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Configural Measurement Equivalence Testing of the Comprehensive Trait Based Model of Self-Regulated Learning in Engineering Undergraduates

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Abstract : The present study extended the integrative trait model of self regulated learning by [30] by including the remaining behavioral and emotional components. Measurement invariance testing was conducted to check for the equivalence of the model with respect to gender, stream and batch among 488 (351 male and 137 female; 321 Computer Science and 167 Mechanical; 263 IInd Year and 225 IIIrd Year) engineering students selected through stratified random sampling from the three regions, Majha, Doaba and Malwa, of the Punjab state of India. [25] measurement invariance criterion of ΔCFI be less than or equal to 0.01 was used to test for equivalence of the model across the selected groups, since it is unaffected by model complexity, sample size and unrelated to overall fit measures. The revised integrative trait model of self regulated learning among engineering undergraduates was found to be Configural measurement invariant with respect to gender, stream and batch using SPSS Amos Ver. 23.0, meaning that the construct of self regulated learning is conceptualized by the participants across the groups of the study in same way. Reliability of the instrument's 14 variables was estimated using Pearson's correlation-based Cronbach's alpha (using SPSS Statistics Ver. 23.0) and Polychoric correlation based ordinal alpha (using R Package Psych), along with estimation of attenuation index to show the extent of underestimation of the vital psychometric property by assuming the data of Likert scale based questionnaires as continuous interval and on ignoring its categorical ordinal nature. The effect size of the validated model conducted as part of post-hoc power analysis using semPower R package was found to be satisfactorily high at 0.941. The academic implications of the study with respect to engineering education in the country are discussed.

Keywords :Attenuation Index, Configural Measurement Invariance Testing, Engineering Education, Polychoric ordinal reliability, Sophomore Slump, Revised Integrative Trait Model of Self Regulated Learning.

1. Introduction

When learners take up the responsibility of studies on their own shoulders, exercising autonomy in learning, the mechanism of this phenomenon, forms the subject of study under the construct of self-regulated learning in educational psychology. Self-regulated learning is a vital competency required in 21st century learners [76], paving the way for the acquisition of yet another critical trait of lifelong learning in them [83]. Its close relationship with

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academic performance makes it, an important variable of research cut across disciplines [42];[26].

The conceptualization of self-regulated learning was done by [82] and is grounded in the Social Cognitive theory of Bandura as "the extent that students are cognitively, motivationally, and behaviorally "active participants" in an academic task (p.308)". When operationalized, self-regulated learning (SRL) is defined as "dynamic and cyclical processes that consist of three independent phases: forethought, performance, and self-reflection" [84],[85],[87]. When learners experience these phases of self-regulated learning, they employ certain strategies of learning, namely, the self-regulated learning strategies.

As a concept, self-regulated learning can exist both as a trait [9] and as a state [64]. Although, [37] mentioned that states are in turn influenced by the corresponding traits and hence the study of individual differences in self-regulated learning can be better done by treating it as a trait alone instead [38], where self-regulated learning is considered to be a temporally stable entity making it amenable to research through its empirical measurement.

An important contribution in the research of self-regulated learning was done by Pintrich and colleagues who developed a tool, the Motivated Strategies for Learning Questionnaire (MSLQ), to measure these strategies [61], and according to whom self-regulated learning is "active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment" [62]. Availability of the Motivated Strategies for Learning Questionnaire (MSLQ), lead to the commencement of its adaptation studies in multiple local contexts across the world, which is continuing till this date [56], along with the initiation of empirical studies on exploring the relationship of self-regulated learning with host of other related psychological variables over the years.

However, owing to the existence of its multiple facets, the construct of self-regulated learning consists of many components and several variables which are the strategies employed to represent these components in turn [63]. The interrelationships between the components of the construct self-regulated learning and the variables making up the self-regulated learning strategies, are studied by developing and testing models of self-regulated learning.

There are two approaches used in the development of the models of self-regulated learning which are the Student Approaches to Learning (SAL) and Information Processing Approach (IP) [13],[28],[31]. The former approach employs grounded qualitative work followed by empirical quantitative studies making it a bottom-up approach. The information processing approach begins with the exploration of the theories of self- regulated learning in the available literature to develop its framework to be latter substantiated by empirical studies, and hence called the top-down approach. Since the information processing approach was found to be inapt in encompassing the advancements in the understanding of the construct of self- regulated learning, it was replaced by the self-regulated learning perspective [62];[77];[88], around the year 2000, which included cognitive, motivational and affective components of the construct self-regulated learning along with the social contexts in its research at tertiary level. However, around the same year of 2000, research on volition as a vital component of self-regulated learning was also gaining traction [16],[27]. The variables academic delay of gratification, future time perspective and academic procrastination were identified as the candidate strategies to represent volition [7],[65].[30] developed a comprehensive model of self- regulated learning by incorporating volition as a subcomponent of motivation, since such a need was felt by many researchers [76],[86], besides its well- established cognitive, meta-cognitive and motivation (motivational beliefs sub component) components and their strategic variables. However, this model lacked the remaining components of behavior [20] and emotion regulation [11] of self-regulated learning.

[19],[20],[21],[22] mentioned about the behavioral component of self regulated learning in their research and used the time and study management, effort regulation, peer learning and help seeking subscales of MSLQ [61] to represent the behavioral self regulation strategies. Moreover, the tool to measure the strategies employed to regulate specifically the academic emotions among university students, the Academic Emotion Regulation Questionnaire (AERQ), was developed by [3], based on the "Process model of emotion regulation" by [33] comprising of eight academic regulation strategies.

Also, the model proposed by [30] was not tested for measurement invariance and comprised mostly of female subjects pursuing graduation in Psychology discipline. This research gap called for the development and testing of a revised and integrative model of the self-regulated learning on a different population context.

The objective of the present study was to develop and validate, basing on and by clubbing the above-mentioned works, a revised integrative model of self regulated learning, comprising of all the known components, cognitive, metacognitive, motivational (with volitional sub-component), behavioral and emotional, on second and third year Indian engineering undergraduates as population. According to [14], there is a huge demand for qualified engineering professionals in India due to the boom in the information and technology sector, coupled with globalization and hence delivery of quality engineering education is the need of the hour for meeting the increasing demand of engineering professionals. [59] released by Aspiring minds, placed Punjab in the second tier of states which provided employability to the engineering graduates, along with Karnataka and West Bengal. However, very little study exists on the psychological constructs which influence the quality of engineering education and successively the quality of the product, the engineering graduates, in India and especially in the context of Punjab. The scope of this study was hence restricted to the three regions, Majha, Doaba and Malwa, of the northern state of Punjab. The rationale behind the selection of the mentioned population is further discussed below in the methodology section. The proposed model of the study was tested for measurement invariance of its factor structure with respect to the groups gender, batch and stream of engineering undergraduates with null hypothesis H0 that the proposed structure is measurement invariant across the mentioned groups. The mentioned research objectives of the study intended to answer two research questions, of the presence of a comprehensive trait based empirical model for measuring the self-regulated learning characteristic in the engineering students and most importantly to address the measurement equivalence of the model across multiple groups like gender, batch and stream of these students. In this way, an objective, trait based and hence temporally stable means to measure the critical variable of self- regulation in the engineering students could be made available for the researchers and practitioners of this field.

In the following sections, the methodology of the study, including the sampling design, details of the tools used, the statistical techniques applied, data analysis, results, their interpretations are mentioned. It is further followed by the discussion section presenting the implications of the study with respect to engineering education, limitations of the study and finally the conclusion.

2. Methodology

The present study intended to measure the presence of the trait self-regulated learning and the employment of its strategies by second and third year engineering undergraduates, in the target population in a cross-sectional mode through the administration of a questionnaire and online survey [57],[67], the survey method of data collection was selected in this study [12],[32], with its component as follows:

Table 1: Components of Survey Method

S.No.	Component
1	Statement of the purpose
2	Rationale for choosing survey design
3	Nature of the survey identification (Cross-sectional Vs Longitudinal)
4	Population with its sample size
5	Stratification of the population
6	Sample selection criteria and size
7	Sampling procedure (Random Vs Non Random)
8	Instruments used in the study
9	The dimensions of the instruments
10	Pilot study procedure of the survey
11	Timeline of the administration of the study
12	Variables
13	Sample items of the survey variable
14	Data analysis steps or Statistical techniques
15	Bias check in subject responses
16	Descriptive analysis
17	Item deletion criteria
18	Reliability analysis
19	Inferential analysis
20	Interpretation of the results

A. Population

[40] estimated the workforce of the country to be around 600 million by 2022 with the Bachelor of Engineering / Bachelor of Technology domain graduates representing the largest employable talent leading to its direct contribution to the country's economy. Two critical aspects of hiring during the campus recruitment of these engineering students are their academic achievement indicator and learning agility displayed through the intent of being a life-long learner. Both these aspects are hallmarks of self-regulated learners [1]. Also, the four years duration of engineering program is overloaded with content, making it not possible for the faculty of engineering courses to teach the syllabus in its entirety [49], calling for the display of self-regulated learning trait by the engineering undergraduates.

In particular, [18] identified the natural area of research in engineering education to be on the retention of second and third students since they experience a phenomenon known as Sophomore Slump defined as "a loss of students' engagement as they return and begin their second year" [50], which happens due to rise in the academic and social factors of stress in the second year of study brought about through the choice of engineering majors [45] and maintaining the previous year's study related and social engagements. The choice of the engineering majors decides further academic performance [35] and has consequences all along the professional life of the engineering student [73]. The sophomore engineering students feel less connected with the campus since the curriculum is not designed to address the phenomenon of sophomore slump [66], making it the least academically active year out of the four years of engineering study [34].

Little research is available for addressing the phenomenon of sophomore slump in second year and third year engineering students in the Indian context [70], and along with the research studies on self-regulated learning in engineering domain across the world [58];[71], owing to the lack of a psychometrically sound instrument for conducting empirical studies on this specific population. Such empirical studies can pave way for profiling of students based on their self-regulated learning trait and further development of much needed intervention programs to curb the negative consequences of sophomore slump [47]. Hence, in the present study, the engineering students of second year and its immediate third year, belonging from two of the most sought- after streams of engineering, the computer science and mechanical streams [2], were selected as the population.

B. Sample

Since survey design was used in this study, all the 94 educational institutions of the Indian state of Punjab, from all its three geographical regions, Majha, Doaba and Malwa and the 22 districts were listed from the AICTE and UGC websites, to form the sampling frame of the study [74]. Complete coverage of a certain geographical region is an important factor for getting a bona fide probability sampling. As such, stratified random sampling was selected as the sampling technique. 10 percent of the institutions mentioned in the sampling frame list, were randomly selected from each of the regions, to form final list of institutions from where the final sample data was to be collected, in accordance with the "10 percent condition" assumption of the Central Limit Theorem [4],[54] as per the following details:

Table 2: Details of Engineering Institutions of Punjab

Region	Total Engineering Institutions of Punjab	10% of Total Engineering Institutions	Sample Institutions Visited for Data Collection (Round off Value)
Majha	18	1.8	2
Doaba	22	2.2	2
Malwa	54	5.4	5
Punjab	94	9.4	**9**

The sample design is as follows:

Table 3 : Universities / Institutions in Punjab – 94 as per UGC and AICTE (2020-2021)

Majha Region (Strata – 2)				Doaba Region (Strata – 2)				Malwa Region (Strata – 2)			
IInd yr		IIIrd yr		IInd yr		IIIrd yr		IInd yr		IIIrd yr	
CSE	ME	CSE	ME	CSE	ME	CSE	ME	CSE	ME	CSE	ME
B / G	B / G	B / G	B / G	B / G	B / G	B / G	B / G	B / G	B / G	B / G	B / G
Students of average age 19.5 years **(Stratum)**											

C. Sample Size Calculation – Power Analysis

Researchers need to figure out the required sample size prior to the data collection [72]. Also, the method employed in determining the sample size plays an important role in hypothesis testing using inferential statistics, with several such methods of sample size justification available [53],[46],[44]. When sample size planning and justification is done in retrospective

after the results of the study are known, such an exercise is called "Sample-size planning after the results are known (SPARKing)", which damages the study's reliability and credibility.

However, in the present study, power analysis was conducted to determine the final sample size for anticipated effect size of 0.3, desired power level of 0.9, 14 variables and their 62 items, and for the level of significance 0.05, using the online sample size calculator by [69] based on the theoretical work of [17] and [78]. The recommended minimum sample size was 252.

Moreover, the criteria of [80] was adopted to determine the adequacy of the sample size during data collection, considering application of the statistical technique of confirmatory factor analysis under structural equation modelling on the comprehensive model of self-regulated learning

D. Sampling Procedure

The researcher personally visited the nine institutions and explained the purpose of the visit to the each of the head of these institutions during the data collection exercise which lasted for a period of 10 months. A copy of the final tool was shared with the heads and formal permission was sought to allow data collection from the second- and third-year computer science and mechanical engineering students of these respective institutions in physical copies of the instrument and its electronic type using a google form. The data was collected during regular classroom session in the presence of the engineering faculty, after explaining the instructions of filling the questionnaire and assuring the subjects of data confidentiality and the usage of the data for strictly research purpose only. The students 50 to 55 minutes for completing the physical questionnaire and an hour and 10 minutes to fill the same in electronic mode. While the data obtained through physical questionnaire was manually punched in SPSS Statistics Ver.23.0 data file, the responses obtained from google form were coded back to ordinal data from the graded response categories of the respective tools in MS Excel spreadsheet and imported to SPSS Statistics data file.

E. Instruments

The details of the variables representing the strategies of self- regulated learning under its components, the tools used to measure these variables, theories based on which these tools were developed and their proponents are mentioned below:

S.No.	SRL Variable	SRL St.	Theory of origin	Proposed by	Tool of Origin
1	Critical Thinking	COG	Social cognitive theory	[5]	MSLQ - R by [41]
2	Organization				
3	Self - Evaluation	META			
4	Self - Recording				
5	Planning				
6	Self-Efficacy	MOT-MB			
7	Goal Orientation				
8	Academic Intrinsic Motivation		Self Determination theory	[29]	AMS 28 by [75] (1992)
9	Academic Delay of Gratification	MOT - VOL	Hot-cool systems theory	[48]	ADGS by [8]
10	Academic Procrastination		Temporal	[68]	APS SF
11	Future Time Perspective		Socioemotional selectivity theory	[23]	ZTP-SF by [60]
12	Reappraisal	EMO	Process theory	[33]	AERQ by [3]
13	Suppression				
14	Time and study environment	BEH	Social cognitive theory	[5]	MSLQ - R by [41]

F. Statistical Analysis

The comprehensive model of self-regulated learning among engineering undergraduates in the context of sophomore slump phenomenon was tested using confirmatory factor analysis (CFA), followed by measurement invariance testing of the factor structure through configural measurement invariance across groups using structural equation modeling (SEM) (using SPSS Amos Ver. 23.0), owing to the cross-cultural nature and German origin of the previous model in the Indian context. Reliability of the instrument's 14 variables was estimated using Pearson's correlation-based Cronbach's alpha (using SPSS Statistics Ver. 23.0) and Polychoric correlation based ordinal alpha (using R Package Psych), along with estimation of attenuation index to show the extent of underestimation of the vital psychometric property by assuming the data of Likert scale-based questionnaires as continuous interval and on ignoring its categorical ordinal nature. The validation studies of all the instruments and the scale purified final items of the study can be obtained from [24].

3. Results

Under descriptive statistics, the measure of central tendency mean, the measure of dispersion standard deviation, the measures of asymmetry, skewness and kurtosis are reported below:

Table 5: Descriptive Statistics

	Mean	Standard Deviation	Skewness	Kurtosis
ADG	3.4706	.61024	-1.479	2.290
AP	2.8607	1.00770	.038	-.606
FTP	3.5799	.67954	-.098	.365
Reapp	3.1598	.78843	-.063	-.173
Supp	3.4910	.63576	-.086	.323
AIM	4.9834	1.21718	-.615	.197
SE	5.3750	1.09612	-.572	-.229
GO	5.2587	1.02562	-.288	-.361
BEH	4.9969	1.08624	-.147	-.615
CT	5.1619	1.04674	-.377	-.196
ORG	5.3227	1.10340	-.547	-.100
Planning	5.4679	1.09522	-.605	-.163
Srec	5.2290	1.02394	-.270	-.480
Seval	5.4180	1.06063	-.648	-.087

Table 6: Regression Weights

	Estimate	S.E.	C.R.	P-Value
BEH <-SRL	.876	.046	19.053	***
COG <-SRL	1.000			***
METACOG<SRL	.893	.034	25.935	***
MOT <-SRL	.419	.021	20.186	***
EMO <-SRL	·148	·029	5.081	***
GPA <-SRL	·138	·059	2.344	0.019

Table 7: Standardized Regression Weights

	Estimate
BEH <-SRL	.717
COG <-SRL	.921
METACOG <-SRL	.866
MOT <-SRL	.743
EMO <-SRL	.236
GPA <-SRL	.110

The factor loadings of the components of self-regulated learning with the construct are fairly strong (above 0.6) and significant. Although, the path analysis of the emotional component of the self-regulated learning was relatively less at 0.24 though significant. Also establishing criterion validity, the path analysis of self-regulated learning with academic achievement was also significant with the regression coefficient being 0.11 for a p- value = 0.019, which is less than the level of significance $\alpha = 0.05$.

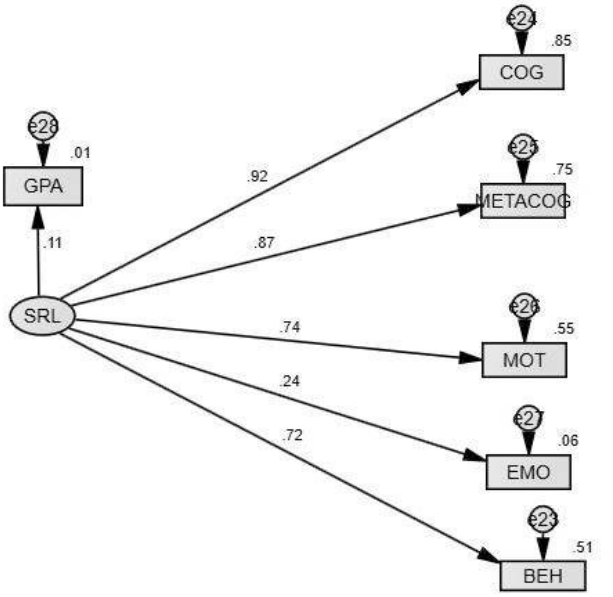

Fig. 1: Unconstrained Factor Structure of the Revised Integrative Trait Model of Self-Regulated Learning

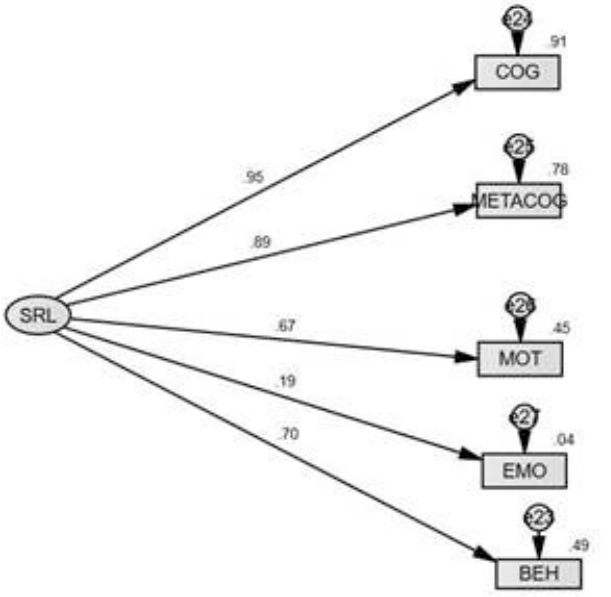

Fig. 2 : Constrained Factor Structure of the Revised Integrative Trait Model of Self-Regulated Learning with respect to Gender

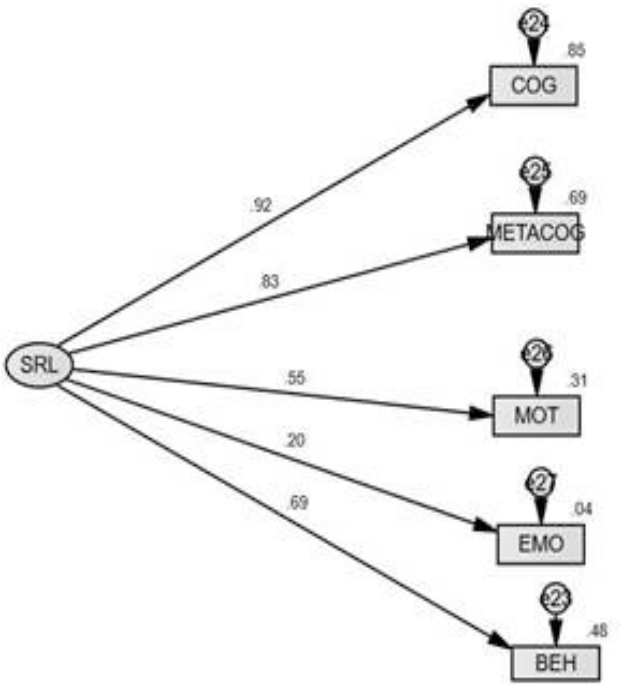

Fig. 3: Constrained Factor Structure of the Revised Integrative Trait Model of Self-Regulated Learning with respect to Batch

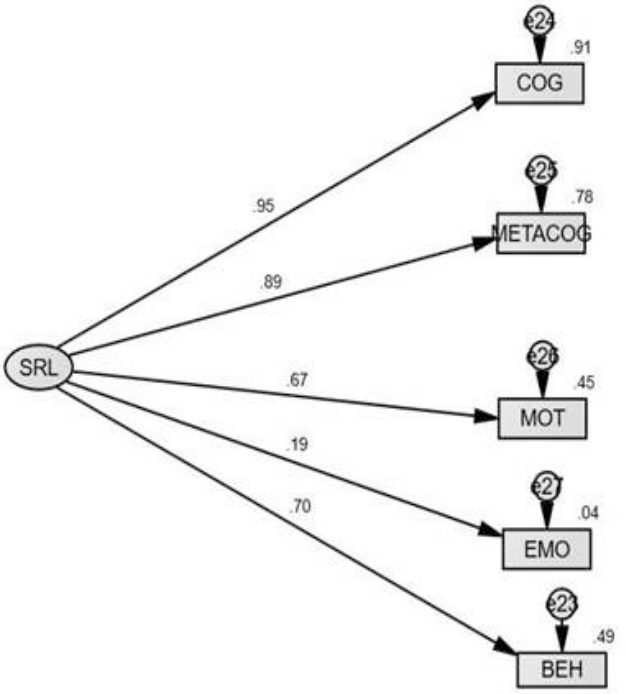

Fig. 4 : Constrained Factor Structure of the Revised Integrative Trait Model of Self-Regulated Learning with respect to Stream

Confirmatory factor analysis using maximum likelihood ML estimator was conducted using SPSS AMOS Ver. 23.0 software for establishing the validation of the newly proposed model. The obtained goodness of fit estimates indicate that the data support the proposed model of self-regulated learning. This is because the obtained values of TLI and CFI at 0.968 and 0.981 are above their benchmarks of 0.95. Also, the SRMR value at 0.0302 is less than its benchmark of 0.05, along with the obtained RMSEA value at 0.072 which is less than its benchmark value of 0.08. Post hoc power analysis was conducted using the R package semPower [51] Ver. 4.2.3, using RMSEA as the measure of effect size, for level of significance 0.05, N=488, df=9 and p=14. The obtained power was 0.941, greater than 0.8, which proves that there is enough evidence to show that self-regulated learning with its five components and respective strategies not only exists in the population but also exists in the studied sample.

Table 8: Configural Measurement Equivalence Testing of the Comprehensive Trait Based Self-Regulated Learning Model:

Estimates	SRMR	TLI	CFI	RMSEA	Result
Unconstrained SRL Model	0.0302	0.968	0.981	0.072	***Invariant***
Constrained SRL Model -Gender	0.0269	0.982	0.991	0.045	
Constrained SRL Model -Batch	0.0247	0.974	0.987	0.054	
Constrained SRL Model -Stream	0.0291	0.980	0.990	0.047	
Δ CFI - Gender	-	-	0.01	-	
Δ CFI - Batch			0.006		***Invariant***
Δ CFI - Stream			0.009		***Invariant***

Remark: [25] criteria of Δ CFI <= 0.01 is applied for determining model invariance.

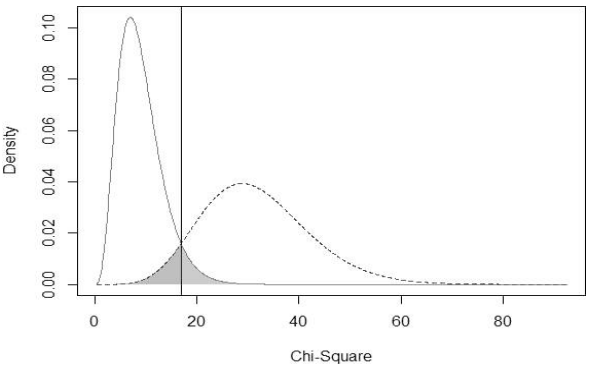

Figure 5: Post-hoc Power Analysis Output

Table 9: semPower: Post-hoc Power Analysis

F0	0.046
RMSEA	0.072
MC	0.976
GFI	0.993
AGFI	0.922
df	9
Num Observations	488
NCP	22.721
Critical Ch-square	16.91
Alpha	0.05
Beta	0.058
Power (1-Beta)	0.941
Implied Alpha/Beta ratio	0.847

Further studies suggested that the factor structure of self- regulated learning with its five component is invariant with respect to groups like gender, batch and stream of the engineering sample subjects of the study. It is because, compared to unconstrained factor structure, the constrained factor structures with respect to gender, batch and stream have differences of their CFI values less than or equal to 0.01 as per [25] criterion of measurement invariance. It means the operational definition of self-regulated learning means the same for boys and girls of second year and third year students of computer science and mechanical engineering streams. Hence the null hypothesis of the factor structure of the proposed model of self-regulated learning being measurement equivalent across the groups of gender, batch and streams of computer science and mechanical engineering students is accepted.

Table 10: Reliability Analysis

S.No	Component of SRL	Variable	α	Ordinal α	A.I
1	EMOTIONAL	Reappraisal	0.629	0.68	7.5
2		Suppression	0.513	0.57*	10*
3	VOLITION UNDER MOTIVATION	Academic Procrastination	0.65	0.71	8.45
4		Future Time Perspective	0.479	0.54*	11.29*
5		Academic Delay of Gratification	0.479	0.58*	17.41*
6	MOTIVATIONAL BELIEFS UNDER MOTIVATION	Academic Intrinsic Motivation	0.832	0.86	3.25
7		Self-Efficacy	0.817	0.85	3.88
8		Goal Orientation	0.726	0.77	5.71
9	BEHAVIORAL	Time and Study Environment	0.719	0.76	5.39
10	COGNITIVE	Critical Thinking	0.783	0.82	4.51
11		Organization	0.776	0.82	5.36
12	META-COGNITIVE	Planning	0.765	0.81	5.55
13		Self-recording	0.722	0.78	7.43
14		Self evaluation	0.77	0.81	4.93

The under estimation of the reliability coefficient for all the 14 variables of self-regulated learning model, by the Cronbach's alpha and its precise tetrachoric correlation based ordinal alpha reliability coefficients of the variables are shown above, along with the percentage of attenuation index. 11 out of 14 variables, barring suppression, academic delay of gratification and future time perspective variables have their reliability above the conventional threshold of 0.6 [55]. However, these reliability estimates of all the variables are acceptable according to [39], where the reliability of a scale with coefficient 0.5 to 0.7 is moderate, high from 0.7 to 0.9 and poor below 0.5.

4. Discussion

According to [36], the definition of engineering profession is "the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically, the materials and forces of nature for benefit of mankind". It suggested that the relationship between advancement in engineering and technology sector and the economy is intertwined as per the very definition of this profession. Practically, it is evident in the economic progress achieved by countries like Ireland, Finland and South Korea having invested hugely on engineering and technology education. In India, both the manufacturing and infrastructure sectors are intimately related to the engineering sector which is critical for the country's economy. Moreover, India became a permanent signatory of [79] in June 2014, which lists self-regulated and lifelong learners as the vital attributes of graduates of engineering belonging to its signatory countries. This implies that it is now binding on India to produce such self-regulated and lifelong learning engineering graduates from its educational institutions, which is also the need of the hour internationally [15]. Also, it is worth mentioning here that a 2018 Science and Engineering Indicators report published by the National Science Board, the United States, mentioned that India produces maximum number of engineering graduates at 25 percent in the world, followed by China at 22 percent. Since close of 50 percent of engineering graduates of the world are produced by these nations, it is important that enough attention and resource be allocated towards engineering education research in these countries.

With the presence of a gender, batch and stream-wise measurement equivalent empirical framework

Table 11 [80] : Criteria for Sampling Adequacy in Structural Equation Modeling

Criteria	Details	Result	Remarks
Bias	Level of significance=0.05	0.05	Adequate
Power	0.8 or more	0.941	Adequate
Solution Propriety	Larger the sample size, lower the error leading to model convergence	Model converged n=311 itself	Adequate
Effect of Number of Factors	When a latent variable has three or more factors, the effect of sample size is plateaued	SRL has five component factors	Adequate
Effect of number of Indicators or Items	When the indicators are six or more per latent variable, the effect is plateaued	On average the 14 variables, had 4 indicators or items to keep the model complexity in check	Not Adequate
Effect of magnitude of factor loading	Models with factor loadings above 0.5 require smaller sample size for model convergence	Four out of the five factors of SRL have factor loadings well above 0.6	Adequate
Effect of magnitude of factor correlations	Stronger the interrelationship between the factors, smaller the sample size required	The inter-relationships Between the five factors arevery strong and highly significant at 0.01 level of significance (Except for emotional component) with coefficients ranging from 0.169 □ 0.802	Adequate

for measuring self-regulated learning, it is expected that research in this specific and vital topic of engineering education would pick up pace in India, along with the curbing of the harmful effects of sophomore slump through proper designing of engineering curriculum in the second and third years. The prevalent approach of measurement invariance testing of the Likelihood ratio test (LRT) was not adopted in this study, because of the dependence of this method on chi-square estimand which is sample size sensitive [6],[43]. Finally, the criteria of [80] was adopted to end the data collection at sample size n = 488 for conducting confirmatory factor analysis under structural equation modelling of the comprehensive model of self-regulated learning, which is detailed above.

5. Limitations

The sample size of the study is relatively moderate at 488 though not large enough and hence, it is imperative that further studies be conducted on larger sample sizes in the Indian context. Due to the scarcity of quality works in the India with respect to self-regulated learning aspects of engineering education, there is little body of literature of this topic, painting an unclear picture of the state of the art. The scales of suppression, future time perspective and academic delay of gratification displayed relatively weaker reliability estimates with the present number of their items in the final instrument. More studies with the inclusion of further items or indicators of these variables from their original tools is warranted. The reliability of these scales can increase with the replication of the present study with higher sample size. Also, the number of response categories in the several instruments used of the member variables of self-regulated learning differs, which poses a threat to the psychometrics of the overall measuring instrument. Studies meant to validate these member tools with a desirable five-point Likert scale response category can be very beneficial.

6. Conclusion

Present study tried to validate a comprehensive model of self- regulated learning in the context of sophomore slump for the targeted population of engineering undergraduates, and the results are encouraging with cursory educational implications in engineering education of India. The study was conducted during the trying times of COVID-19 pandemic. However, the proposed model's contribution in measuring the trait based and hence temporally stable individual differences of self-regulated learning strategies of second-and-third year engineering students, across gender, batch and stream remains unchanged. The model was successfully used in a latest study to find the impact of self- efficacy as a mediating variable in the relationship of self-regulated learning strategies on engineering competency in India [52]. It is hoped that, the present

comprehensive model of self-regulated learning would emerge validated in other contexts and with larger sample sizes when administered on tertiary level subjects of other streams of engineering and multiple disciplines alike in India and engineering education students, teachers, scholars and policy makers would take notice of the mentioned implications of the study and play their respective niche parts to bring necessary changes in the curriculum of engineering discipline in second year of engineering education.

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