and expectation (observed indices reflecting self-management ability and lifelong learning consciousness) as evaluation indices of Level 4. To sum up, students' satisfaction, learning motivation, learning style, academic achievement and learning attitude and expectation were taken respectively as alternative indices for the four levels of K model to evaluate education effect. For above four level indices, the recognition rates of 30 experts were respectively 96.7%, 93.3%, 96.7% and 90.0%. They thought chosen indices had reflected appraising significance of the four levels of K model and could generally evaluate education effect well, the difficulty in unifying indices to evaluate education effect was solved, and the application of K model in education have been already reported before, this study had sufficient evidence in theory.

Thirdly, SEMs was constructed in four steps[13]. **1) Model setting:** relations between variables were described by establishing path graphs. Variables that are difficult to observe and measure directly are called latent variables and variables that can be measured directly (being usually indices) are called observed variables[14]. **2) Index estimation and model evaluating:** there were many methods for index estimation in SEM, mainly including maximum likelihood estimation, unweighted least squares estimation and general weighted least squares estimation, etc., here the maximum likelihood estimation was adopted. **3) Model identifying:** identifying method was used to judge whether SEM was identifiable, only when the model met the requirements of statistical analysis and software execution, could the SEM approach be carried out smoothly, the identifying rules of SEM generally include t rule and two-step rule, t rule was applied here, before evaluating all SEMs, the validity of measurement models should be evaluated by CFA. **4) Model modifying:** after index estimation, it was necessary to examine some fit indices to evaluate whether the model could correctly describe the relations between observed variables,

mainly including NFI (Normal Fit Index), NNFI (Non-Normal Fit Index), GFI (Goodness of Fit Index) and RMSEA (Root Mean Square Error of Approximation). If the model fitting is bad, the model needs to be revised. The GFI is between 0 and 1, the closer to 1, the better the fitting is, it's generally required to be above 0.80 or at least close to 0.60, which indicate the model fits well.[15]

The preliminary SEM included four parts: **The first** was students' satisfaction with college cultivating works, recorded as f4. In addition to the overall satisfaction (recorded as OS), 16 items (recorded as SS1-16) were subdivided in order to make them more practical and operable. Each observed variable corresponded to a specific question in the questionnaire and was evaluated by Likert 5-level scoring, ranking 1 to 5 from "no satisfaction" to "absolute satisfaction". **The second** was the intensity of students' learning motivation (non-intellectual factors), recorded as f5. **The third** was learning style of three types, namely, sensory learning style (related to physiological element) recorded as f1 and measured by VARK with the standardized score (between 0 and 1, actual score divided by full score) of type V, A, R and K being the index; personality type (related to psychological element) recorded as f2 and measured by MBTI with standardized score of the first endpoints (E, S, T, J) in the four dimensions (E-I, S-N, T-F and J-P) (the standardized scores of the other endpoints was 1 minus the first ones) being the index; empirical learning style (related to psychological element) recorded as f3 and measured by KLSI with the scores of four stages in empirical learning cycle (actual score divided by full score) being the index. In order to explore more accurately the education effect for learning style, we took these three types of learning style as indices of Level 3 in K model. **The fourth** was comprehensive quality, recorded as f6, the observed indices included learning attitude, learning expectation and academic achievement, accordingly recorded as ATTI, EXPE and SCORE.

The theoretical hypothesis was that the better college cultivating works are (the higher the evaluation score of satisfaction), the better its adaptability to students' learning style, the higher students' learning motivation, which contribute to their comprehensive quality; meanwhile motivation and appropriate learning style could also promote comprehensive quality; besides, motivation may directly contribute to learning style.

The SEM was established by SAS9.4 software.

## ***Participants***

Empirical Investigation: In June 2017, according to administrative division, except Hong Kong, Macao and Taiwan, we surveyed students from 11 medical colleges in 7 main regions of China (the East, South, Central, North, Northwest, Southwest and Northeast) with the self-compiled comprehensive questionnaire. The ethical committees of all the universities involved has verified that all the students who voluntarily participated in this survey were well-informed in advance. They were assured that their responses had no effect on their grades and were completely confidential. The questionnaires were distributed centrally and collected immediately after completion. 17460 valid questionnaires were collected from 20000 distributed ones (87.3%): 2688 (15.4%) from the Central, 576 (3.3%) North, 1323 (7.6%) South, 3180

(18.2%) Northwest, 4390 (25.1%) Northeast, 1249 (7.2%) Southwest and 4054 (23.2%) East; 5681 from comprehensive universities (32.5%) and 11779 from medical colleges (with independent organizational system) (67.5%); 8676 from western medicine clinical (49.7%), 825 from Chinese medicine clinical (4.7%) and 7959 from non-clinical (45.6%); 5588 freshmen (32.0%), 5229 sophomores (29.9%), 4194 juniors (24.0%), 2048 seniors (11.7%) and 401 graduating students (2.3%); 9408 males (53.9%) and 8052 females (46.1%); the age ranged from 15 to 31, with an average of  $20.33 \pm 1.594$ .

## ***Data collection***

The data mainly came from the questionnaire and students' final examination scores of last term collected from the administration department according to the Student ID filled in on the questionnaire, scores below 70 (inclusive), 70-80, 80-90 and 90-100 were classified from bad to excellent, accordingly scored 1-4 points.

## **Results**

### ***The four levels of K model***

Level 1 Satisfaction Analysis. Chinese medical students' overall satisfaction with cultivating work was  $4.19 \pm 0.993$ . Specifically, their satisfaction with seriousness of teaching ( $4.24 \pm 0.814$ ) was the highest, followed by teaching level ( $4.19 \pm 0.809$ ), the college ethos ( $4.07 \pm 0.905$ ), the learning atmosphere ( $4.04 \pm 0.904$ ) and importance the leaders attached to teaching work ( $4.04 \pm 0.904$ ), then came the opening of teaching facilities (libraries, etc.) ( $3.98 \pm 0.996$ ), suitability of requirements on students' graduation ( $3.97 \pm 0.883$ ); while their satisfaction with the condition of dormitory and other accommodation was relatively the lowest ( $3.37 \pm 1.300$ ), followed by canteen and other food support ( $3.50 \pm 1.193$ ), and then whether students' choice being respected in teaching management and reform ( $3.77 \pm 1.063$ ), the analysis and guidance the college provided on graduates' employment and development ( $3.84 \pm 1.030$ ), the assessment methods ( $3.85 \pm 0.940$ ) and the campus culture ( $3.86 \pm 1.004$ ), then came practical teaching such as practical training and social practice ( $3.90 \pm 0.965$ ), curriculum resources (network courses, teaching materials, etc.) ( $3.93 \pm 0.985$ ), the guidance and service for students on their study and life in college ( $3.94 \pm 0.964$ ).

Level 2 Learning Motivation Analysis. The overall score was  $1.95 \pm 0.568$ .

Level 3 Three Types of Learning Style Analysis. **VARK sensory learning style:** Chinese medical students were mainly single, accounting for 45.5%, followed by the quadruple (20.4%), then came the double (20.0%) and the triple (14.1%); among the single, the ratio of type V, A, R, K were respectively 4.2%, 13.3%, 9.5% and 18.5%, their standardized scores were respectively  $0.227 \pm 0.131$ ,  $0.300 \pm 0.138$ ,  $0.273 \pm 0.138$  and  $0.324 \pm 0.144$ . **MBTI personality type:** the standardized score of Extroversion was  $0.531 \pm 0.207$ , Introversion  $0.469 \pm 0.207$ , Sensing  $0.597 \pm 0.186$ , Intuition  $0.402 \pm 0.185$ , Thinking  $0.585 \pm 0.207$ , Feeling  $0.414 \pm 0.206$ , Judging  $0.662 \pm 0.225$  and Perception  $0.337 \pm 0.225$ . **KLSI empirical learning style:** the

dominate type was the Diverging (80.1%), followed by Assimilating (13.1%), Accommodating (4.5%) and Converging (2.3%). The scores of the four learning links were  $32.03 \pm 6.394$  for CE,  $33.41 \pm 6.486$  RO,  $34.13 \pm 6.650$  AC and  $34.00 \pm 6.600$  AE.

Level 4 Comprehensive Quality Analysis. The overall self-rated scores of learning attitude and learning expectation were  $2.68 \pm 0.781$  and  $2.14 \pm 0.953$ , the overall status of academic achievement scored  $2.43 \pm 0.793$ .

## ***The relations among the levels of K model***

When VARK was taken as the representative of Level 3 in K model, SEM 1 (**Figure 1**) based on the theoretical hypothesis was constructed to explore relations between latent variables of cultivating works, learning motivation, sensory learning style and comprehensive quality, as well as between latent variables and observed variables.

The GFI of SEM 1 was 0.5742 and AGFI 0.5357 which were slightly low, the model didn't fit well with the sample data model, thus we revised it by removing the f1 and overall satisfaction part and constructed SEM 2 (Figure 2), the GFI was 0.6870, the model reflected relations between variables well and was adopted as the final model after testing. It was showed that the measures proposed in this study of improving students' comprehensive quality by promoting students' learning motivation was effective and meaningful (being successfully-tested by SEM with high fit index), but sensory learning style was irrelevant to them.

By maximum likelihood estimation, fitting results of the measurement model were obtained and collated into **Table 2**, including the estimated value of factor load (i.e., the regression coefficient), standard error and t value, etc., they all had statistical significance ( $t > 2$ ), indicating high goodness of fit index, most of the observed variables had high factor loads and could define well corresponding latent variables. Based on the standardized regression coefficient, the most important observed variable for latent variable of medical students' comprehensive quality was learning attitude (0.72260), followed by learning expectation (0.66376), academic achievement was relatively the least (0.63429). For latent variable of college cultivating works, observed variable SS15 canteen and other food support (0.79541), SS7 whether students' choice being respected in teaching management and reform (0.79463), SS16 the condition of dormitory and other accommodation (0.79199) were comparatively more important, followed by SS14 the analysis and guidance the college provided on graduates' employment and development (0.78007), SS10 the campus culture (social, scientific and technological activities, domestic and international exchanges, etc.) (0.77407), SS12 the guidance and service for students on their study and life in college (0.76124), SS9 practical teaching (0.75594), SS6 curriculum resources (0.75154), SS8 the assessment methods (0.74338), SS5 the opening of teaching facilities (0.73223), SS11 the college ethos (0.72185), SS13 the learning atmosphere (0.72054), SS2 importance the leaders attached to teaching work (0.71700), SS1 suitability of requirements on students' graduation (0.70711), and then the least SS3 teaching level (0.63187) and SS4 seriousness of the teaching (0.60961).

The factor loads in SEM were all statistically significant ( $t > 2$ ,  $p < 0.05$ ). It could be seen from the standardized regression coefficient that college cultivating works had an influence on students' learning motivation (0.12069), and motivation had certain negative influence on comprehensive quality (-0.29132), excessive motivation could lead to decline of comprehensive quality. Therefore, the influence of cultivating works on students' learning motivation and comprehensive quality was obvious. However, none of the  $f_1$  part appeared in the model, which meant that sensory learning style was irrelevant to learning motivation, comprehensive quality and cultivating works.

By combining the standardized regression coefficients of measurement model and SEM, the path graph and standardized solution of SEM 2 for cultivating works, learning motivation, sensory learning style and comprehensive quality were drawn (**Figure 2**), each solid-line path represented a corresponding hypothesis and the path parameters were listed next to them.

## ***“Importance - Satisfaction” analysis***

It could be found that the satisfaction obtained by general statistical method (Chi-square test, variance analysis, etc.) was not consistent with the importance gained by SEM based on standardized regression coefficient. In order to clarify the importance and satisfaction of specific cultivating works, we sorted them according to their importance to the superior indices and students' satisfaction on them. **Table 3** listed the rankings and weight of importance (the standardized regression coefficient of this item/the sum of all items at this index level) and the rankings and scores of satisfaction (actual implementing performance), accordingly various works were divided into four types: A important and satisfactory, B important but unsatisfactory, C satisfactory but unimportant, D neither important nor satisfactory. The judgment criterion was the total ranking, the first 50% were recorded as important or satisfactory and the last were unimportant or unsatisfactory. There was only one work falling into category A: the guidance and service for students on their study and life in college; 7 works fell into category B: curriculum resources, whether students' choice being respected in teaching management and reform, practical teaching, the campus culture, the analysis and guidance the college provided on graduates' employment and development, canteen and other food support, the condition of dormitory and other accommodation; Category C included suitability of requirements on students' graduation, importance the leaders attached to teaching work, teaching level, seriousness of teaching, and the opening of teaching facilities, the college ethos and learning atmosphere; only one item fell into category D: the assessment method.

When MBTI was taken as the parameter of Level 3, SEM 3 (**Figure 3**) for cultivating works, learning motivation, personality type and comprehensive quality was preliminarily built. The E-endpoint of the first dimension was used as contrast to identify and modify the model. The GFI was 0.5870 and AGFI 0.5462, which basically met the model adaptation standard, the hypothesized causal model was acceptable and basically satisfied with the sample data model.

**Table 4** shows the fitting results, the regression path hypothesis test showed that the path coefficient difference were all statistically significant ( $t > 2$ ,  $P < 0.05$ ) except  $f_5 \rightarrow f_2$  between latent variables ( $f_4 \rightarrow f_2$

just came to pass) and  $T \rightarrow f_2$ ,  $J \rightarrow f_2$  between latent variable and observed variable. As expected, these variables could define well corresponding latent variables.

After the removing of bad fitting part, the path graph and standardized solution of SEM 4 for medical students' cultivating works, learning motivation, personality type and comprehensive quality were drawn (**Figure 4**, with E as the reference). It shows that relation between cultivating works and students' personality type was slight, For personality type, the Extroversion (E) was the most important (0.70722), far more than other dimensions; Sensing (S 0.02493) only had a slight contribution, while Thinking (T) and Judging (J) had no relation with personality type.

When KLSI was taken as the parameter of Level 3, SEM 5 (**Figure 5**) for cultivating works, learning motivation, empirical learning style and comprehensive quality was preliminarily built. CE was used as the contrast to identify and modify the model. The GFI was 0.5809 and AGFI 0.5395, basically meeting the model adaptation standard, the hypothesized causal model was acceptable and satisfied with the sample data model.

**Table 5** shows the fitting results, the regression path hypothesis test showed that the path coefficient difference were all statistically significant ( $t > 2$ ,  $P < 0.05$ ) except  $f_5 \rightarrow f_3$  between latent variables. As expected, these variables could define well corresponding latent variables.

After the removing of bad fitting part ( $f_5 \rightarrow f_3$ ), the final path graph and standardized solution of SEM 6 for cultivating works, learning motivation, empirical learning style and comprehensive quality were drawn (**Figure 6**), it shows that cultivating works were related to empirical learning style, but learning motivation was not. For empirical learning style, CE was the most important (0.70875), the importance of other dimensions were similar: RO (0.10563), AC (0.10537) and AE (0.10667), far lower than CE. For comprehensive quality, learning attitude was comparatively most important (0.72978), followed by learning expectation (0.71599) and academic achievement (0.67847).

## Discussion

### ***Selected indices evaluated comprehensively education effect and broke through K model's previous practical limitation***

As mentioned above, there were previously many indices to evaluate education effect, each had its own basis and significance, but one mere index was unilateral. The building of K model solved the dilemma and unified the indices of different levels. **Level 1** students' satisfaction was the most basic index, according to the survey, the overall satisfaction was high ( $4.19 \pm 0.993$ ), especially for the software conditions as seriousness of teaching ( $4.19 \pm 0.993$ ) and teaching level ( $4.19 \pm 0.809$ ) and the implicit culture as the college ethos ( $4.07 \pm 0.905$ ) and the learning atmosphere ( $4.04 \pm 0.904$ ), while the satisfaction was comparatively low for the hardware conditions, such as the condition of dormitory and

other accommodation ( $3.37\pm 1.300$ ), canteen and other food support ( $3.50\pm 1.193$ ). **Level 2** learning motivation scored  $1.95\pm 0.568$  (the full score was 3), between the low and intermediate level, closer to intermediate. Since medical students need to memorize more knowledge and the difficulty of their learning tasks is medium, the intermediate motivation is more appropriate. **Level 3** learning style, for sensory learning style, Chinese medical students with multiple styles (54.5%) were slightly more than those with single style (45.5%), among the single, the K (18.5%) and A (13.3%) were relatively high, they were both above 0.30 in standardized score (K  $0.324\pm 0.144$ , A  $0.300\pm 0.138$ ); for personality type, the four endpoints with higher standardized scores were Extroversion ( $0.531\pm 0.207$ ), Sensing ( $0.597\pm 0.186$ ), Thinking ( $0.585\pm 0.207$ ) and Judging ( $0.662\pm 0.225$ ); for empirical learning style, the standardized scores of four links were: CE  $0.890\pm 0.178$ , RO  $0.928\pm 0.180$ , AC  $0.948\pm 0.185$  and AE  $0.944\pm 0.183$ . **Level 4** comprehensive quality, students' self-rated learning attitude scored  $2.68\pm 0.781$ , locating between the general and comparatively hard-working; their learning expectation scored  $2.14\pm 0.953$ , locating between the qualified and good; the overall score of academic achievement was  $2.43\pm 0.793$ , locating between the intermediate and good. The progressive four levels comprehensively evaluated the education effect of medical colleges with students' learning style taken into consideration.

Meanwhile, since existing authoritative scales to measure learning style, which could reflect students' learning method and behavior (to be used as index of Level 3), as well as the index of learning attitude, learning expectation and academic achievement (to be used as index of Level 4) to assess learning effectiveness which could reflect comprehensive quality, K model's limitation of being seldom used at the latter two levels when evaluating enterprise training effect was broken through, the significance and value of medical students cultivation was demonstrated more profoundly.

## ***There were actually relations among the indices***

We not only used K model to evaluate Chinese medical education effect, but also applied SEM to explore the correlation. It was showed that there were actually potential relations among the indices of four levels in K model.

When VARK being applied (Model 2), cultivating works had influence on students' learning motivation (the standardized path coefficient was 0.12069), and motivation had negative influence on comprehensive quality (-0.29132), but there was no relation between sensory learning style and cultivating works, comprehensive quality.

When MBTI was adopted, cultivating works had a promoting effect on motivation (0.13023), and motivation had a negative effect on comprehensive quality (-0.31481), meanwhile, cultivating works had slight promotion on personality type (0.02342), and personality type had slight negative influence on comprehensive quality (-0.08072); but among the four dimensions of personality type, only Extroversion-Introversion and Sensing-Intuition dimensions, mainly Extroversion, had contribution to it (0.70722); both learning motivation and personality type had a reversed effect on comprehensive quality, that was to say, students' comprehensive quality was not in accordance with their learning motivation intensity and

personality type. Instead, if students' personality type with Extroversion as the main feature was too obvious and learning motivation too strong, it would be harmful to their comprehensive quality.

When KLSI was adopted, cultivating works had influence on motivation (0.12750), and motivation had negative influence on comprehensive quality (-0.30148); meanwhile, cultivating works had an effect on empirical learning style (0.08924), and empirical learning style had a negative effect on comprehensive quality (-0.16642); moreover, the four dimensions of empirical learning style all had contribution to it, but mainly lied in CE (0.70875), supplemented by RO (0.10563), AC (0.10537) and AE (0.10667). It could be concluded that medical college cultivating works could promote students' learning motivation and empirical learning style, but both learning motivation and empirical learning style had a reversed effect on comprehensive quality, if students' empirical learning style with CE as the main feature was too obvious and learning motivation too strong, it would inhibit to their comprehensive quality.

To sum up, there was little relation between cultivating works and sensory learning style, while cultivating works was related to personality type mainly in Extroversion-Introversion dimension and empirical learning style in all dimensions. Among the three types of learning style, empirical learning style had the closest relation with cultivating works. That was to say, cultivating works had certain influence on medical students' learning style, which is mainly manifested in personality type and empirical learning style, especially in the Extroversion-Introversion and Sensing-Intuition dimensions in personality type and all dimensions of empirical learning style. While Extroversion in personality type and CE in empirical learning style had certain negative effect on students' comprehensive quality. Appropriate cultivating measures could improve students' learning motivation (0.12069) and then improve their comprehensive quality (0.29132), therefore, cultivating works had certain impact on students' comprehensive quality, affirming the effect and significance of cultivating works in medical colleges.

## ***The observed variables measured corresponding latent variables well***

Confirmatory factor analysis model could judge whether the exogenous observed variables had significant measurement effect on corresponding latent factors, the explanatory ability or prediction degree (the extent latent variables affected observed variables) can be manifested in factor load[16]. Only when the factor load reached a significant standard, could it be indicated that the measured variable effectively reflect the latent variable it measured, the measurement had good validity[17]. In SEM, when the path coefficient was positive or negative, the relation between observed variable and latent variable or between latent variables was correspondingly positive or negative. The greater the absolute value of the path coefficient, the closer the relation was. The value of factor load could be expressed by standardized regression coefficient (representing the degree of contribution which can be compared) of measurement model in structural equation analysis; its value could reflect the relative importance of measured variable on latent factor.

In this study, some observed variables were set up for latent variables such as three types of learning style, learning motivation, comprehensive quality and cultivating works. Except sensory learning style, which had no significant path coefficients due to poor model fitting, the observed variables were all representative for corresponding latent variables. According to standardized regression coefficient, learning motivation (0.70970) were represented well by observed variable; for comprehensive quality, the most important observed variable was learning attitude (0.72260), followed by learning expectation (0.66736) and academic achievement (0.63429), which meant learning attitude, determining learning behavior and further learning results, could best represent students' comprehensive quality; for personality type, the most important observed variable was Extroversion (0.70722), Sensing also had some significance (0.02493), while Thinking and Judging were not representative; for empirical learning style, the most important observed variable was CE (0.70875), followed by AE (0.10667), RO (0.10563) and AC (0.10537). Generally the observed variables measured corresponding latent variables well, which also illustrated the scientificity of MBTI and KLSI. The importance analysis of observed variables provided a basis for the effective cultivating of medical students.

## ***Those important but unsatisfactory works urge most to be strengthened***

This study observed Chinese medical education effect from multiple perspectives, i.e. students' learning motivation, learning style and comprehensive quality, and investigated the direct or indirect influence between variables to search for the internal structural relations among them, it provided a scientific reference for discovering factors affecting the effectiveness of cultivating works in order to excavate effective and practical improvement measures.

To increase the practical operability of education management, we subdivided the cultivating works into 16 specific ones, the effective works been tested by SEM were put forward concretely. According to their importance (i.e. path coefficient in SEM) and implementing performance (satisfaction), these works were divided into four types: A, advantage approach, i.e. the "important and satisfactory" work, the resources input of which was suggested to be maintained to keep existing advantage, there was only one item falling into this category, i.e. the guidance and service on students' study and life in college; B, repairing approach, i.e. the "important but unsatisfactory" work, the resource investment of which should be strengthened and special attention should be paid in order to repair the existing "loopholes" and improve the overall satisfaction, 7 items fell into this category, naming curriculum resources, whether students' choice being respected in teaching management and reform, practical teaching, the campus culture, the analysis and guidance the college provided on graduates' employment and development, canteen and other food support, the condition of dormitory and other accommodation, these works need to be noticed urgently and improved in the first sequence; C, maintaining approach, namely "satisfactory but unimportant" work, the investment could be reduced as appropriate on the basis of maintaining satisfaction or be temporarily shelved, these items are: suitability of requirements on students' graduation, importance the leaders attached to teaching work, teaching level, seriousness of teaching, the

opening of teaching facilities, the college ethos and learning atmosphere; D, opportunity approach, i.e. “neither important nor satisfactory” work, there was only one item, i.e. assessment methods, which must be reformed and improved in the second sequence.

Students’ satisfaction evaluation could provide first-hand material for decision-making of education administration departments and colleges; it had long been one of main methods for efficient education management in developed countries[18]. There were still two problems need to be clarified: 1)satisfaction alone cannot judge whether the item should be raised in resource input, at least its importance should be taken into consideration; 2)satisfaction, an emotional index, couldn’t remain unchanged for a long time, this required colleges to take satisfaction survey as a regular work in order to improve the pertinence of decision-making.

## Conclusions

Different evaluating indicators were showed simultaneously by using K model to evaluate the education effect for Chinese medical students’ learning style. These indicators were proved mutual-connected by SEM, cultivating works had influence on students’ learning style, which is mainly manifested in personality type and empirical learning style, appropriate cultivating measures could also improve students’ learning motivation and then improve their comprehensive quality, which affirmed the effect and significance of cultivating works in medical colleges. The effective works been tested by SEM were put forward concretely and sorted into four types according to their importance (path coefficient) and students’ satisfaction; among which type B, those important but unsatisfactory works, urge most to be strengthened.

Despite the significance and innovations of this study as mentioned above, it has deficiencies which provide future research directions. Firstly, indices at Level 2 and 4 in K model need to be further excavated. Since the original intention of level 2 was to evaluate trainee’s improvement in knowledge and skills, learning motivation could be an alternative index as it’s one of the main factors affecting student’s knowledge and ability development, but it’s not the best one. Also students’ academic achievement, learning attitude and expectation at level 4 could represent learning effectiveness, they were still not the best and comprehensive indices since the original intention was to assess students’ contribution to economical and social development. Secondly, classifying cultivating works based on the importance and satisfaction is meaningful for colleges to manage education reasonably and orderly, but specific cultivating works must be constantly adjusted and improved with the development of the times.

## Declarations

*Ethics approval and consent to participate*

The ethical committees of Naval Medical University and all other universities involved in this study have verified that all the students who voluntarily participated in this survey were well-informed in advance. They were assured that their responses had no effect on their grades and were completely confidential. We considered the return of a completed questionnaire to represent the provision of informed consent and other ethics approvals were not required given the study design.

#### *Consent for publication*

Not applicable

#### *Availability of data and materials*

All data generated or analyzed during this study are included in this published article.

#### *Competing interests*

The authors declare that they have no competing interests.

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#### *Authors' contributions*

JL designed the study and composed the article. YS was responsible for the design of the two models. XHH was responsible for the statistical analysis. XPQ conducted the detailed questionnaire survey. QH established and modified SEM. JL revised the article and approved of the final version to be published. All authors read and approved the final manuscript.

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## **Abbreviations**

K Model, Kirkpatrick Model; SEM, Structural Equation Model; VARK, the Visual, Aural, Read/Write, Kinesthetic; MBTI, Myers Briggs Type Indicator; KLSI, Kolb Learning Style Inventory; CFA, Confirmatory Factor Analysis; E-I, Extroversion-Introversion; S-N, Sensing-Intuition; T-F, Thinking-Feeling; J-P, Judging-Perception; CE, Concrete Experience; AC, Abstract Conceptualization; RO, Reflective Observation; AE, Abstract Conceptualization; NFI, Normal Fit Index; NNFI, Non-Normal Fit Index; GFI, Goodness of Fit Index; RMSEA, Root Mean Square Error of Approximation; OS, overall satisfaction; ATTI, learning attitude; EXPE, learning expectation; SCORE, academic achievement.

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## Tables

**Table 1 Reliability and validity of the questionnaires**

Questionnaire	$\alpha$ reliability coefficient	KMO factor analysis (validity)
Learning Motivation	0.634	0.831
VARK	0.726	0.870
MBTI	0.514	0.827
KLSI	0.941	0.859
Satisfaction	0.953	0.961

**Table 2 Maximum likelihood estimation result of the final measurement model and SEM for cultivating works, learning motivation and comprehensive quality**

Latent Variable (Dimension)	Observed Variable (Items)	Regression Coefficient (Factor load)	Standard Error	t	P	Standardized Regression Coefficient	R <sup>2</sup>
<b>Measurement Model</b>							
f4	SS1	1.00000			<0.0001	0.70711	0.5000
	SS2	1.02859	0.00998	103.1	<0.0001	0.71700	0.5141
	SS3	0.81525	0.00948	85.9711	<0.0001	0.63187	0.3993
	SS4	0.76903	0.00939	81.9227	<0.0001	0.60961	0.3716
	SS5	1.07512	0.01010	106.4	<0.0001	0.73223	0.5362
	SS6	1.13924	0.01027	110.9	<0.0001	0.75154	0.5648
	SS7	1.30891	0.01076	121.7	<0.0001	0.79463	0.6314
	SS8	1.11138	0.01020	109.0	<0.0001	0.74338	0.5526
	SS9	1.15475	0.01031	112.0	<0.0001	0.75594	0.5715
	SS10	1.22265	0.01051	116.4	<0.0001	0.77407	0.5992
	SS11	1.04306	0.01002	104.1	<0.0001	0.72185	0.5211
	SS12	1.17390	0.01037	113.2	<0.0001	0.76124	0.5795
	SS13	1.03912	0.01001	103.8	<0.0001	0.72054	0.5192
	SS14	1.24675	0.01058	117.9	<0.0001	0.78007	0.6085
	SS15	1.31239	0.01077	121.9	<0.0001	0.79541	0.6327
	SS16	1.29722	0.01072	121.0	<0.0001	0.79199	0.6273
f5	MI	1.00000				0.70970	0.5037
f7	ATITU	1.00000				0.72260	0.5222
	EXPE	0.85724	0.01054	81.3073	<0.0001	0.66736	0.4454
	SCORE	0.78486	0.01037	75.6926	<0.0001	0.63429	0.4023
<b>SEM</b>							
f4	f5	0.12158	0.01197	10.1607	<0.0001	0.12069	0.0146
f5	f7	-0.30230	0.01426	-21.1925	<0.0001	-0.29132	0.0849

**Table 3 The sort of cultivating works based on importance and satisfaction**

Cultivating works	Specific items	Rankings /weight of importance[%]	Importance	Rankings /score of satisfaction[%]	Satisfaction	Type
SS1	suitability of requirements on students' graduation	14/70.71%	unimportant	7/3.97	satisfactory	C
SS2	importance the leaders attached to teaching work	13/71.70%	unimportant	5/4.04	satisfactory	C
SS3	teaching level	15/63.19%	unimportant	2/4.19	satisfactory	C
SS4	seriousness of teaching	16/60.96%	unimportant	1/4.24	satisfactory	C
SS5	the opening of teaching facilities (libraries, etc.)	10/73.22%	unimportant	6/3.98	satisfactory	C
SS6	curriculum resources (network courses, teaching materials, etc.)	8/75.15%	important	9/3.93	unsatisfactory	B
SS7	whether students' choice being respected in teaching management and reform	2/79.46%	important	14/3.77	unsatisfactory	B
SS8	the assessment methods	9/74.34%	unimportant	12/3.85	unsatisfactory	D
SS9	practical teaching such as practical training and social practice	7/75.59%	important	10/3.9	unsatisfactory	B
SS10	the campus culture (social, scientific and technological activities, domestic and international exchanges, etc.)	5/77.41%	important	11/3.86	unsatisfactory	B
SS11	the college ethos	11/72.19%	unimportant	3/4.07	satisfactory	C
SS12	the guidance and service for students on their study and life in college	6/76.12%	important	8/3.94	satisfactory	A
SS13	the learning atmosphere	12/72.05%	unimportant	4/4.05	satisfactory	C
SS14	the analysis and guidance the college provided	4/78.01%	important	13/3.84	unsatisfactory	B

	on graduates' employment and development					
SS15	canteen and other food support	1/79.54%	important	15/3.50	unsatisfactory	B
SS16	the condition of dormitory and other accommodation	3/79.20%	important	16/3.37	unsatisfactory	B

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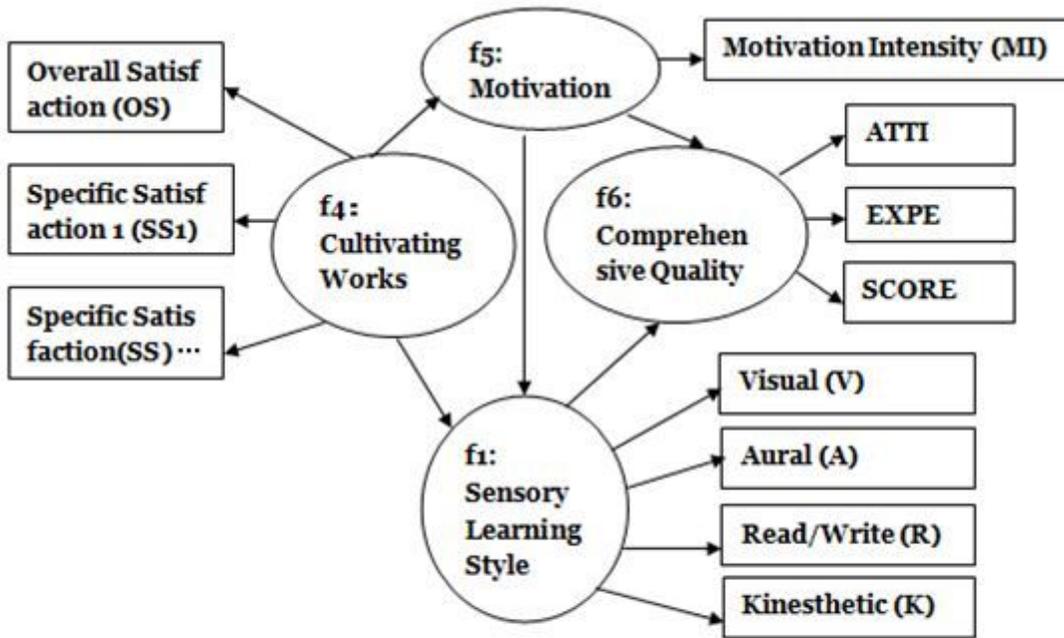
**Table 4 Maximum likelihood estimation result of the measurement model and SEM for cultivating works, learning motivation, personality type and comprehensive quality**

Latent Variable (Dimension)	Observed Variable (Items)	Regression coefficient (Factor load)	Standard Error	t	P	Standardized Regression Coefficient	R <sup>2</sup>
<b>Measurement Model</b>							
f2	E	1.00000	-	-		0.70722	0.5002
	S	0.02493	0.01181	2.1107	0.0348	0.02493	0.000622
	T	0.01378	0.01181	1.1670	0.2432	0.01379	0.000190
	J	0.01456	0.01181	1.2328	0.2177	0.01456	0.000212
f4	DC1	1.08430	0.01007	100.6	<0.0001	0.73511	0.5404
	DC2	1.12401	0.01092	102.9	<0.0001	0.74712	0.5582
	DC3	0.89093	0.01010	88.1782	<0.0001	0.66521	0.4425
	DC4	0.84044	0.00994	84.5184	<0.0001	0.64339	0.4140
	DC5	1.17502	0.01112	105.7	<0.0001	0.76154	0.5799
	DC6	1.24508	0.01139	109.3	<0.0001	0.77967	0.6079
	DC7	1.43045	0.01217	117.6	<0.0001	0.81959	0.6717
	DC8	1.21456	0.01127	107.7	<0.0001	0.77200	0.5960
	DC9	1.26201	0.01146	110.1	<0.0001	0.78377	0.6143
	DC10	1.33622	0.01177	113.6	<0.0001	0.80062	0.6410
	DC11	1.13994	0.01098	103.8	<0.0001	0.75174	0.5651
	DC12	1.28294	0.01155	111.1	<0.0001	0.78871	0.6221
	DC13	1.13562	0.01097	103.6	<0.0001	0.75050	0.5633
	DC14	1.36251	0.01188	114.7	<0.0001	0.80617	0.6499
	DC15	1.43434	0.01218	117.7	<0.0001	0.82032	0.6729
	DC16	1.41782	0.01211	117.1	<0.0001	0.81719	0.6678
f5	DJ	1.00000				0.71012	0.5043
f7	ATITU	1.00000				0.72665	0.5280
	EXPE	0.96363	0.01058	91.0489	<0.0001	0.71381	0.5095
	SCORE	0.86542	0.01032	83.8879	<0.0001	0.67520	0.4559
<b>SEM</b>							
f4	f2	0.02343	0.01227	1.9093	0.0562	0.02342	0.000650
f5	f2	0.00741	0.01674	0.4426	0.6581	0.00747	
f4	f5	0.13135	0.01189	11.0444	<0.0001	0.13023	0.0170
f2	f7	-0.08535	0.01443	-5.9152	<0.0001	-0.08072	0.1062
f5	f7	-0.33014	0.01410	-23.4183	<0.0001	-0.31481	

**Table 5 Maximum likelihood estimation result of the measurement model and SEM for cultivating works, learning motivation, empirical learning style and comprehensive quality**

Latent Variable (Dimension)	Observational Variable (Items)	Regression coefficient (factor load)	standard Error	t	P	Standardized Regression Coefficient	R <sup>2</sup>
<b>Measurement Model</b>							
f 3	CE	1.00000	-	-		0.70875	0.5023
	RO	0.10573	0.01158	9.1301	<0.0001	0.10563	0.0112
	AC	0.10546	0.01158	9.1073	<0.0001	0.10537	0.0111
	AE	0.10678	0.01158	9.2211	<0.0001	0.10667	0.0114
f4	DC1	1.08722	0.01078	100.8	<0.0001	0.73601	0.5417
	DC2	1.12703	0.01093	103.1	<0.0001	0.74800	0.5595
	DC3	0.89335	0.01011	88.3557	<0.0001	0.66622	0.4438
	DC4	0.84274	0.00995	84.6956	<0.0001	0.64442	0.4153
	DC5	1.17817	0.01113	105.9	<0.0001	0.76240	0.5813
	DC6	1.24843	0.01141	109.4	<0.0001	0.78049	0.6092
	DC7	1.43427	0.01218	117.7	<0.0001	0.82030	0.6729
	DC8	1.21783	0.01128	107.9	<0.0001	0.77284	0.5973
	DC9	1.26541	0.01147	110.3	<0.0001	0.78458	0.6156
	DC10	1.33979	0.01178	113.7	<0.0001	0.80139	0.6422
	DC11	1.14301	0.01099	104.0	<0.0001	0.75262	0.5664
	DC12	1.28639	0.01156	111.3	<0.0001	0.78951	0.6233
	DC13	1.13870	0.01098	103.7	<0.0001	0.75139	0.5646
	DC14	1.36615	0.01189	114.9	<0.0001	0.80692	0.6511
	DC15	1.43818	0.01220	117.9	<0.0001	0.82103	0.6741
	DC16	1.42164	0.01213	117.2	<0.0001	0.81792	0.6690
f5	DJ	1.00000				0.71000	0.5041
f7	ATITU	1.00000				0.72978	0.5326
	EXPE	0.96081	0.01051	91.3907	<0.0001	0.71599	0.5126
	SCORE	0.86521	0.0125	84.4392	<0.0001	0.67847	0.4603
<b>SEM</b>							
f4	f3	0.08966	0.01214	7.3879	<0.0001	0.08924	0.00924
f5	f3	0.02603	0.01659	1.5692	0.1166	0.02613	
f4	f5	0.12855	0.01191	10.7939	<0.0001	0.12750	0.0163
f3	f7	-0.17682	0.01428	-12.3807	<0.0001	-0.16642	0.1224
f5	f7	-0.31919	0.01420	-22.4775	<0.0001	-0.30148	

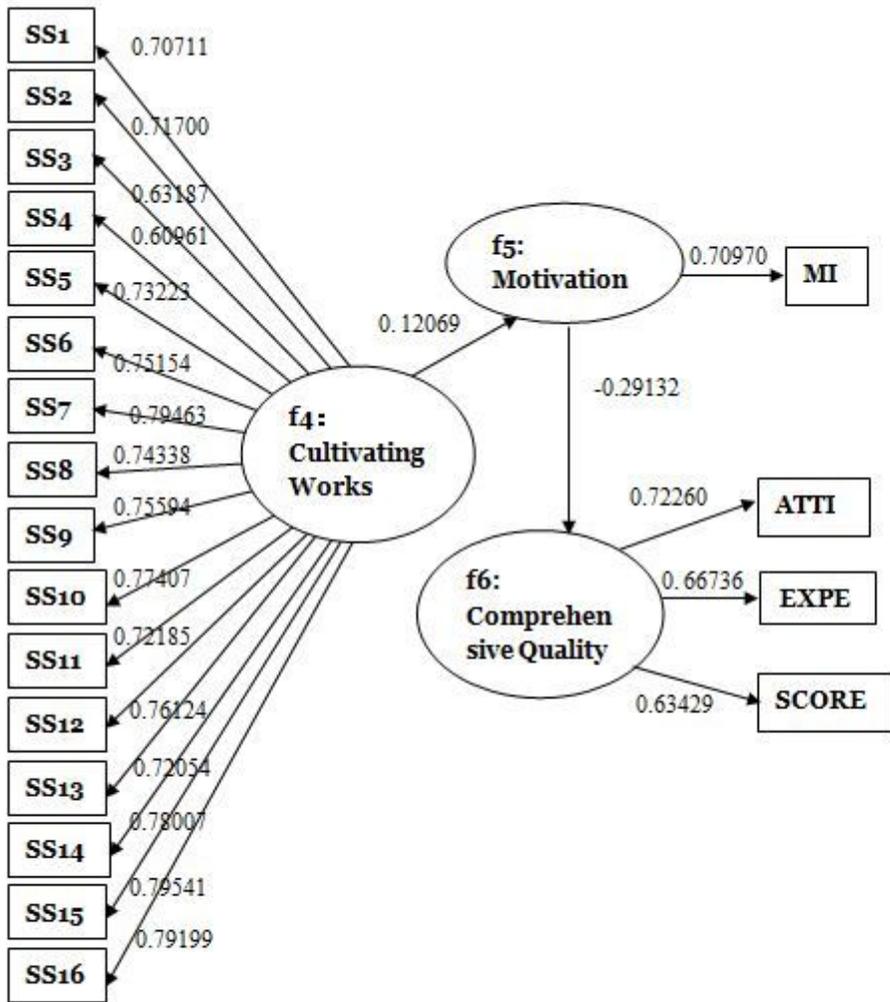
## Figures



**Figure 1**

**Figure 1**

The path graph of preliminary SEM 1 for cultivating works, learning motivation, sensory learning style and comprehensive quality (with latent variables in circles, measured variables in boxes, arrows representing causal direction);



**Figure 2**

**Figure 2**

The path graph and standardized solution of the final SEM 2 for cultivating works, learning motivation, sensory learning style and comprehensive quality (with sensory learning style being deleted);

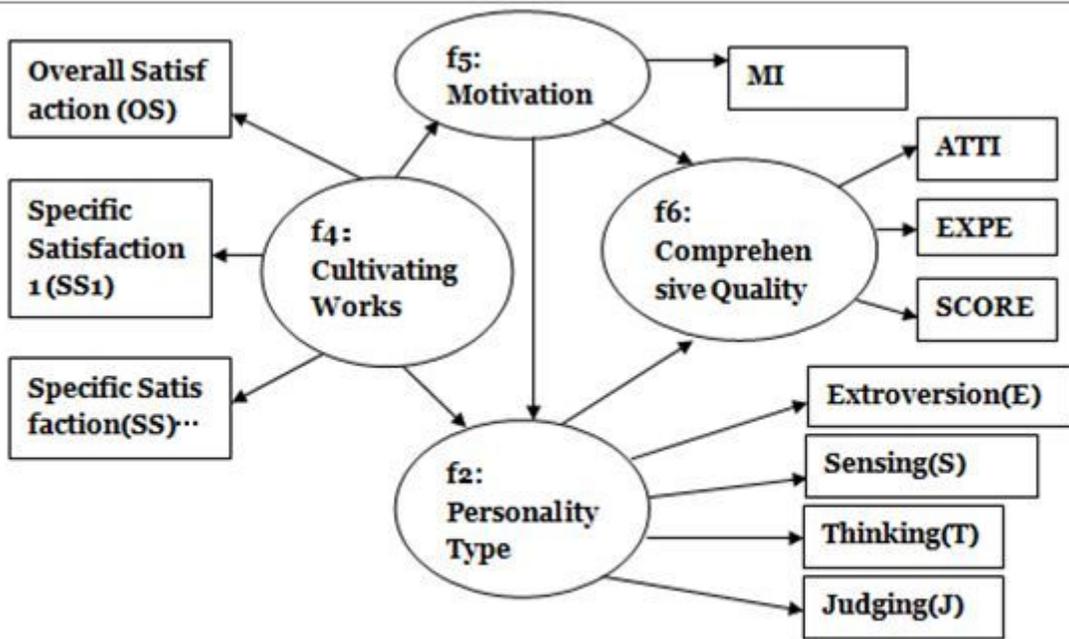
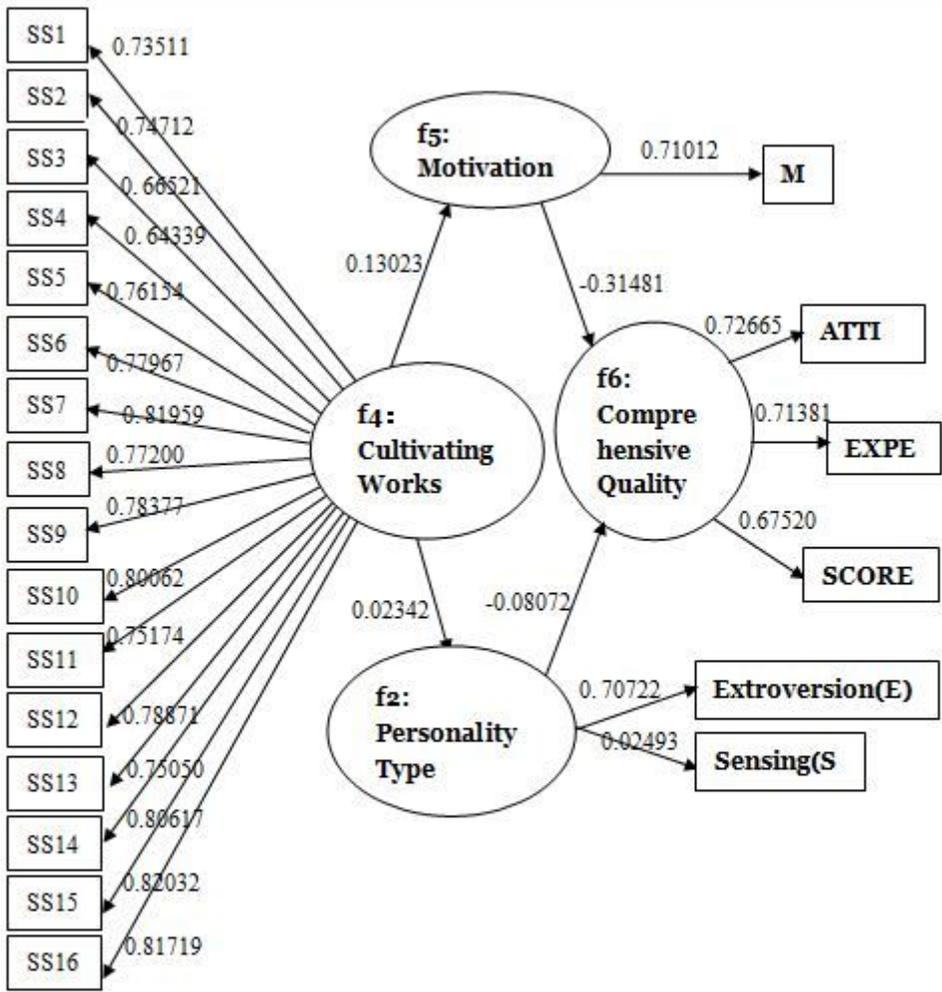


Figure 3

Figure 3

The path graph of preliminary SEM 3 for cultivating works, learning motivation, personality type and comprehensive quality;



**Figure 4**

**Figure 4**

The path graph and standardized solution of the final SEM 4 for cultivating works, learning motivation, personality type and comprehensive quality (with E as the reference);

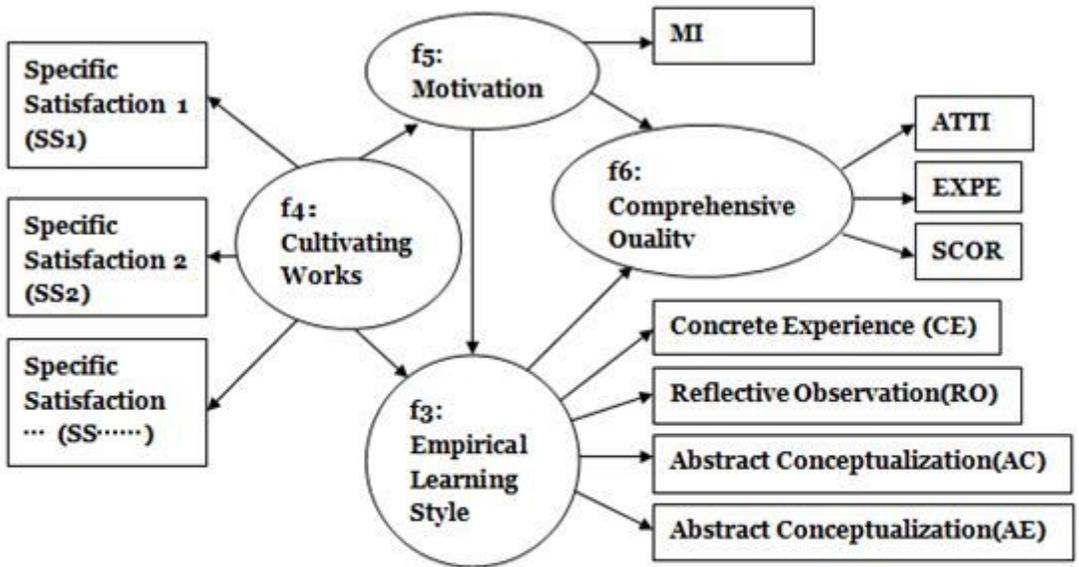
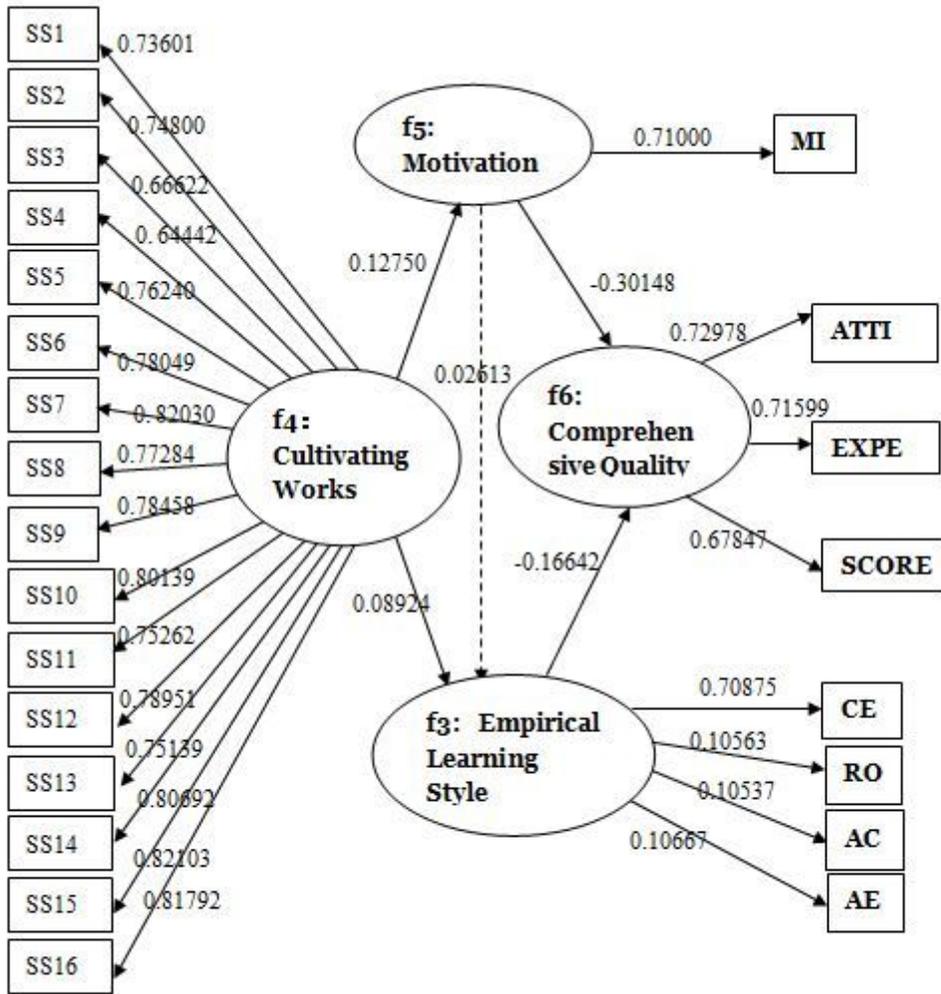


Figure 5

Figure 5

The path graph of preliminary SEM 5 for cultivating works, learning motivation, empirical learning style and comprehensive quality;



**Figure 6**

**Figure 6**

The path graph and standardized solution of the final SEM 6 for cultivating works, learning motivation, empirical learning style and comprehensive quality (with CE as the reference).