

# Modelling and Simulation of Quality Management in Higher Education: A System Dynamics Approach

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## Abstract:

This paper focuses on the quality management of newer higher educational institutions through ABET criterion. The method used in this research is model-based simulation to support the decision making. Standard methodology adopted in System Dynamics (SD) is used for modelling and simulation. The simulation results have indicated that the optimum time based strategy would be to adopt 30% increase per year in facilities and concentrate on 40% increase in all the rest of the factors as defined by ABET criterion. The implications of the study is to have a holistic approach towards quality enhancement and adopt a moderate increase in infrastructure and facilities but focus on continuous improvement of other factors of quality. As higher education is one of the services listed in General Agreement on Trade in Services (GATS), the strategy for quality improvement suggested through this research would be of significant use for the institutions trying to enter into globalized market.

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## SECTION I. Introduction

The importance of education for the development of excellence, expertise and knowledge leading to overall development in economy cannot be undermined. This has necessitated the formulation of a sound strategy for the development of higher education across the institutions round the globe. Total Quality Management (TQM) is inevitably common factor that will shape the strategies of higher educational institutions in their attempt to satisfy various stakeholders including students, parents, industry and society as a whole. In today's world of global competition, rendering quality service is the key for success, and many experts concur that the most powerful competitive trend currently shaping marketing and business strategy is 'service quality'.

Quality Management is generally described as a collective, interlinked system of quality management practices that is associated with organizational performance [1]. There is a prevailing belief that higher education has entered a new environment in which quality plays an increasingly important role [2]. Feigenbaum [3], argues that "quality of education" is the key factor in "invisible" competition between countries since the quality of products and services are determined by the way that managers, teachers, workers, engineers, and economists think, act, and make decisions about quality. Higher education is being driven towards commercial competition imposed by economic forces [4]. In the present globalized scenario, higher education plays a dominant role in the service sector.

In order to improve the quality of the higher education system, it is very much necessary to know the primary factors affecting the TQM system of higher education. This calls for a need to consider all the factors that affect the TQM system in higher education and develop a holistic model which can address the issues related to the monitoring of quality. This paper takes help of System Dynamics based modelling and simulation to study the influence of various parameters on the system quality. As time is one of the important parameters in the implementation of total quality, it is important to know the time lag between the start of the quality



initiatives to the obtaining of the desired results. So this paper is focused on the study of the time factor involved in TQM of higher education.

## SECTION II.

### Objectives of research

The aim of this research is to provide a model-based decision support for newer institutions to initiate quality management through various improvement strategies. Following are the objectives of research: (1) identify the factors which govern the quality of an educational institution, (2) establish inter-relationships between these factors, (3) develop a system dynamics based model to study the influence of various factors, (4) plan various scenarios and perform simulations, (5) determine the optimum timebased strategy for quality management.

## SECTION III.

### Literature Review

TQM practitioners claim that if a company's culture is not conducive to total quality, the culture must be changed before a total quality programme can be implemented. There appears to be a multitude of reasons why companies fail in their effort to implement a quality management system. However, two common problems appear to be a lack of strategic planning and a lack of appropriate culture supportive of TQM programmes [5]. The study of Liu [6] and Rahim and Whalen [7] showed lack of top management support and lack of proper training as the main barriers for TQM implementation. The barriers to implementing TQM will show up in all sectors – manufacturing, services, government, and education. The focus of this research is to apply modelling and simulation as the support tool in strategic planning for quality management in higher education sector.

Education being one of the important service sector, continuous improvement of quality is very much essential owing to the fact that there is a need for these institutions to compete globally. Having realized this educational research is already in progress since the past several decades and models are being built to study the factors influencing the system quality [7] [8] [9] [10] [11] [12] [13] [14]. Student achievement has also been a concern area in recent past and it has been observed that various factors affect student achievement at higher education level like personal confidence and a feeling of competence in learning; hopeful but realistic projection into the future occupational roles and social roles; emotional stability; temperamental tendency towards introversion; relative independence from teachers and a tacit acceptance of the curricular and work demands arising within the structure of tuition [15]. Self-efficacy has been identified as a positive predictor of academic performance [16]. Achievement is affected by students' personal characteristics, attitudes, activities and most of all students' interest and engagement. Students with low academic self-esteem and the students that are not interested and actively engaged are at a significantly higher risk of low achievement. [17]. Students' attitude towards a particular subject has a positive relation with achievement [18]. Cognitive aspects, motivational factors, teaching methodology and classroom-contextual factors exercise a significant influence.

Cognitive factors including cognitive capabilities, previous knowledge, and, to some extent, subject-specific self-concept are important for achievement in the context of higher education [19]. It is very important to nurture the elements of academic achievement which are controllable to some degree. While making any important decisions and developing policies, parents, teachers, community and other stake-holders should take into consideration the students' opinions and preferences and in this way should play their active and effective role to maximize their achievement and to get the most out of the students.

Along with these factors pertaining to the students' personalities, family background is also very important. Research indicates that students from lower socio-economic background in terms of parents' occupational status faced a higher risk of low achievement. Home educational background and parents' educational attainment greatly influences the quality of education for their children. Student achievement was found to be directly proportional to the education of their parents [18] [20]. The cultural factors of the home were another family characteristic that proved significant in predicting low achievement [17]. The educational institute has the key importance in this regard. Social climate of the institute indicated by characteristics such as the teachers' inclination towards improving educational achievement, and their expectations for pupil achievement are crucial for student achievement [21]. Teaching directly affects attitudes toward a particular school subject [22] and achievement is directly related to attitude. Conducive environment and other facilities provided by the institute affect the student learning positively [23]. Along with physical facilities,

guidance services provided by the institute play a significant role in achievement. Guidance services have significantly positive effect on student's study attitudes, study habits and academic achievement [24].

Instruction has often been identified as an important mediator in the enhancement of students' motivation in the classroom [25] [26] [27]. On the other hand, Good [28] reported that older students ignored the praise that they perceived as invalid and interpreted praise given for easy tasks as an indication that the teacher had low expectations of them. Another factor which is distinctive to higher education is peer assisted learning that encourages students of higher education to take the responsibility for the learning process in terms of academic achievement and social development [29]. Assessment system of the Higher education demands remarkably different criteria from the school level assessment. The ultimate aim within Higher Education is to develop independent learners and the university student is required, to a much greater extent, take responsibility for their own learning.

Strategic planning in higher education is also an area where a lot of research is in progress [30] [31]. Salegna and Fazel [32] have listed 16 obstacles which any organizations faces when implementing TQM and most of them are at the intellectual and cognizance domain rather than infrastructure or facilities related. So, it is also important for the educational institutions to identify these barriers both before and during TQM implementation [33].

Another concern observed through literature review is the misfit between focuses and the decision to be taken whether successful acceptance and implementation of quality system in higher education is influenced by the external factors such as favourable government regulations, economic climate, confident leaderships and a certain level of stress to initiate the need for change [34].

Having realized the importance of maintaining quality in all aspects that influence student learning in higher education, the accreditation bodies of different countries have designed and developed an assessment criteria. While all these accreditation bodies co-exist standardization of the assessment criteria is difficult to achieve as the need of each country varies with reference to the student performance. The Quality assessment (QA) criteria is one such standard that covers the totality of systems, resources and information devoted to maintaining and improving the quality and standards of teaching, scholarship and research, and of students' learning experience in the public universities [35]. The QA is designed to promote public confidence that quality in higher education is being maintained and improved continuously. ABET is another accreditation body which has given nine distinct criterion which includes: Organization governance, Evaluation of teaching learning process, Students entry and outputs, Faculty contribution, Facilities & technical support, Continuous improvement, Curriculum, Program educational objectives and general report about the strengths weaknesses and deficiencies.

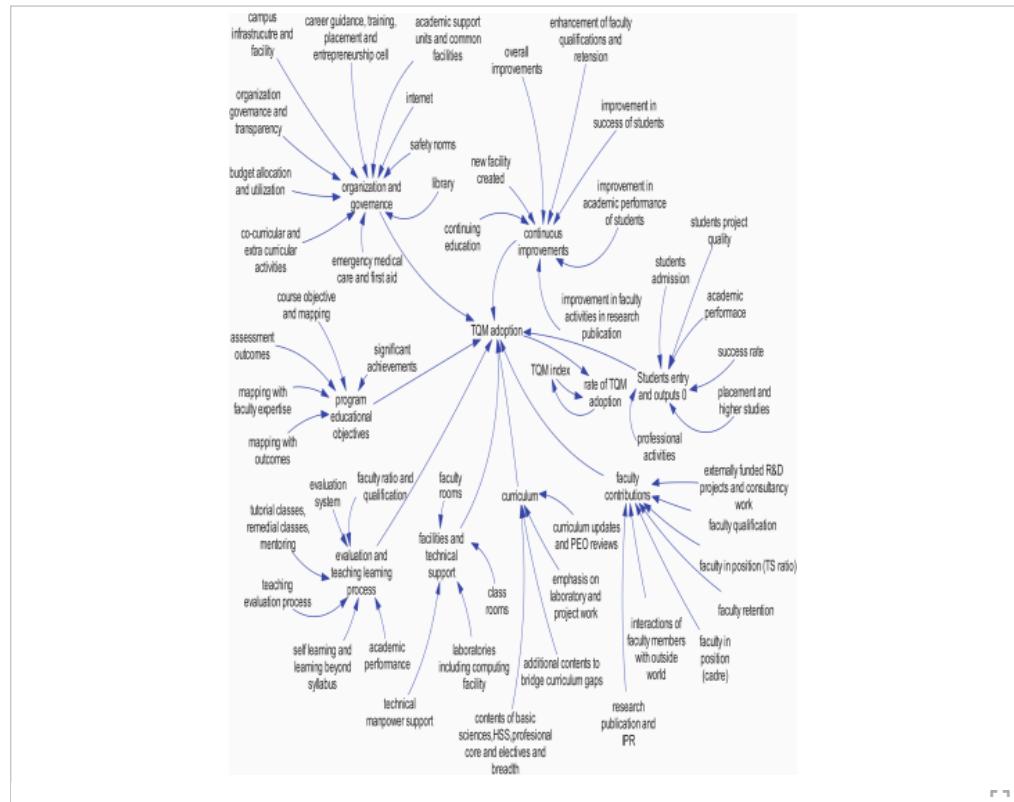
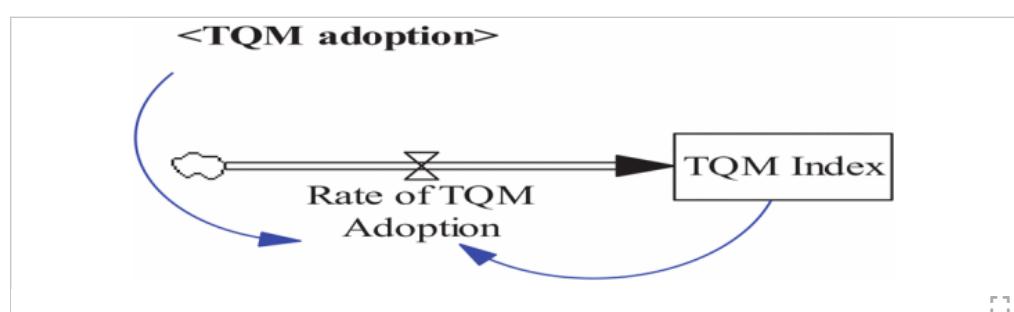
This research is based on ABET criteria as it is very widely accepted and is in practice in many universities round the globe. The attempt is to develop a System Dynamics based model which can address the issues related to delays in implementation of each of the criterion when an institution tries to aim towards the achievement of total quality with reference to these criteria.

## SECTION IV. CONSTRUCTION OF THE MODEL

The design of the TQM system is undertaken by analyzing the factors affecting the service quality of higher education (Fig.1) as defined by USA based Accreditation Board of Engineering and Technology (ABET). The study of the influence of these factors demands a systems perspective as the actual behaviour of the system would be the net result of the influence of reinforcing and balancing loops within the system.

**Figure 1.** TQM system for higher education

The causal loop and the stock and flow diagrams facilitating the SD based simulation ([Fig.2](#) & [Fig.3](#)) shows the inter-relationships of the variables under consideration. The rate of adoption of the individual factors affects the TQM score, which in turn, affects TQM index. These variables have been formulated and simulated with a purpose of identifying the number of years needed to reach the required level of TQM adoption.

**Figure 2.** Causal loop diagram for higher education system**Figure 3.** Stock and Flow diagram for TQM index

The point-based assessment of the institution by ABET criterion consists of 1000 points which is split on the eight dimensions based on their relative importance ([Table I](#)). Among the nine factors of ABET the factor General report about the strengths, weaknesses and deficiencies is not considered for simulation as there is no point allotted to it. The total points obtained by an institution during assessment is considered as the TQM Index in the model. The institutions will be accredited based on the total scores obtained by them during the assessment. In the construction of the model various scenarios have been analyzed based on the effort directed towards a particular criterion ([Table II](#)).

- Base run - Efforts are taken to increase all the factors by 30% from a base value of 300 points in a newly started institution.
- Scenario 1 to 3 - In these scenarios it is considered that the facilities is increased by 30%, 50% and 70% and remaining variables such as Organization governance, students entry and outputs, Evaluation of teaching learning process, Curriculum, Program educational objectives etc., are maintained at an increase rate of 20 % to 80% in steps of 20%.

**TABLE I.** The abet criteria of institutional assessment

Description	Points Assigned
1. Organization and Governance, Resources, Institutional Support, Development and Planning (ONG)	150
2. Evaluation and Teaching Learning (ET)	175
3. Student's Entry and Output (SEO)	150
4. Faculty Contribution (FC)	150
5. Program Educational Objectives (PEO)	100
6. Curriculum (CM)	125
7. Continuous Improvement (CI)	75
8. Facilities and Technical Support (FTS)	75
<b>TOTAL</b>	<b>1000</b>

**TABLE II.** Scenario planning of simulation parameters

Percentage variations	ONG (150)	ET (175)	SEO (150)	FC (150)	FTS (75)	CI (75)	CM (125)	PEO (125)
<b>Scenario 1</b>								
30- 20	30	35	30	30	23	15	25	25
30-40	60	70	60	60	23	30	50	50
30-60	90	115	90	90	23	45	75	75
30-80	120	150	120	120	23	60	100	100
<b>Scenario 2</b>								
50- 20	30	35	30	30	38	15	25	25
50-40	60	70	60	60	38	30	50	50
50-60	90	115	90	90	38	45	75	75
50-80	120	150	120	120	38	60	100	100
<b>Scenario 3</b>								
70- 20	30	35	30	30	53	15	25	25
70-40	60	70	60	60	53	30	50	50
70-60	90	115	90	90	53	45	75	75
70-80	120	150	120	120	53	60	100	100

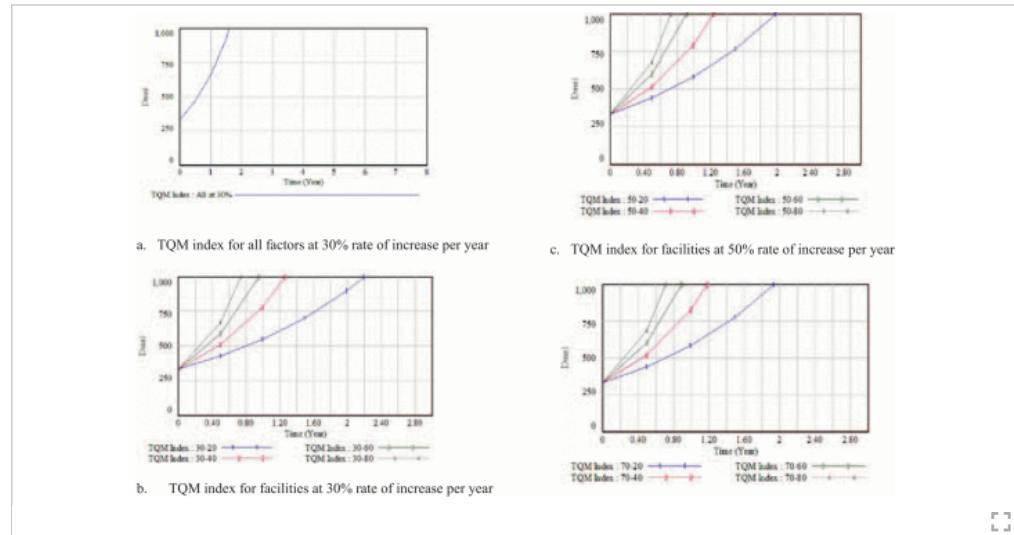
## SECTION V.

### Simulation results, analysis and discussions

#### A. Base run

It can be observed that in about 1 1/2 years the institution will be able to approach towards the desired level of 1000 points with 30% increase each year in all the eight factors contributing towards institutional

effectiveness ([Fig. 4a](#)).



**Figure 4.** Influence of quality factors on quality index

### B. Scenario 1

When facilities are augmented by 30% and the remaining factors are increased from 20 to 80%, the institution can aim to achieve the desired state from as low as 8 ½ months to an extended period of 2 ½ years ([Fig. 4b](#)).

### C. Scenario 2

When the facilities are augmented by 50% and remaining factors are increased at a rate of 20% per year, it can be noticed that 1 year and 10 months period will be required to reach the desired points and at 20 % increase and if 80% improvement can be aimed at, then it can be achieved in around 7 months ([Fig. 4c](#)).

### D. Scenario 3

When the facilities are augmented by 70% and remaining factors are increased at a rate of 20% per year, it can be noticed that 1 year and 8 months period will be required to reach the desired points and at 20 % increase and if 80% improvement can be improved by a few weeks in comparison to the previous scenario ([Fig. 4d](#)).

It is evident from the above simulations that even though facilities play an important role in building institutions of global standards, the other associated factors play a dominant role in the institutional performance on the whole. The implication of the study is that increase in facility augmentation from 30 to 70% doesn't contribute substantially to the rate of enhancement of institutional performance. So, the ideal choice for the newly started institutions, which aims at ABET accreditation is that it can aim at a 30% increase per year in facilities and concentrate on 40% increase in all the rest of the factors.

## SECTION VI. CONCLUSION & FUTURE WORK

The factors such as organization and governance, evaluation of teaching learning process, students' entry and output, faculty contribution, facilities and technical support, continuous improvement, curriculum, program educational objectives define the performance standard of a higher education system. Model based decision making in management is becoming popular day by day as it has the ability to reveal the system performance over a period of time. This capability of System Dynamics has been exploited in this paper. The Causal loop diagram has identified the interaction of all factors, which are instrumental in maintaining the total quality of the higher education.

From the simulation results it is clear that when a newly started institution is aiming towards excellence it needs to direct its energies in salient aspects which govern quality. Most of the privately owned higher educational systems are under the opinion that facilities and infrastructure alone can attract the students to their campus, but this study has challenged this assumption. The implications of the study is to have a moderate increase in infrastructure and facilities but a sustained focus on other dimensions of quality would pave the way for achieving excellence. The future scope of this work lies in extending the study to all the rest of the dominant factors of quality in similar manner, so that the most optimum mix of the improvement of effort required to move towards excellence may be determined.

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