Academic International Journal of Engineering Sciences
ISSN: 2984-7745
Aca. Intl. J. E. Sci. 2024; 2(1) 01-14
Journal homepage: www.aipublishers.org/aijes

Document heading.

# Effect of Training on the Construction Project Performance Using System Dynamic

**Suha Falih Mahdi[1], Roaa Faleh Mahdi[2]**
[1]Department of Highway and Airport Engineering, College of Engineering, University of Diyala, 32001, Ba'aqubah, Diyala, Iraq
[2]Directorate of Education
falehsuha@gmail.com

**Article Info.**
**Article history:**
Received 15.02.2024
Revised 15.03.2024
Published 8.04.2024
**Keywords:**
Training, System Dynamic, Construction Projects.
**How to cite:**
Suha Falih Mahdi&Roaa Faleh Mahdi Effect of Training on the Construction Project Performance Using System Dynamic. *Aca. Intl. J. E. Sci. 2024; 2(1) 01-14*


## Abstract
The sector of construction is important for the country's economic, community, and ecological agendas and therefore takes an important role in Iraq's future; managers of the project are in charge of activities planning and coordinating, and at the same time, obtaining the best charge, period, resources of the human and material so that objectives of the predetermined project are finally gotten. Hence, it is productivity can be increased if the skills of the managers of the projects are improved the paper aims to determine the effect of training on the project's performance in terms of both time and quality to obtain the causal effect on the projects. The paper's methodology consists of a questionnaire distributed to 140 experts in different sectors to obtain the problem that affects the time and quality of the projects and then analyze these problems using the system dynamic technique. Depending on the effort of the research, the subsequent assumptions can be utilized: The training system in Iraqi construction is very weak and very negligible and doesn't contain any supervision Most of the engineers are not multidiscipline, and even if they work on the other discipline, the luck the principle of it. The nature of the construction industry in Iraq tends to use traditional methods in construction and refuses to use modern techniques. There are a series of shortages in communication between different disciplines and that creates a gap that leads to becoming an obstacle in the front of project completion.

## Introduction
The sector of construction is important for the country's economic, community, and ecological agendas and therefore takes an important role in Iraq's future, managers of the project are in charge of activities planning and coordinating, and at the same time obtaining the best charge, period,

resources of the human and material so that objectives of the predetermined project are finally gotten. Hence, it is productivity can be increased if the skill of the managers of the projects is improved. The level of skill levels continues to deteriorate while clients crush the contractors for producing projects with low cost and more rapid schedules through the process of low-bid distribution. Consequently, contractors decrease training and complete the projects with fewer skills to be reasonable. The primary objective of the training is to prepare employees both new and old, for promotions to positions that require added skills and knowledge. This means that the training may range from highly specific instruction as steps in the performance of a given job to very general information concerning the economy and society [1] survey needs of professional training in Portugal in the scope of management of international projects and infrastructure, the results display that the areas nominated by the organizations investigated reflect the desire for the business on more knowledge to overcome the problems approached by the project[2]. Studying the idea of multiskilling as applied in both construction and non-construction sectors as a background for evaluating multiskilling in the UK construction sector A structure for supporting a general multiskilling barrier - inadequate training provision- is conceptualized [3], this aim to acquire suitable plans to decrease the number of unskilled employees and also to improve the skills of construction labors to have global competitiveness, the outcomes presented that the approaches that should be applied to improve the construction skills works are certification, standards and training, coordination, awareness, clearinghouse, and research. [4]. study addressed the effect of using a multiskilled workforce in the execution of project activities by studying the changes in project execution resource scheduling flexibility and project costs in response to workforce multi-skilling strategy [5]. The results show that a positive relationship between multiskilling and job redesign exists, and multiskilling hence there is a need to adopt multi-skills. Therefore, the paper aims to determine the effect of training on the project's performance in terms of both time and quality to obtain the causal effect on the projects. The second part includes building the model using system dynamics to show the effect of training on the cost of construction , System dynamics is a methodology of dynamically complex systems studying and management simulation model building [6]. System dynamics (SD) development was in the late 1950s for industrial systems analysis (Forrester,1961). SD has been applied successfully to problems, ranging from social, environmental, and industrial project management systems[7]. View of the world of an event-oriented or linear causal thinking cannot solve complicated problems adequately This kind of thinking tool used for many problems, can show the variation of the current state and the state that is desired or expected, then it can select and handled the problem by separating it from the environment that surrounds the problem, this paper aims to study the effect of training on project performance using the System Dynamics

**Research Objectives**

The main objectives of this research include the following:

•To identify the effect of training on construction project performance.

•To find the use of System Dynamics affecting time and quality constraints

**Methodology**

The methodology of the paper consists of a questionnaire that was distributed to 140 experts in different sectors to obtain the problem that affects the time and quality of the projects and then analyze these problems by using the system dynamic technique The initial step comprises a questionnaire and how the author gathers and prepared the questionnaire from different ministries

which spate into open and closed questionnaires. Many visits to the projects were made to obtain a pure idea about the reality and the facts of the training system in these projects and how the skills are been hired to get a flawless idea of how to prepare the right and the most useful questionnaire. The survey form was prepared in two phases.

### A. Open Survey(interviews)

The phase comprises guiding many interviews with professionals. That can be defined as someone who possesses exceptional knowledge committed to their job or knowledge connected to research skill. In a specific feature of the study, the advice wanted from the experts considering their related subject as they protracted or a concentrated knowledge in occupied and education in a specific area the questionnaire used to assess the training condition in the construction industry and their effect on projects, and it can be described as follow:

A. The time that contains the following problems rate of completion, delay in the project rework and rehabilitations
B. Quality contains the following problems defects, scrap.

### B. Closed Survey

This phase comprises as follows:
A) Early survey: Specialists' interviews have been done, and the thesis issues were divided into many items' encirclement, training effect, discipline, and the skill available. Hence, the questionnaire is prepared in its early method, this has been dispersed to eight professionals as a modest test, to distinguish the uncertainties and the faintness.

B) Final Survey: when the questionnaires were gathered from the eight specialists and the remarks were reviewed and the finding from every expert was taken into consideration there are some modifications to the questions to eliminate the nebulousness and mistakes in the last questionnaire preparation.

The second part includes using system dynamics to simulate the training effect on time and quality of the projects. The system that has a framework for dynamically simulating and building the model is system dynamic (SD) [6]. The discovery of SD was late in the 1950s for industrial systems analysis [8]. The range of areas that SD has been, ecological, and systems for engineering project management.

The issues of the world that consider causal thinking require the use of SD [8] Figure (1) explain the unidirectional philosophy pattern, which is based on the concrete hypothesis that is a result of a group of effect or feedback that make the final outputs or actions successively [8]. This type of thinking method can be used to solve many issues that require showing the difference between the required solution and the actual one, which leads to separating the outside effect to find the correct action.

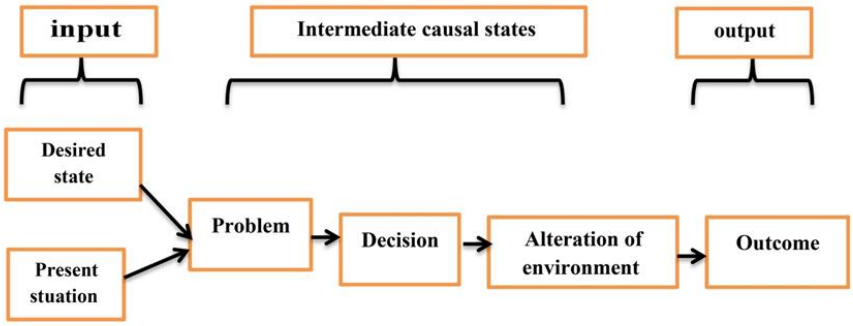



Figure 1. Causal Thinking of Linear Type [8]

The use of the SDM modeling technique to explore and understand a composite system completely by ascertaining its reaction structures and subsequent behavior [8]. The method was first proposed in 1958 by Forrester at the Massachusetts Institute of Technology (MIT) to explore the dynamics of industrial systems. In the past two decades, SDM has evolved into a pivotal approach to modeling the behavior and characteristics of complex systems in terms of internal feedback [9.10] The technique can provide a solution for macro-level issues while avoiding micro-level fragmented details [8.11]. Thus, it is suitable for handling multi-level complex systems (e.g., modern corporations and social organizations) [11].

**Distribution of Questionnaire Forms**

The questionnaire was distributed to the 140 individuals that made up the target sample. Using this method, the researcher gave a clear overview of the objectives of the study and offered any additional explanations that were needed. By enabling direct interaction and follow-up with the participants, this method guarantees a higher degree of accuracy and realistic results. Direct encounters resulted in the engagement of seventy individuals. Only 130 questionnaires, meanwhile, were returned by participants. An overview of the research sample, including the quantity of questionnaires sent and received,

The remaining 10 were neglected because of some missing answers and not receiving some forms. There could be several justifications for the lack of response and not receiving the questionnaire forms. Here are a few possible explanations:

1. Time constraints: The participants might have been occupied with other commitments or faced time constraints that prevented them from completing and returning the questionnaire within the given timeframe.
2. Lack of interest or motivation: Some participants may not have found the topic or the questionnaire itself sufficiently engaging or relevant to their interests or professional responsibilities.
3. Forgetfulness or oversight: In some cases, participants might have simply forgotten or overlooked the questionnaire, unintentionally failing to complete and return it within the specified timeframe. Human error or oversight can contribute to non-response rates.

The final part of this section involves the following steps:

- Conducting personal interviews with each respondent to discuss the questionnaire contents and address any potential misunderstandings regarding the questions.
- Emphasizing neutrality in the distribution of the questionnaire and promoting free-thinking among the selected sample.
- Ensuring that each respondent submits their answers and meticulously reviewing them to confirm the completion of the questionnaire.
- Organizing the answers to the questionnaire in an organized manner and preparing them for statistical analysis through arrangement.

**5.1Ministry**This part includes the ministry of the sample as shown in figure (2) as the group of higher education represented by 20.7% and from education ministry 15. % and the ministry of Housing is 39.3% and finally, the Ministry of the Road is 25%.

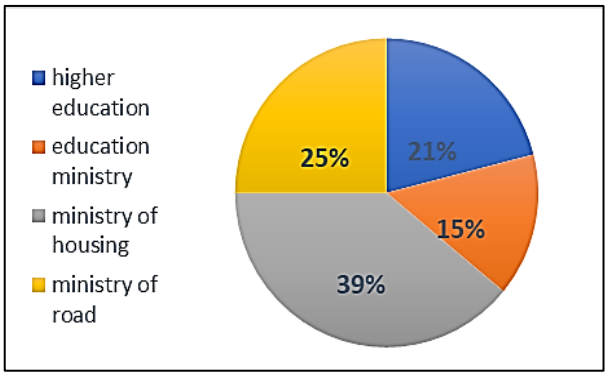



Figure 2: Distribution of ministry

**Academic degree**

figure (3) shows the Academic Degree of the sample where the percentages as follows: master equal to 30% , Bsc is equal to 33 % , Ph.D. equal to is 20% and others equal to 17%.

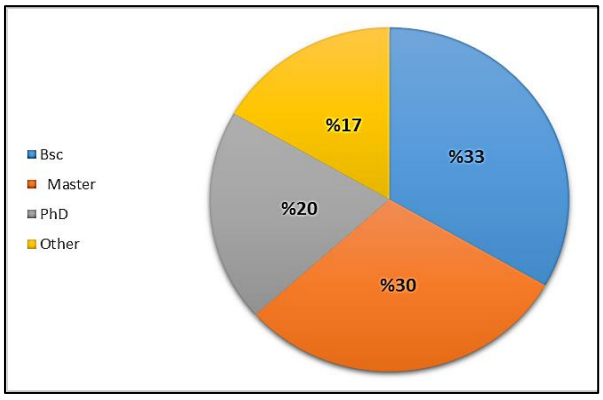



Figure 3: Distribution of Academic Degree

**Experience years**

figure (4) shows the years of experience in the sample where the percentages as follows: (0-5) equal to 30%, (5-10 equal to 33%, (10-25) equal to 20%, and 25-30 equal to 17%.

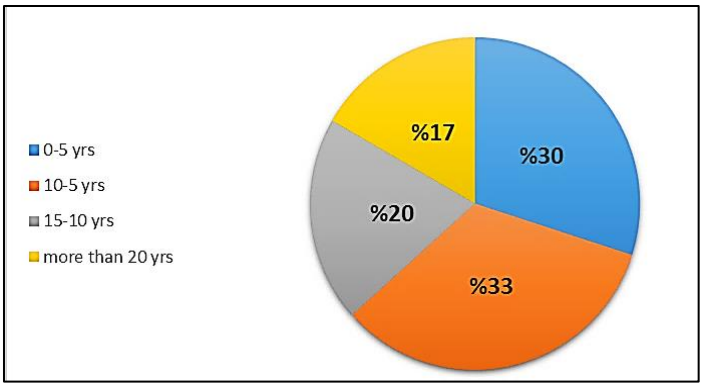



Figure 4: Distribution of Experience year

**Specialization of Engineering**

Figure (5) shows Specialization of Engineering the sample where the percentages as follows: civil equal to 30%, architectural equal to 17 %, mechanical equal to 13% electrical equal to 7% , contractor equal to 20% and other equal to 10%.

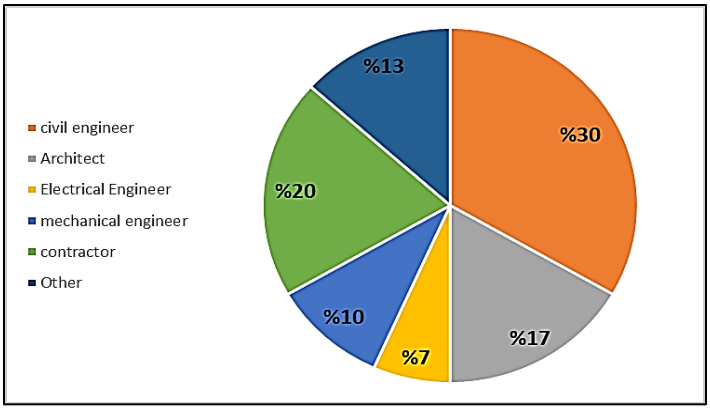



Figure: Distribution of Specialization of Engineering

**Work sector.**

figure (6) shows the work sector of the sample where the percentages as follow: for the public sector equal to 67% and 33% for the private sector.

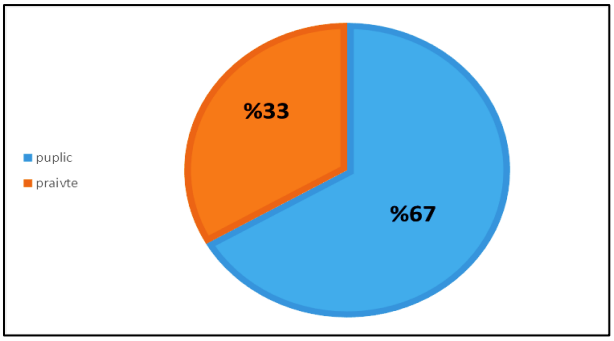



Figure 6: Distribution of Work sector

**Data Analysis**

The forms were gathered and organized in tables to compute the statistical analysis by using the statistical program SPSS version 25.

**Central Tendency Measurement**

The notion of representative value (the average) in statistics pertains to the concept of central tendency, which seeks to reflect the distribution of values with the best single value, and the mean is one of the most significant measures of central tendency. The mean score for each factor or option was calculated by using the following formula (Gravetter and Wallnau, 2016):

$$Ms = \sum_{k=0}^{n} (X1 * S1 + X2 * S2 + X3 * S3 + \cdots Xn * Sn) /N$$

Where

Ms= mean score (1≤Ms≤5)

(1)

**Measure of Variation**

The standard deviation is one of the most significant measurements of variability. It is a quantitative measure that is used to assess variations between values in a distribution and to determine whether the data is centered or dispersed (SD) Calculation of the standard deviation (SD) for respondents for each criterion is based on the following equation [14-16].

$$SD = \sqrt{\sum_{k=0}^{n} (xi - x)^2 * fi / (\sum_{k=0}^{n} fi)}$$

(2)

where *SD* = standard deviation
*x*= mean score
xi= degree of the criterion importance
fi= frequency

**Results and Discussion**

The results of the first part include several questions that relate to the research problem as shown in Tables (1:4)

To what extent do you possess these competencies?

2- How many disciplines are available in the construction projects?

Table 1 Shows the Competencies of Possession

| Items | Mean | Std. Deviation | Linguistic |
|---|---|---|---|
| Technical Knowledge | 2.2432 | 1.55287 | Low |
| Knowledge of Management | 3.1622 | 1.64170 | Medium |
| Communication skills | 2.8108 | 1.43058 | Medium |
| Marketing skills | 3.0541 | 1.56251 | Medium |
| Interpersonal skills | 3.2432 | 1.55287 | Medium |
| Behavior skills | 3.1622 | 1.64170 | Medium |
| Innovation skills | 2.8108 | 1.43058 | Medium |

Table 2 Shows the Discipline Available

| Items | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| Civil engineering | 1 | 5 | 3.2432 | 1.55287 |
| Architectural engineering | 1 | 5 | 3.1622 | 1.64170 |
| Electrical engineering | 1 | 5 | 2.8108 | 1.43058 |
| Survey engineering | 1 | 5 | 3.0541 | 1.56251 |
| Mechanical engineering | 1 | 5 | 3.2432 | 1.55287 |
| Computer engineering | 1 | 5 | 3.5 | 1.2 |
| Communication engineering | 1 | 5 | 3.1 | 1.2 |
| Others | 1 | 5 | 2.1 | 1.3 |

**How much skill is available in the different disciplines of construction projects?**

**What is the difference in skill between a new engineer and one with experience?**

Table 3 Shows the Skill Available

| Discipline | Skill | Mean | Std. Deviation |
|---|---|---|---|
| Civil engineering | Site Manager | 3.7 | 1.77 |
| | Construction manager | 3.1622 | 1.64170 |
| | Contractual manager | 2.778 | 1.3358 |
| | Contractual engineering | 3.0541 | 1.56251 |
| | Contract engineering | 3.2432 | 1.55287 |
| | Resident engineering | 2.3 | 1.3 |
| | Supervisor | 3.1 | 1.2 |
| Architectural engineering | Architectural | 3.5 | 1.2 |
| | Supervisor | 3.2432 | 1.55287 |
| | Consultant | 3.4 | 1.2 |
| | Construction manager | 2.9 | 1.9 |
| Contractor | Supplier | 3.0541 | 1.56251 |
| | Supervisor | 3.33 | 1.22 |
| | Construction manager | 2.8 | 1.8 |

Finally, this stage shows the difference between new engineers and experts in the field.

Table 4 Shows the Compression between new engineering and those with experience.

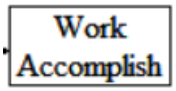
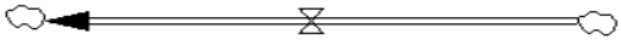
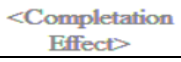
| Item | Skill | | | |
|---|---|---|---|---|
| Newly engineers | | Poor | Poor to good | Good |
| | design | 50% | 25% | 25% |
| | Construction | 45% | 30% | 25% |
| | Contractual procedure | 70% | 20% | 10% |
| | Consultant | 75% | 25% | 5% |
| | Supervisor | 65% | 25% | 10% |
| | Site investigator | 55% | 30% | 25% |
| Engineers with experience | design | 35% | 50% | 25% |
| | Construction | 25% | 30% | 55% |
| | Contractual procedure | 50% | 25% | 25% |
| | Consultant | 35% | 20% | 45% |
| | Supervisor | 10% | 40% | 50% |
| | Site investigator | 25% | 30% | 45% |

The later part is to find the discipline that available in the projects and the most specific field that overcome and the type of the skill they possess that are presented in tables (1) to (4)
The Cronbach Alpha for the questionnaire ranged from 0.78 to 0.88 which indicates high internal consistency. The second part includes system dynamic simulation as follows:

**System Dynamic Model**

The model of the system dynamic was constructed based on the real state of the current projects, which mean, an evaluation is made to assess the present reality. Table (5) shows the element that is used to build the model.

Table (5): System Dynamic Elements

| Element | Type | Description |
|---|---|---|
|   | Stock | Its show the accumulated effect at the end of a specific period |
|  | Flow | Its shows the change over time |
|  | Arrow | Its shows a causal relationship |
|   | Shadow variable | Its mirror for the same variable |

Then the effect of the time, and quality will be shown, and it is divided into two model.

Part1: system Dynamic for time Overruns

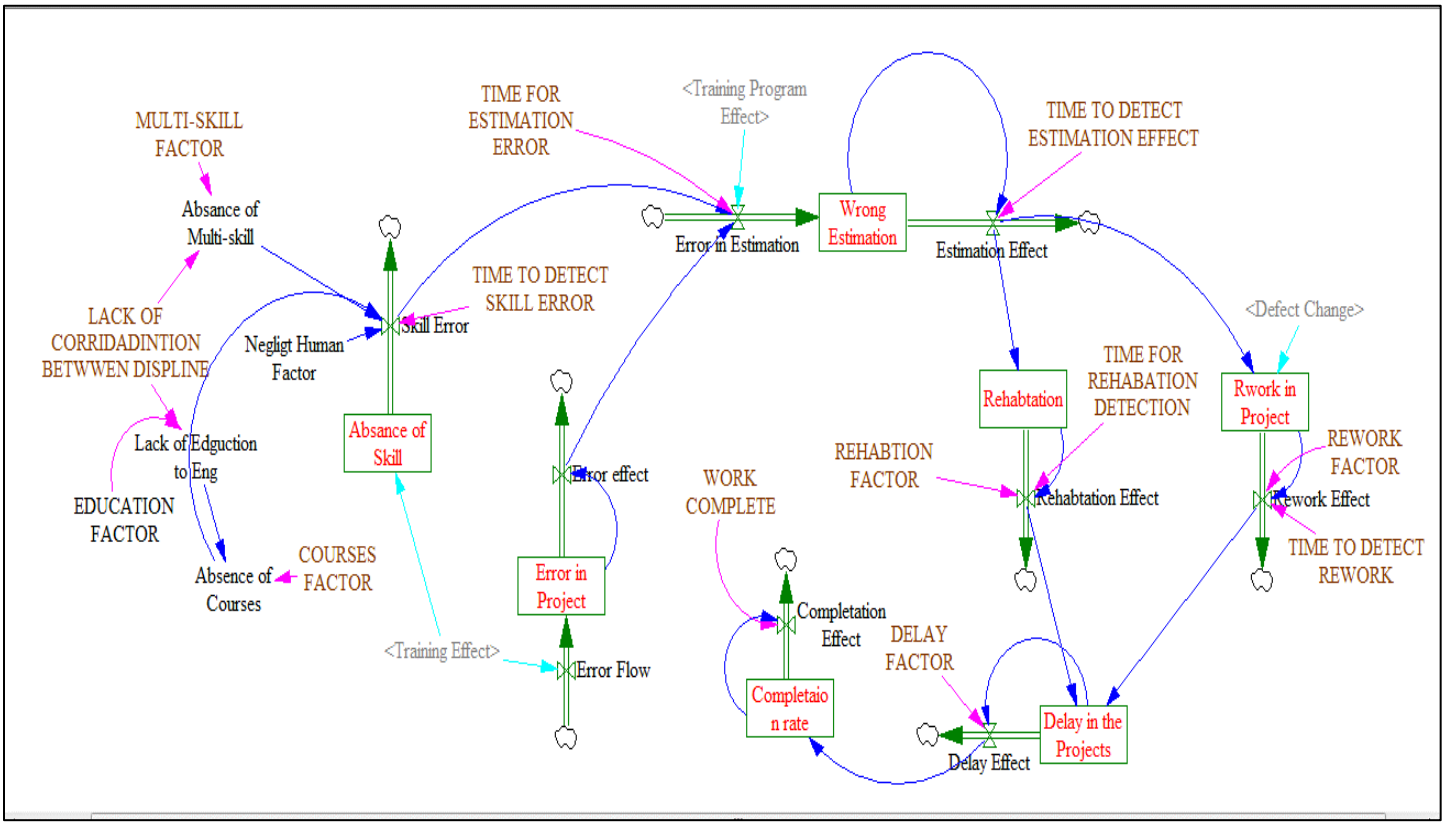



Fig.5 System Dynamic Model under Time Effect

The wrong estimation and their possible causes are then entered into the system to determine its effect, as the training absence and absence of the skill lead to many delay issues, and the rework of the project causes time overrun. The results of the model are presented from Figure (6-9)

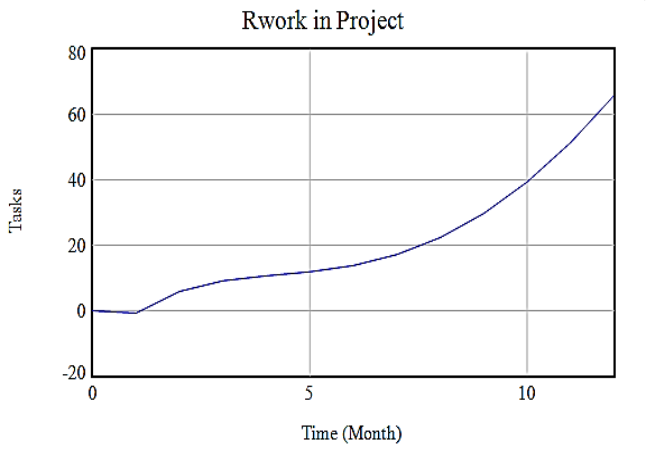



Fig.6 Wrong estimation

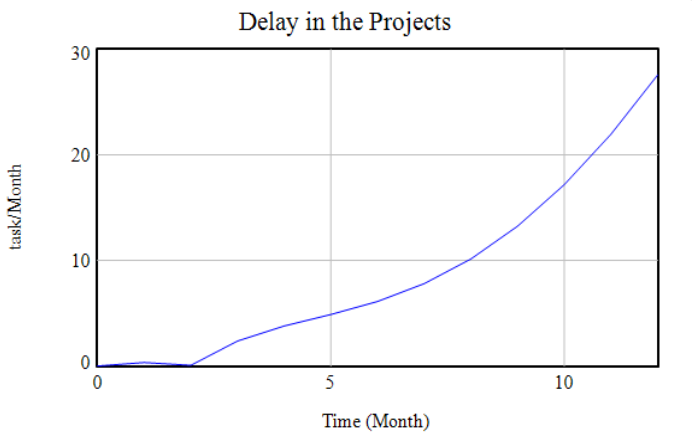
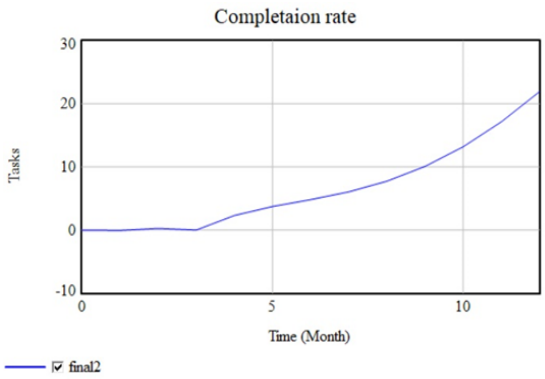



Fig.7 Absence of Skill



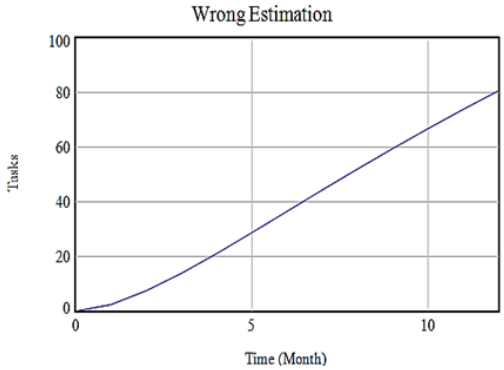




Fig.8 Rework in project

Fig.9 Delay in projects.

Fig.9 Completion rate

**Part2: system Dynamic for Quality Defect**

Figure (10): shows the main branches and the factors of Defect, scrap, late delivers, and quality defect

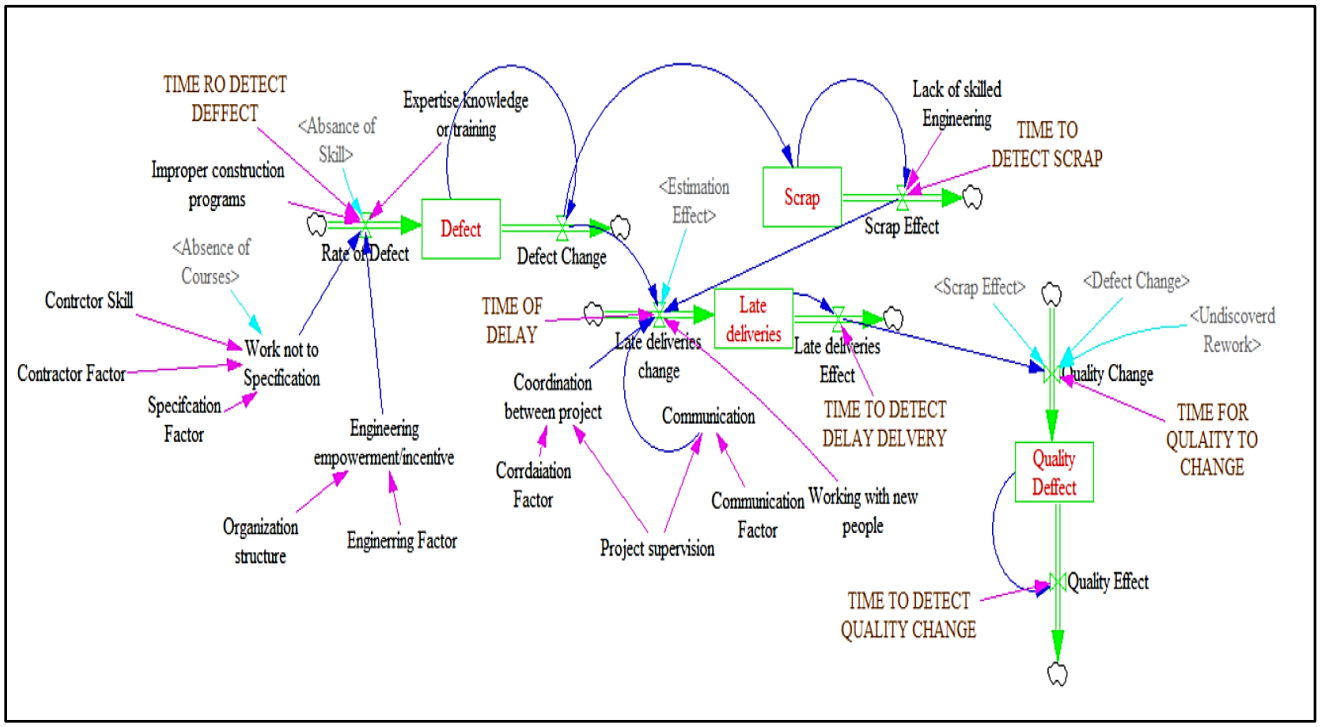



Fig.10.system Dynamic for Quality Defect

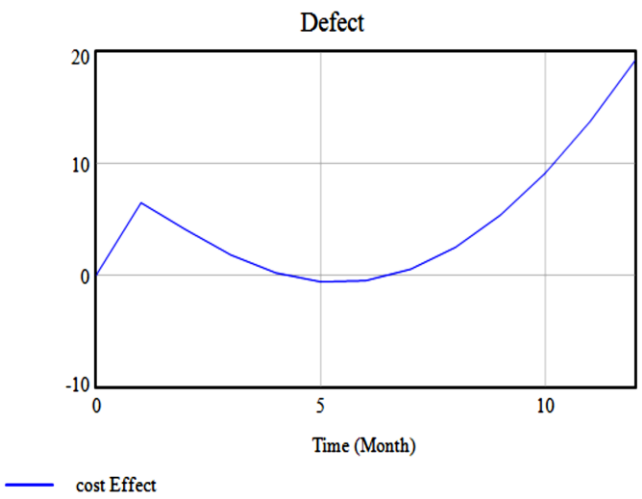



Fig.11. Late Deliveries


Fig.12 Late Deliveries

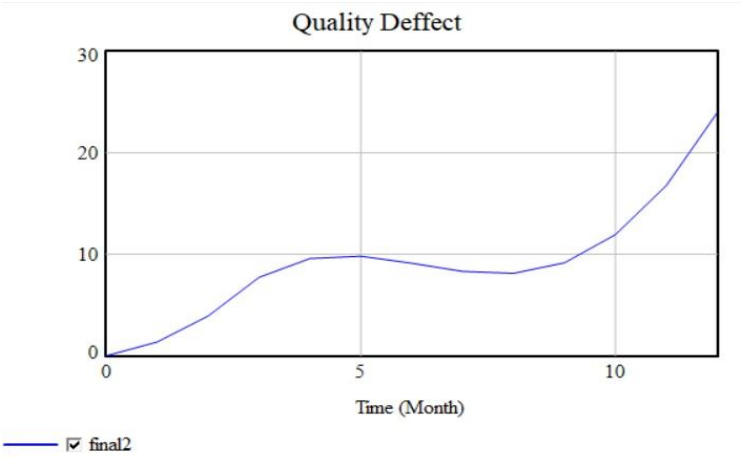



Fig.13. Quality Defect

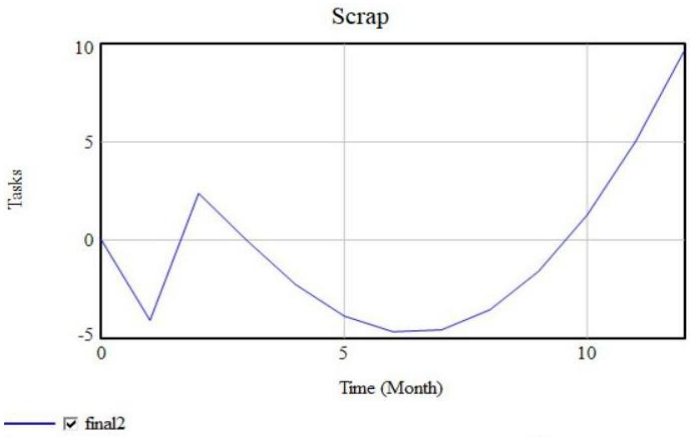



Fig.14. Scrap

The figures from (11-4) show that the defect in quality due to problems in the training increases the tasks to be performed by the engineers to more than 20 tasks which leads to consuming more cost and time, late deliveries increase the task to 30, quality defect in crease ton 25 and scrap increase more than 10.

**Conclusions**

Depending on the effort of the research, the subsequent assumptions can be utilized:

1- The training system in Iraqi construction is very weak and very negligible and doesn't contain any supervision.
2- Most engineers are not multidisciplined and even if they work in the other discipline, luck is the principle of it.
3- The nature of the construction industry in Iraq tends to use traditional methods in construction and refuses to use modern techniques.

4- There is a series of shortages in communication between different disciplines and that creates a gap that leads to becoming an obstacle in front of project completion.
5- System dynamic is a simulation tool that is used to simulate the construction nature in terms of training and multidiscipline and its effect on the constraints of the project which are cost, time, and quality.
6- The finance factor regard one of the main factors that lead to the absence of the training, as the budget of the project doesn't contain a percentage for the training.
7- The training evaluation, training program, and miss in training consider the main item that controls the training system and have an effect on the number of tasks to be implemented as it increased from 11 tasks to more than 50 tasks.
8- Education and training increased the level of the engineers and led to fewer mistakes.

**References**


1. Nassazi A. Effects of training on employee performance.: Evidence from Uganda.2013.[Cross ref.]
2. Teixeira JM, Pires B. Training needs in construction project management in Portugal.2006.
3. Ejohwomu OA, Proverbs DG, Olomolaiye P. Multiskilling: A UK construction and building services perspective. InProcs 22nd Annual ARCOM Conference 2006 Sep 1 (pp. 4-6).
4. Adi RP, Ni'am MF. Improving skill's strategies of Indonesian construction labours to have global competitiveness. International Journal of Civil & Structural Engineering. 2012;3(1):150-7.
5. Manyi T. The effect of using multi-skilled workforce on the flexibility of project resource scheduling and project costs: Eskom PTM central group project execution *department* (Doctoral dissertation).
6. Ford DN, Anderson SD, Damron AJ, de Las Casas R, Gokmen N, Kuennen ST. Managing constructibility reviews to reduce highway project durations. Journal of Construction Engineering and Management. 2004 Feb;130(1):33-42.
7. Forrester JW. Industrial dynamics mit press cambridge. MA. [Google Scholar]. 1961.
8. Sterman JD. Business Dynamics. Systems thinking and modeling for a complexworld. McGraw-Hill, Boston, 982 pp.
9. Sterman JD. System dynamics modeling for project management. Unpublished manuscript, Cambridge, MA. 1992 Mar;246.
10. Yuan H, Wang J. A system dynamics model for determining the waste disposal charging fee in construction. European Journal of Operational Research. 2014 Sep 16;237(3):988-96.
11. Ko CH, Chung NF. Lean design process. Journal of Construction Engineering and Management. 2014 Jun 1;140(6):04014011.
12. Carvalho AB, Fonseca SM, Guia A, Mota M, Carvalho M. Strategic Management of Cultural Projects—CIM DOURO Training. InInternational Conference on Tourism, Technology and Systems 2023 Nov 2 (pp. 1-13). Singapore: Springer Nature Singapore.
13. Gravetter FJ, Wallnau LB. Statistics for the behavioral sciences. Cengage Learning.
14. Pucuhuaranga Espinoza TN, Espinoza Montes FA, Cerrón Piñas LK, Torres Timoteo R. Training projects to develop fundamental learning in students of the Initial Education career. Revista San Gregorio. 2023 Dec;1:147-58.

15. Pucuhuaranga Espinoza TN, Espinoza Montes FA, Cerrón Piñas LK, Torres Timoteo R. Training projects to develop fundamental learning in students of the Initial Education career. Revista San Gregorio. 2023 Dec;1:147-58.
16. Chen Jiang, Changqing Yu, Tiantian Yang, Ziyue Lu, Furui Xue. Research on the Implementation Path of College Students' Innovation and Entrepreneurship Ability Training——Take the New Semiconductor Cooling Clothing Innovation and Entrepreneurship Projects for College Students of Automatic Temperature Control System as an Example. Frontiers in Educational Research (2022) Vol. 5, Issue 15:56-59. https://doi.org/10.25236/FER.2022.051512. [Cross Ref.]