The effects of flipped classroom on learning effectiveness: using learning satisfaction as the mediator

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ABSTRACT: This study aims to verify and to understand the effects of flipped classroom on the learning effectiveness, while using learning satisfaction as the mediator. The findings show that: 1) both the instructors and students of technical and vocational colleges (the first half) believe that flipped learning has a positive effect on learning satisfaction; while the students of the second half of technical a vocational colleges believe that flipped learning has a negative effect on learning satisfaction; 2) both the instructors and students of technical and vocational colleges (both halves) believe that flipped learning has a significant positive effect on learning effectiveness; and 3) both the instructors and students of technical and vocational colleges (the first half) believe that flipped learning has a positive effect on learning effectiveness; while the instructors and students of the second half of technical and vocational colleges believe that flipped learning has a negative effect on learning effectiveness. Summarising the above, learning satisfaction has a partial mediating effect.

INTRODUCTION

Flipped learning is one of the world's more important educational topics. Thanks to the Internet and information technology, revolutionary changes are happening to the way teachers teach and students learn. Teachers are breaking away from the role of being a knowledge provider to becoming a facilitator and coordinator of the students' learning process; while students are also getting away from the *…copying and memorisation equals high test scores* learning model to that of a self-initiating learner model. Digital teaching materials, massive open on-line courses (MOOCs) are all self-learning materials for students; while classroom discussion has become the catalyst for effective learning outcomes [1]. However, when the teachers in the school are poised to implement the flipped learning method, are students willing to accept the self-initiated learning?

One of the more important elements of successfully implementing the flip learning method is the willingness of students to take the initiative in learning. Under the impact of a low-birth rate, many schools in Taiwan are facing the challenge of recruiting students. Some schools are near to closing down, while in some schools, for the sake of sustainability, the acceptable student-quality has been affected. It is not clear if some of these students go to school for learning or for other purposes.

This is the first reason contributing to the motivation of this research. Bergmann and Sams argued that the success of a flipped classroom is closely related to students' enthusiasm in learning, and teachers should provide more opportunities for students to choose, so as to maintain or nurture their learning enthusiasm [2]. Lastly, as with traditional teaching, teachers should design a complete mechanism to ensure the quality of group discussion, and design lesson-preparation content that is interesting, while being appropriate to the student's level.

All of these factors are key elements in the success of a flipped classroom. Is the learning motivation of the top 27% of students of the first half of Taiwan's technical and vocational colleges the same as the bottom 27% of students of the second half? That is, when implementing flipped learning, is there a difference in the learning effectiveness between the students in the first half and the second half? This is the second reason contributing to the motivation for undertaking this research.

Moreover, learning satisfaction and learning effectiveness are both critical factors in the measurement of learning effectiveness. There are many factors that can affect students' learning satisfaction and learning effectiveness; apart from students' individual factors, teachers, curriculum, and learning environment are all possible factors. Researchers may focus on any one particular factor due to research objectives or research environments. Lynch et al have studied, specifically, medical school students, the effects and the relationship between learning patterns and learning performance [3].

Jones also discussed the effects of capability, self-efficacy, and personal goals on performance, and found that a number of different personal traits can indeed affect learning performance [4]. Overall, learning satisfaction and learning effectiveness dimensions may be slightly different in various research discussions due to the differences in research topics; however, the dimensions they cover include no more than the following six items: learning environment, administration, teachers, curriculum, learning outcomes and interpersonal relationships.

Compared with other dimensions, the discussion on innovative teaching - the study on the effects of flipped classroom on learning effectiveness, while using students' learning satisfaction as the intervening variable, is considered quite novel. However, the constant updating of teaching methods, the persistent presence of the emphasis on students' learning satisfaction, and the effective development of learning effectiveness can bring forth the basis of effectiveness between teaching and learning for teachers and students in the school, and enhance learning willingness and learning effectiveness. This is the third reason contributing to the motivation for undertaking this research. Therefore, this study is attempting to verify and to understand the effects of flipped learning on the learning effectiveness in Taiwan's technical and vocational colleges, while using learning satisfaction as the intervening variable. Specific research objectives can be summarised as the following items:

1) To verify and understand whether or not adopting flipped learning in Taiwan's technical and vocational colleges has a significant positive effect on learning satisfaction (H_1).

    a. To verify and understand, whether or not, adopting flipped learning in Taiwan's technical and vocational colleges (the first half) has a significant positive effect on learning satisfaction (H_{1-1}).
    b. To verify and understand, whether or not, adopting flipped learning in Taiwan's technical and vocational colleges (the second half) has a significant positive effect on learning satisfaction (H_{1-2}).

2) To verify and understand, whether or not, students' learning satisfaction in Taiwan's technical and vocational colleges also has a significant positive effect on learning effectiveness (H_2).

    a. To verify and understand, whether or not, students' learning satisfaction in Taiwan's technical and vocational colleges (the first half) also has a significant positive effect on learning effectiveness (H_{2-1})
    b. To verify and understand, whether or not, students' learning satisfaction in Taiwan's technical and vocational colleges (the second half) also has a significant positive effect on learning effectiveness (H_{2-2})

3) To verify and understand, whether or not, adopting flipped learning in Taiwan's technical and vocational colleges has a significant positive effect on learning effectiveness (H_3).

    a. To verify and understand, whether or not, adopting flipped learning in Taiwan's technical and vocational colleges (the first half) has a significant positive effect on learning effectiveness (H_{3-1}).
    b. To verify and understand, whether or not, adopting flipped learning in Taiwan's technical and vocational colleges (the second half) has a significant positive effect on learning effectiveness (H_{3-2}).

LITERATURE REVIEW

Flipped Learning

The conceptual definition of flipped learning in this study is …*a learning model where students learn the online course materials first, then have their questions answered by the teacher, and participate in the guided discussion and experiments during the classroom hour. This model flips the concept of the traditional model, where teachers lecture in the classroom and students do their lessons at home, thus it is also called flipped classroom.*

This study integrated the ideas proposed by Forsey et al as the sub-dimensions for flipped learning: 1) lower-order learning - refers to the students' learning during the second half of school duration; and 2) higher-order learning - refers to the students' learning during the first half of school duration and performed verification, respectively [5]. The above mentioned conceptual definition concerning flipped learning is summarised from the following literature review.

Hamdan et al proposed in 2013 the key concept of flipped classroom, using the word *FLIP*, where *F* means *flexible* learning environment, and where the method is *learner* centred with *intentional* content, and where the teachers must have *professional* knowledge and attitude [6].

Bergmann and Sams argued that the so-called flipped classroom is not an innovated teaching strategy, but it flips the teaching procedure of a traditional classroom, and blends technology into the teaching method (video, in particular), in which the inverted instruction requires students to prepare ahead [2].

The method adopts a blended learning model that utilises the Internet for delivering instructions and the traditional face-to-face teaching, so as to help students achieve their goals with a higher level of learning. That is, before going to the class, students should take the initiative to prepare for the class, while the teacher utilises the time that was designed

for face-to-face classroom instruction to guide students in completing their homework, and to help students in solving course problems, in addition to facilitating the opportunity for students to participate in classroom discussions and to engage in classroom activities.

As a result, the interaction between the teacher and students is greatly improved. It can even help students to achieve their goals with a higher level of learning. During this process, students must take responsibility for gaining knowledge on their own, while receiving individualised learning assistance (achieving the goal of differentiated instruction) in the classroom.

Chou suggested that flipped classroom refers to the learning model where …*students prepare the lesson before the class, and attend interactive discussions during the class* [7]. There are many ways to achieve lesson preparation and interactive discussions. The learning method of *flipped classroom* adopts the mobile learning method for pre-class preparation, and cooperative learning for in-class interaction between students and the teacher.

Additionally, similarly to Hamdan [6], Liu pointed out that flipped classroom or as termed, flipped teaching, is where F means *flexible* learning environment, and where the method is *learner* centred with *intentional* content, and where the teachers must have *professional* knowledge and attitude [8].

The key to implementing flip learning or inverted classroom, is twofold: 1) before the class, the teacher uploads or links the recorded instruction contents (or relevant ready-made materials) to a knowledge platform for students to learn, on their own initiative, the provided contents and to record the problems they encounter during the learning process; and 2) during the class, the teacher responds to the questions that students encountered, and conducts discussion-based cooperative learning or individualised guidance. This method, in which students learn the on-line course materials first, then, have their questions answered by the teacher, and participate in the guided discussion and experiments during the classroom hour, flips the concept of the traditional model, where teachers lecture in the classroom and students do their lessons at home; thus, it is called flipped classroom.

Forsey et al proposed that if the course contents of humanities studies (including educational fields) are oriented to lower-order learning (remembering and understanding learning activities), and that if students do not feel they gain much from the classroom sessions, i.e. they only need to read materials or watch relevant video without going to the classroom, and can still pass the examination or turn-in reports, they will choose to be absent or not pay attention in the class [5]. However, higher-order learning activities, i.e. higher-order and individualised learning (for example: solving mathematical problems or social topic discussions) are time-consuming and more difficult for the traditional teaching method to achieve.

Hau argued that the concept of a flipped classroom is focused on putting students in the centre: teachers flip (i.e. transform) the traditional teacher-centred idea of the past and turn it into a concept that focuses on the student [9].

By blending appropriate technological tools (video, in particular) in to the teaching process, students are required to learn the basic content ahead of time; during the class period, students are guided by the teacher and have more opportunities to interact with peers and the teacher for higher-order, individualised learning (for example: solving mathematical problems and discussing social issues).

Additionally, the four pillars of flipped classroom contain the four principles that enable teachers, who want to implement flipped classroom, to get a quick start: 1) select a topic that can be completed in a 15-minute lecture: the teaching method of flipped classroom applies to topics that students can master themselves. Teachers should prepare ahead of time videos or information that students can easily understand quality over quantity; 2) clearly define the time frame for a planned discussion during the class period, similar to coaching a team-practice with a pre-designed game plan, rather than a student-run discussion or self-study period; 3) do not apply flipped method to all subjects, since it is not the only teaching method available. To get started, the teacher might apply the flipped method to various subjects at a frequency of one class period per week; and 4) design an alternative programme for students who have no Internet access at home. The flipped learning method is dependent on pre-class preparation. If the preparation requires an Internet connection to complete, teachers must consider a substitute programme to provide information for pre-class preparation for students who have no Internet access or who have no computers [10][11].

Learning Satisfaction

Learning satisfaction is one of the major items used for measuring learning results. In addition to students' individual issues, teachers, curriculum and learning environment are possible factors that can affect students' learning satisfaction. Summarising the perspectives of the following scholars, the conceptual definition concerning *learning satisfaction* in this study is …*students' feelings of pleasantry or attitudes on learning activities*. Explanations on the dimensions of the *latent variables* [5] of learning satisfaction and their operational definitions are described as follows:

The discussion of learning satisfaction in this study is divided into the following three *observable variables*, i.e. 1) *learning attitude*: it is a relatively stable psychological tendency that a student shows towards learning and

learning status. It may be determined by observation of, or described as, the attention paid, emotions displayed, and mental status that the student shows while learning; 2) *learning motivation*: it refers to the driving force that propels a person to learn. Learning motivation is directly related to how active, how happy and how successful the student is while learning; and 3) *interest in learning*: it refers to a positive emotional tendency that the student has towards the learning target, and where the student understands and is actively seeking contact with it. They are the forces that drive students to actively learn.

The above-mentioned conceptual definition and dimensions of learning satisfaction are derived from the following items from the literature:

Tough defined learning satisfaction as …*a learning attitude and feeling that school children have in the learning process: feeling happy with positive attitude means satisfaction; conversely, dis-satisfaction* [12].

Chen proposed that the definition of learning satisfaction refers to …*a feeling and learning attitude that a student has with the learning process. When such a feeling and attitude is pleasant during a learning activity, the student will actively participate in and acquire or pursuit the required level of achievement* [13].

Lee defined learning satisfaction as …*a student's feelings about learning results, which stem from the gap between the actually acquired knowledge and the expected learning outcome from a student's learning process. If the gap is small, learning satisfaction is high; conversely, the learning satisfaction is low* [14].

Cheng proposed that the definition of learning satisfaction refers to …*the feeling and attitude that a student has about the learning activity. The formation of such a feeling or attitude is attributed to a student's enjoyment of the learning activity, or to the student's aspirations and needs being achieved at a satisfactory level during the learning process* [15].

Chen defined learning satisfaction as …*while in the process of participating and learning, it is a student's level of participation and attitude towards such an activity, as well as his feelings and resulting achievement level of the expected target* [16].

Yang proposed that the definition of learning satisfaction refers to …*Students feelings or attitudes about the learning activity, where a happy feeling or active attitude suggests satisfaction, and an unhappy feeling or passive attitude suggests dis-satisfaction* [17].

Yang defined learning satisfaction as …*a student's mental state, where his psychological needs are met by the designed activity during his participation in a learning process, thus generating the positive feeling of joy* [18].

Concerning the method for measuring learning satisfaction, scholars have derived a variety of perspectives and research findings.

Starr indicated in his research that there are five aspects included in his survey questionnaire on measuring college students' learning satisfaction: school environment and equipment, learning outcomes, administrative measures and services, interpersonal relationships, and the respect given to the students from teachers and administrative personnel [19].

Corts et al adopted five environmental factors to study their impact on student satisfaction [20]. Their research findings show: career preparation and course offerings have the biggest impact on student satisfaction; while advising also has a positive effect on student satisfaction.

Learning Effectiveness (the Study Effect of Students)

Learning effectiveness refers to the changes imparted on a student concerning knowledge, skills and attitudes as observed at the end of the teaching [21][22]. The conceptual definition of *learning effectiveness* in this study can be defined as …*that which can be measured by indicators of three explicit variables, namely: students' grades after learning in school, demonstrated professional skills, and proficiency results from various external exams.*

Its dimensions definition is briefly described as follows: 1) school grades: refers to, during the process of learning in school, the test scores obtained after learning; 2) the number of professional certificates: refers to the number of professional certificates obtained from various professional proficiency examinations after the process of learning in school or other venues of capability training; and 3) external examinations: refers to the process of participating in various external professional proficiency tests after the process of learning in school or other venues of professional training. The above-mentioned conceptual definition and dimensions of learning effectiveness are derived from the following items from the literature:

Chen pointed out that the definition of learning effectiveness refers to …*the indicator that is used to measure a student's learning effectiveness, and is one of the important criteria used to evaluate teaching quality* [23].

Wen defined learning effectiveness as *...a student's learning performance, including formative and summative evaluation results* [24].

Li pointed out that learning effectiveness refers to *...a student's learning results obtained by way of a certain form of assessment, which may include time, tools, or indicators, as conducted by an assessor on the student after a period of time of certain learning activities* [25].

Lin defined learning effectiveness as:

> *...it is an indicator for measuring learning outcomes, and is one of the most important criteria used for assessing teaching quality. It refers to a student's learning results, as measured on Cognitive, Affective, and Psychomotor Domains with defined test tools, after the learner has spent a prescribed time studying in a certain field. The methods used for assessing learning effectiveness should include factors: accuracy, completion time, expected difficulty, complexity, and proper values for the answer, thus offering a fairer and reasonable assessment method. Teachers may use various learning performance records for the evaluation, such as oral exams, writing exams, hands-on operation, reports, homework, worksheets, quizzes, and regular assessment tests. All of these are broad definitions of learning effectiveness. If defined from a narrower perspective, it may refer to academic performance on each subject, or on the average performance of a combination of subjects* [26].

Concerning the methods for measuring learning effectiveness, scholars have derived a variety of perspectives and research findings.

The research of Jones suggested that learning effectiveness is affected by factors, such as learning styles, course design and teaching [4].

The study of Loo also suggested that learning effectiveness is affected by factors, such as learning styles, course design, and teaching. In terms of the assessment for learning effectiveness, in general, the assessment results can be obtained directly from students' grades, their abilities to acquire professional certification and their performance results from participated external examinations [27].

Flipped Learning and Learning Satisfaction

Du utilised the implementation of learning activity design on the subject of geographic information to further enhance high school students' interest in learning, and verified the implementation results with learning satisfaction variable [28]. The results show that after going through the learning activity on geographic information technology, the learning effectiveness of all of the high school students reached high levels of satisfaction.

Feng et al adopted the method of micro-lesson teaching practice by student, with the help of the new flipped-classroom idea, in the instruction design of their *Instruction Design* course [29]. The results show that students' learning satisfaction is higher when this method is implemented.

Summarising the above, the following hypothesis has been deduced in this study:

H_1: flipped learning has a significant positive effect on students' learning satisfaction.

Learning Satisfaction and Learning Effectiveness

Wang pointed out that learning satisfaction and learning performance are significantly correlated [30].

Cao et al argued that learning satisfaction and learning effectiveness are both significantly positively correlated [31].

Chen believed that goal orientation and learning satisfaction have significant positive effects on learning performance [32].

Chuan et al argued that students, who have strong learning motivation, have higher learning satisfaction, thus, the level of learning effectiveness is also higher [33].

Additionally, the content of learning satisfaction that most scholars discussed includes four aspects: course materials, teaching, learning environments and interpersonal relationships [34].

On distance education, Benner et al studied students' learning satisfaction relating to tele-courses, where the dimensions explored concerning students' learning satisfaction cover: teachers, techniques, procedure management, locations of all parties involved, promptness of material exchange, support facilities and teacher contacts [35].

The questionnaire adopted in measuring test subjects' on-line learning effectiveness in this study includes *academic performance* and *learning satisfaction and self-efficacy*, in which learning satisfaction refers to the assessment of students' personal feelings and experiences after using the various factors presented in the learning environment [22]; while, *self-efficacy* refers to students being confident and capable of expressing the acquired knowledge in the external behaviour [22].

As suggested by Yan and He, incorporating information technology into classrooms helps promote learning effectiveness, but the core issue still lies in course content and teaching activities; information technology is just one of the auxiliary tools [36].

Summarising the above, the following hypothesis is deduced in this study:

H_2: the learning satisfaction of students in Taiwan's technical and vocational colleges has a significant positive effect on their learning effectiveness.

Flipped Learning and Learning Effectiveness

New teaching model: it has been confirmed by many studies abroad that flipped learning is helpful in enhancing learning effectiveness.

Yan and He believed that incorporating information technology into classrooms helps promote learning effectiveness, but the core issue still lies in course content and teaching activities; information technology is just one of the auxiliary tools [36].

The research conducted by Wang found that the learning effectiveness of students taught in the concept-map integrated flipped learning model is significantly better than students taught in the traditional instruction model [37].

Wu studied students who accepted the flipped teaching method in their English course, in which the experimental group students' English learning performance was significantly better than those in the control group [38].

Chou believed the learning effectiveness of students who experience the teaching model that integrates flipped classroom and mobile learning is significantly better than that of students who receive traditional teaching [7].

Compared with the students in the group using the traditional teaching model, students who are in the group with flipped classroom and mobile learning integration have a better understanding of the lesson unit *ratio*, and have a higher learning desire. The feedback from questionnaire and interviews show that both the teacher and students are positive and approving of the flipped classroom teaching method.

Summarising the above, the following hypothesis is deduced in this study:

H_3: adopting flipped learning in Taiwan's technical and vocational colleges has a significant positive effect on learning effectiveness.

Based on the above research purpose, and literature review, this study constructs a conceptual research framework, as shown in Figure 1a and Figure 1b:
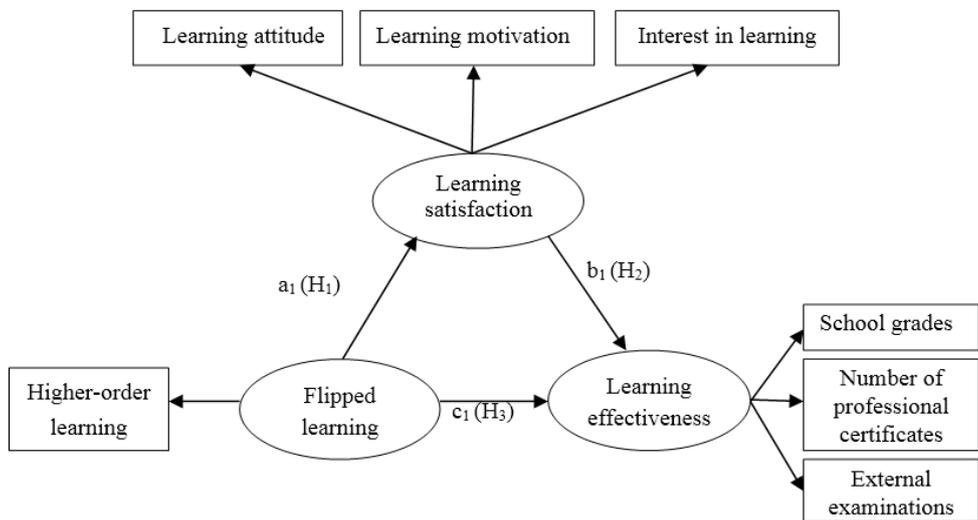

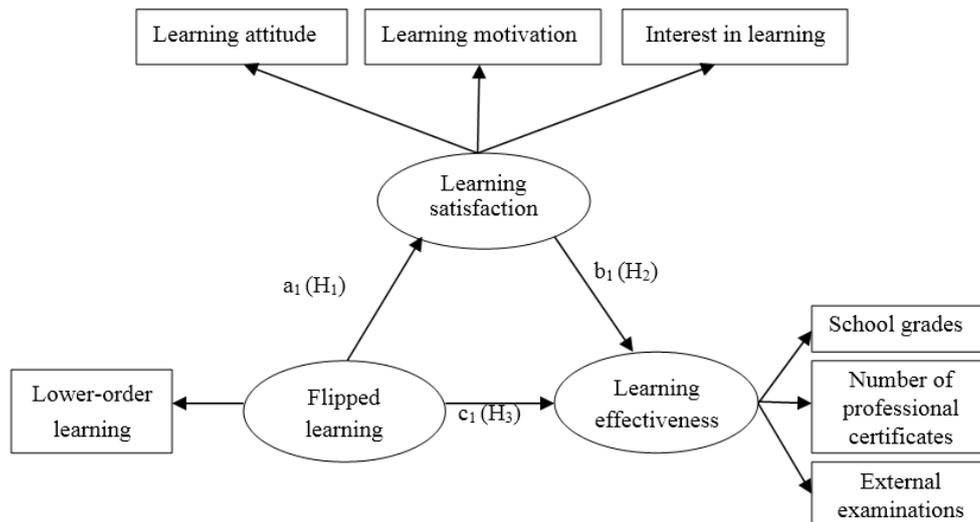Figure 1a: Conceptual research framework.

Figure 1b: Conceptual research framework.

RESEARCH METHODOLOGY

Sampling Method

This study applied the convenience sampling method on the research population and, for the questionnaire survey, targeted teachers at least at the lecturer level and students of ten technical and vocational colleges in the top 27% ranking for the first half of the school duration (they are referred to in this study as the *higher-order learning* schools), and in ten colleges in the bottom 27% of the second half (they are referred to in this study as the *lower-order learning* schools). This study distributed 50 copies of the questionnaire to experts as a pilot test, then, modified the questionnaire in accordance with the experts' feedback recommendations, and performed an official post-test with 250 copies of questionnaire being distributed. Of these, 202 valid questionnaire samples were returned, at a sample-return rate of 80.8%.

Designing the Questionnaire

The questionnaire in this study was compiled on the basis of the itemisation survey method and the afore-mentioned observable dimensions. On a 7-point Likert scale, the answers were measured with 7 denoting *strongly agree* and 1 denoting *strongly disagree*. A higher score represents a greater level of agreement, and *vice versa*.

The questionnaire design relating to flipped learning in this study integrates the dimensions as proposed by Forsey et al i.e. 1) lower-order learning; and 2) higher-order learning, with added improvements (the definition of these dimensions is different in this study), resulting in a total of six questions [5].

The questionnaire design relating to learning satisfaction in this study incorporates the learning satisfaction scale proposed by Starr with added improvements [19]. This dimension includes three variables: learning attitudes, learning motivations and learning interests, where the first two variables are applied to four questions, while the last variable is applied to six questions, resulting in a total of 14 questions.

The questionnaire design, relating to learning effectiveness in this study, integrates the studies proposed by Jones [4], Lynch [3] and others with added improvements. This unobservable variable item includes three variables: school grades, the number of professional certificates and external examinations, while the design follows the method of itemisation survey, with each variable comprising four questions, resulting in a total of 12 questions.

The Data Obtained from Questionnaire and Measurement Model

This study's authors adopted structural equation modelling (SEM) in a confirmatory factor analysis (CFA) of the research framework, and based the questionnaire design on three latent variables (i.e. flipped learning, learning satisfaction and learning effectiveness), each of which was divided into observable/explicit sub-variables containing several questions, as shown in the table below.

After processing the collected data, the authors created a primary file that preceded the design of questionnaire, using itemisation survey method for the construction of this study's measurement system. Although itemisation survey method is applied to the design of the questionnaire, dual measurement was adopted to ensure the computer software efficiently handled and/or measured all data [39]. Table1 shows the number of questions under each implicit or explicit variable, as well as the referential sources.

Table 1: Number of questionnaire items under each *implicit variable*' and *explicit variable*.

Implicit variables	Explicit variables	No. of questions	References
Flipped learning	Higher-order learning	3	Wang [37], Chou [7], Du [28] and Hau [9]
	Lower-order learning	3	
Learning satisfaction	Learning attitude	4	Chen [13], Wang [30], Chen [32], Chuan et al [33] and Yang [18]
	Learning motivation	4	
	Interest in learning	6	
Learning effectiveness	School grades	4	Qiu [21], Wen [24] and Lin [26]
	Number of professional certificates	4	
	External examinations	4	

RESULTS AND DISCUSSION

Linear Structure Model Analysis

This study includes a CFA, an analytical method contrary to the exploratory factor analysis (EFA), on the three unobservable/latent variables of flipped learning, learning satisfaction and learning effectiveness. SEM is made up of structural and measurement models to efficiently tackle the cause-effect relations among implicit/latent variables. The three parts of model-testing in this study are: 1) goodness-of-fit of the measurement model; 2) goodness-of-fit of the structural model; and 3) the overall model's conformity with goodness-of-fit indicators. In other words, goodness-of-fit indictors were applied to a test of the overall goodness-of-fit effect of SEM [40].

Analysing Fit of the Measurement Model

To a large extent, factor loading is intended to measure the intensity of linear correlation between each latent/implicit variable and a manifest/explicit one. The closer the factor loading is to 1, the better an observable variable is in measuring latent variables. Since this study's reliability is supported by the fact that factor loadings for all observable variables range between 0.7 and 0.8, all observable/explicit variables in the measurement model appropriately gauged the latent/implicit ones.

The average variance extracted (AVE), on the other hand, gauges an unobservable/implicit variable's explanatory power of variance with regard to an observable one, with the AVE value growing in proportion to the reliability and convergent validity of that particular implicit/latent variable. As a rule, AVE must be larger than 0.5 for an observable variable's explainable variance to exceed the measurement error [41]. Table 2 and Figure 2 show that all AVEs in this study exceed 0.5; the explicit variables have excellent reliability and convergent validity.

Table 2: Judgment indicators for the measurement model.

Implicit variables	Explicit variables	Factor loading	Average variance extracted (AVE)
Flipped learning (X)	X_1	0.74	0.54
	X_2	0.76	0.56
Learning satisfaction (ME)	ME_1	0.74	0.54
	ME_2	0.75	0.55
Learning effectiveness (Y)	Y_1	0.76	0.56
	Y_2	0.77	0.58

Analysing Fit of Structure Model

Path Analysis Results of Structure Model

After the group model of this study has passed the goodness-of-fit test, the parameter *estimates*, *standard errors* (SE) and *critical ratio* (CR) among latent variables were calculated (as shown in Table 3 and Table 4).

Table 3: Path analysis results of the structural model (the first half).

Path coefficients between implicit variables			Estimate	SE	CR	*p*	Label
Flipped learning (X)	→	Learning satisfaction (ME)	0.532	0.023	23.130	***	a1
Learning satisfaction (ME)	→	Learning effectiveness (Y)	0.563	0.020	28.150	***	b1
Flipped learning (X)	→	Learning effectiveness (Y)	0.541	0.024	22.542	***	c

Note: * indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < 0.001$

Table 4: Path analysis results of the structural model (the second half).

Path coefficients between implicit variables			Estimate	SE	CR	p	Label
Flipped learning (X)	→	Learning satisfaction (ME)	-0.433	0.018	-24.056	***	a1
Learning satisfaction (ME)	→	Learning effectiveness (Y)	0.511	0.021	24.333	***	b1
Flipped learning (X)	→	Learning effectiveness (Y)	-0.482	0.022	21.909	***	c

Note: * indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < 0.001$

Coefficient of Determination

1) The explaining level of each implicit independent variable to each implicit dependent variable is the R^2 value (squared multiple correlation, SMC). Therefore, the R^2 value shown in Table 5 indicates that the implicit independent variable has adequate explaining ability on the implicit dependent variable, respectively.

Table 5: Path coefficient of determination.

Coefficients of determination	R^2
Flipped learning → Learning effectiveness	0.71
Flipped learning → Learning satisfaction	0.74
Learning satisfaction → Learning effectiveness	0.72

Indices of Fit of the Overall Model

The purpose of adopting SEM in the modelling phase of this study is to explore how unobservable variables are interconnected within the structural model, to determine if the measurement model has measurement reliability, and also to measure this study's overall goodness-of-fit effect using such indices as χ^2, d.f., GFI, AGFI, NFI, CFI, RMR and RMSEA. In most cases, it is required that χ^2/d.f. < 5, 1 > GFI > 0.9, 1 > NFI > 0.9, 1 > CFI > 0.9, RMR < 0.05 and RMSEA < 0.05 [42]. The goodness-of-fit of the overall model proved satisfactory because χ^2/d.f. < 5 and GFI, AGFI and NFI all exceed 0.90, with the RMR smaller than 0.05 (see Table 6).

Table 6: Fitting evaluation table of the overall group model.

Determination index	χ^2	DF	GFI	NFI	AGFI	CFI	RMR	RMSEA
Fit value	5.970	6	0.903	0.934	0.905	0.932	0.021	0.023

Standardised Results of SEM Analysis

The computerised standardised results of the overall framework are shown in Figure 2a (the first half), and Figure 2b (the second half).
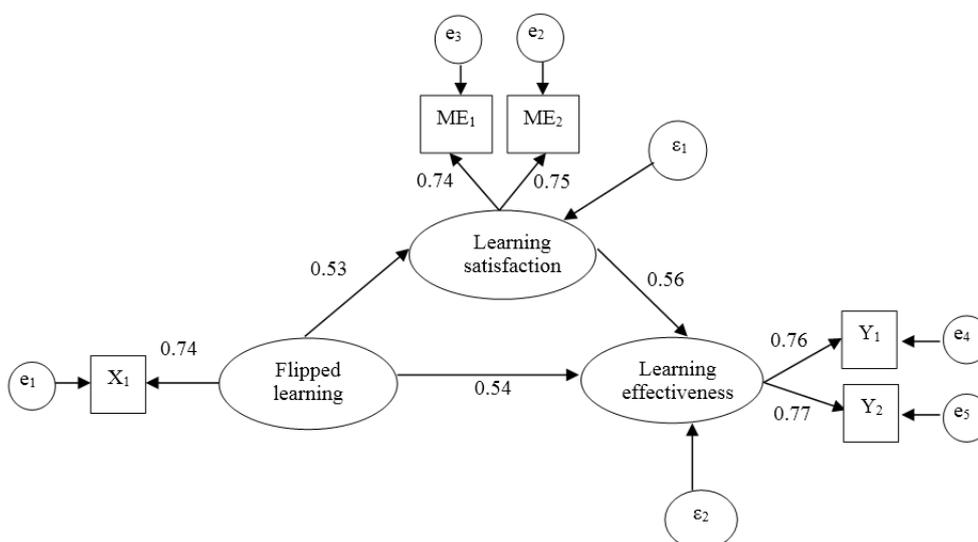

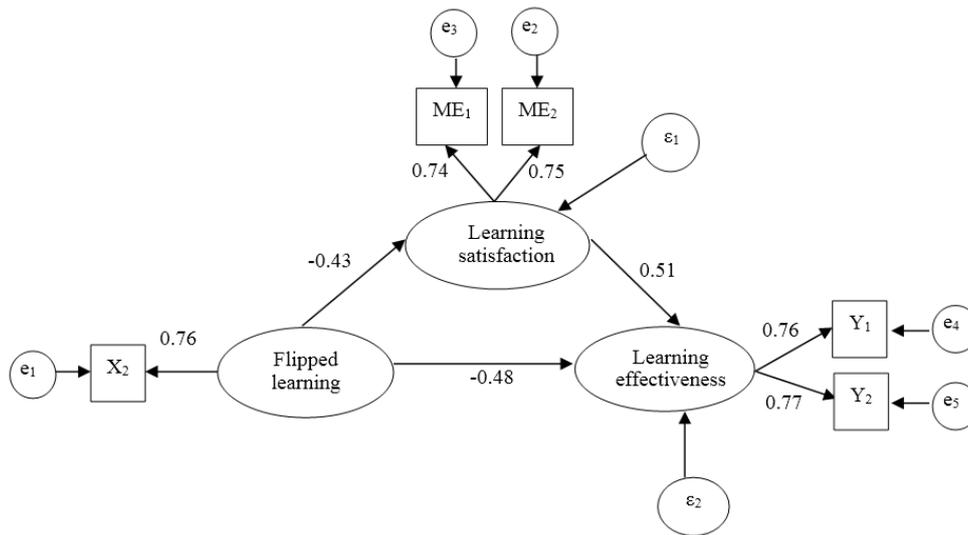Figure 2a: Standardised results of the overall framework - first half.

Figure 2b: Standardised results of the overall framework - second half.

Path Effect Analysis and Tests of Inner Model

The Bayesian estimation is adopted for an analytical test, with specific focus on the path coefficients between implicit (unobservable) variables of the inner model (the first half), to analyse and verify the group inner model's path effect, using students' learning satisfaction (ME) as the mediating variable. Table 7 shows:

2) Because the path coefficient of flipped learning (X) on learning satisfaction (ME) a1 = 0.532, where the 95% confidence interval is (0.419, 0.655), there is a significant positive effect in the first stage effect.
3) Because the path coefficient of learning satisfaction (ME) on learning effectiveness (Y) b1 = 0.563, where the 95% confidence interval is (0.443, 0.650), there is a significant positive effect in the second stage effect.
4) Because the path coefficient of flipped learning (X) on learning effectiveness (Y) c = 0.541, where the 95% confidence interval is (0.417, 0.665), there is a significant positive effect in the third stage effect.

Table 7: Bayesian estimation.

Regression weights	Mean	SD	95% Lower bound	95% Upper bound	Name
Flipped learning (X) → Learning satisfaction (ME)	0.532	0.023	0.419	0.655	a_1
Learning satisfaction (ME) → Learning effectiveness (Y)	0.563	0.020	0.443	0.650	b_1
Flipped learning (X) → Learning effectiveness (Y)	0.541	0.024	0.417	0.665	c

The Bayesian estimation is adopted for an analytical test, with specific focus on the path coefficients between implicit (unobservable) variables of the inner model (the second half), to analyse and verify the group inner model's path effect, using students' learning satisfaction (ME) as the mediating variable. Table 8 shows:

1) Because the path coefficient of flipped learning (X) on learning satisfaction (ME) a1 = -0.443, where the 95% confidence interval is (-0.561, -0.325), there is a significant negative level in the first stage effect.
2) Because the path coefficient of learning satisfaction (ME) on learning effectiveness (Y) b1 = 0.511, where the 95% confidence interval is (0.390, 0.632), there is a significant positive level in the second stage effect.
3) Because the path coefficient of flipped learning (X) on learning effectiveness (Y) c = -0.482, where the 95% confidence interval is (-0.604, -0.360), there is a significant negative effect in the third stage effect.

Table 8: Bayesian estimation.

Regression weights	Mean	SD	95% Lower bound	95% Upper bound	Name
Flipped learning (X) → Learning satisfaction (ME)	-0.443	0.018	-0.561	-0.325	a_1
Learning satisfaction (ME) → Learning effectiveness (Y)	0.511	0.021	0.390	0.632	b_1
Flipped learning (X) → Learning effectiveness (Y)	-0.482	0.022	-0.604	-0.360	c

According to the analysis above, the following verification results are obtained in this study:

1) Flipped learning in the first half of Taiwan's technical and vocational colleges has a significant positive effect on students' learning satisfaction (H_{1-1} is substantiated), but it has a significant negative effect on the second half of the education (H_{1-2} is not substantiated); thus, H_1 is partially supported (Hypothesis 1 is partially substantiated).

2) The learning satisfaction of students of the first half and the second half of education in Taiwan's technical and vocational colleges has significant positive effects on their learning effectiveness (H_{2-1} and H_{2-2} are both substantiated); thus, H_2 is supported (Hypothesis 2 is completely substantiated).

3) Flipped learning in the first half of Taiwan's technical and vocational colleges has a significant positive effect on students' learning effectiveness (H3-1 is substantiated), but it has a significant negative effect on the second half of the education (H_{3-2} is not substantiated); thus, H_3 is partially supported (Hypothesis 3 is partially substantiated).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are obtained from summarising the above mentioned results and analysis:

1) In terms of validating structural equation modelling (SEM), the structures of the measurement model, structure model and overall group model of the SEM in this study have goodness-of-fit, showing good fitting effects.

2) From the practical verification perspective:

    a. Concerning the correlations between flipped learning and students' learning satisfaction dimensions, implementing the flipped learning method in the first half of the education in Taiwan's technical and vocational colleges has a significant positive effect on students' learning satisfaction (significant direct effects); while implementing the flipped learning method in the second half of the education has a significant negative effect on students' learning satisfaction. This conclusion is partially identical to the research conducted by Du [28].

    b. Concerning the correlations between learning satisfaction and learning effectiveness dimensions, students' learning satisfaction in Taiwan's technical and vocational colleges presents a significant positive direct effect on their learning effectiveness. This conclusion is partially identical to the studies conducted by Wang [30], Cao et al [31], Chen [32] and Chuan et al [33].

    c. Concerning the correlations between flipped learning and students' learning effectiveness dimensions, implementing the flipped learning method in the first half of the education in Taiwan's technical and vocational colleges has a positive effect on students' learning effectiveness; however, implementing the flipped learning method in the second half of the education in Taiwan's technical and vocational colleges has a significant negative effect on students' learning effectiveness. This conclusion is partially identical to the research findings proposed by Yan et al [36], Wang [37] and Wu [38].

Overall, despite of the significant positive effect on learning effectiveness when implementing the flipped learning method in the first half of the education in Taiwan's technical and vocational colleges, and the significant negative effect on learning effectiveness when implementing the flipped learning method in the second half of the education in Taiwan's technical and vocational colleges, the dimension of *students' learning satisfaction* has *partial* mediating effects.

Suggestions and Reflections for Teachers and Education Policy-Makers

The flipped classroom is one of the most talked about teaching strategies at this time. Although it is highly valued, and many schools are attempting to implement the method, few studies have been conducted with rigorous research methods that are related to the learning outcomes of flipped classroom. In particular, when implementing the flipped classroom method, teachers must spend more effort on preparing the lesson. It is also important to recognise that the main premise of having an effective flipped classroom is that students must have the desire to learn on their own initiative. Therefore, cultivating the desire for initiative learning in students is one of the key factors for promoting a successful flipped learning method. With the passing of time, many countries are gradually adopting the *teacher*-and-*student* oriented educational reform development, and the relevant significance of curriculum and teaching is also changing.

The traditional teaching model relies on teachers providing information, uni-directionally, with students doing homework as a review after school. However, it is often difficult to find solutions when questions arise while doing homework or find immediate help, and flipped classroom becomes the model that provides solutions to this learning problem. It provides students with the energy to accumulate valuable knowledge as their main resource for enhancing learning quality and learning motivation. The above research findings show that teaching methods in a school must

meet the requirements of social developments. Investing in modern cloud technology, conducting Web-based teaching or utilising the interactive whiteboard can help improve problem-solving when conducting teaching, and may improve teachers' creativity and students' learning satisfaction; thereby, enhancing students' learning effectiveness. Therefore, this study offers the following recommendations for teachers as a reference, when they are constructing flipped learning methods to improve students' learning satisfaction, so as to directly or indirectly enhance students' learning effectiveness.

- Teachers should keep this principle in mind: there is no *one* fixed answer to the student-oriented learning method. Teachers should not be obsessed with external appearance, nor should they and education administrators rush to, or be infatuated with, a certain teaching model. One teaching strategy cannot meet all classroom requirements. Flipped classroom is a choice, but it is not the ultimate choice [43][44]. There are many teaching methods in a flipped classroom; thus, there are many methods for pre-class preparation or in-class interactive discussions. For example, methods such as practice exercises, problem-solving, cooperative learning and small unit or group discussions, can all be adopted as learning methods in a flipped classroom.

- Incorporating appropriate and positive incentive systems in the process of implementing cooperative learning in a flipped classroom can improve learning motivation and learning effectiveness. In other words, under the cooperative learning method in a flipped classroom teaching model, students both improve their daily attitudes in communication, mutual cooperation and respect, and enhance their learning motivation and learning effectiveness.

- Learning motivation is the internal driver for a student, which is one of the critical variables affecting learning. To a teacher, triggering a student's learning motivation is a means to an end. When designing the instructions, if a teacher is able to appropriately introduce strategies that stimulate students' desire to seek knowledge, it would be a great help towards successful teaching. In addition, the teaching method that integrates flipped classroom and question-oriented learning can significantly improve learning effectiveness. Furthermore, the teaching method of question-oriented learning can significantly improve learning motivation.

- The success of a flipped classroom is closely related to students' enthusiasm for learning, and teachers should provide more opportunities for students to choose, so as to maintain or nurture learning enthusiasm. Lastly, as with traditional teaching, teachers should design a complete mechanism that ensures the quality of group discussions, and design lesson-preparation content that is interesting, while being appropriate to the student's level of comprehension. As stated in the ideas proposed by Bergmann and Sams [2], and Hau [44], these factors play a key role in the success of a flipped classroom.

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