On Effort Distribution in Software Project Development for Academic Domain

Jatinderkumar R. Saini, Vikas S. Chomal

Abstract*: Effort distribution in software engineering is a well-known term used to measure cost and effort estimation for each and every phase or activity in software development. Effort distribution is taken in consideration in almost all IT companies while developing software. But it is mostly not considered or overlooked in developing academic software projects by students of computer science courses. The paper presents with results of an experimentation on phase effort distribution data of 84 software academic projects of post graduate final year students of computer science. The phase effort distribution provided by students were collected, analyzed and compared with COCOMO II model which provides effort distribution required in software development. Finally, this paper also discusses and provides recommendation about the use and importance of effort distribution in academic software projects development.

***Keywords*: COCOMO II model, Computer Science, Effort Distribution, Software Development Life Cycle (SDLC), Software Engineering, Software Projects**

I. INTRODUCTION

In developing software different stages such as requirement analysis, designing, coding, testing and documentation are to be followed. At the same time different resources are also allocated and used during development. But accurate amount of effort required in these phases is one of the most important and crucial factor. If effort in software development is not properly measured, calculated and followed then it may result in quality failure or even it may result in a complete failure of software. Different models as well as approaches are used for proper allocation of effort distribution.

In courses of computer science, information technology and computer engineering software project development plays a vital role that provides students with a practical scenario of software development. During this project development, students are mandatorily required to strictly follow all the stages of software development life cycle. Failure to complete their software project development within a stipulated time is the common surveillance found in academic framework. There may be number of reasons behind this failure, but the most important issue is that students do not properly distribute their effort in software development. Therefore, from the very early stage if students are made aware or provided with such guidelines regarding proper effort distribution to be followed in SDLC, we the academicians will be successful in providing healthy IT professionals.

The aim of our research is - (a) To study and analyze overall effort distribution in various phases of software project development, (b) To learn and analyze how the overall phase effort distribution of software project look like, (c) To examine the average, maximum and minimum effort given by students during software project development, (d) To signify the importance of effort distribution in academic software project development and (e) To recommend the use of appropriate effort distribution in software project development in computer science courses. The paper is further structured as, in section II; literature review is presented, accompanied by methodology. Section IV represents finding and analysis followed by conclusion.

II. LITERATURE REVIEW

Balaji et al. [8] uses direct method for estimating effort. Further they compared the result with COCOMO model also. According to Saleh [5] inappropriate allocation of resources and effort distribution is one the main reason that causes variations in software development process. Liu and Wang [25] converse that effort distribution is an important criterion as well as an essential element having significance consequence in software development process and if neglected than software quality degrades. To justify their work, they conducted an experiment and observed that there was some consistency features between effort distribution and project development methods used, project types. Jorgensen and Shepperd [7] studied about the correlation between software size, software complexity and effort distribution and concluded that effort distribution cannot be ignored in software development life cycle. Yang et al. [26] studied 75 industrial projects of China Software Benchmarking Standard Group database. They observed that there was a consistency pattern considering software size and team size. Also they found variations in coding and testing phase. Also they presented in depth comparison with COCOMO model. In Table I, phase effort comparison among different models is presented.

Heijstek and Chaudron [22] explored total effort spent in software project development over different time span. Also, they presented practical data of 20 industrial projects and described various patterns emerged from these industrial data.

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Primandari and Sholiq [10] suggested that for proper allocation of effort distribution and estimation, it is imperative to identify varieties of segments and actions undertaken in software project development irrespective of project type. They categorized activities in two heads, the phased activities and the activities which are in progress respectively. Safavi and Shaikh [12] through their study proposed a modular approach for software development and by doing so effort distribution can be accurately applied. Zivadinovic et al. [4] suggested the use of most relevant methods and models for effort estimation and distribution. They also presented classification of these methods.

Table-I: Percent Wise Comparison of Phase Distribution Among Different Models

Sr. No.	Software Development Phase	Percent wise effort distribution among different models		
		COCOMO 81	COCOMO II Waterfall Distribution Scheme	RUP
1	Plan and Requirement	7	7	5
2	Preliminary & Detailed Design	25	-	20
3	Preliminary Design	-	17	-
4	Detailed Design	-	25	-
5	Code	33	33	65
6	Integration & Test	25	25	-
7	Deployment & Maintenance	-	12	-
8	Transition	-	-	10

According to Batra and Baraua [3] to estimate cost and effort are the most challenging attribute to be undertaken by most of the software development industries. They studied different estimation models and metrics for considering and studying cost and effort distribution in software project development. Mukherjee et al. [11] also stated that effort distribution is having a fundamental place in software development and cannot be neglected. In their study they investigated general effort distribution in software development considering various factors such as various developmental model used, size of the software to be developed, software size, team size developing the software and the business domain. Sangeetha and Dalal [6] articulate that effort estimation and distribution is a critical activity and to be considered in each and every phase of software development whether it is planning for development or monitoring the development process of software or may be delivering the software. Researchers have also presented a detailed analysis of the various reasons responsible for failure of software [15] [16], improvements in the quality of the software [17] and database [18] developed through the documentation of the process of development of software [19] and importance of deciding priorities during requirements analysis [20]. Rosa et al. [23] presents a set of effort and schedule estimation relationships for predicting software development. According to Tan [14] effort distribution is a significant element of software cost estimation. Also in research study, the researcher uses effort distribution used by the COCOMO II model which follows waterfall effort distribution. This is highlighted in Table II.

Table-II: COCOMO II Waterfall Effort Distribution Percentages [14]

Sr. No.	Phase/Activities	Effort (%)
1	Plan and Requirement	7 (2 – 15)
2	Product Design	17
3	Detailed Design	23 – 27
4	Code and Unit Test	29 – 31
5	Integration and Test	19 – 31
6	Transition	12 (0 – 20)

The documentation has been considered the gist of the software development process [27] and used by researchers for analyzing error pattern [28], analyzing attributes of software engineering [29] and design of a scoring system [30]. AHP approach has been used by researchers for finalizing optional subjects by students [31]. Levy [32] suggests estimation of cost involved in development covers two important aspects first is associated with the evaluation of software projects and second with the approval for development. Also, Levy focuses on the importance of effort distribution in software development process. Haapio [13] gave definition of effort which includes – total time needed to complete the software development, total man power required, total time period (days, months and years) and complexity of the project. Madhuri and Arora [24] state that effort distribution plays a driving role in both type of software development process methodology i.e. in traditional methodology as well as in agile methodology of software development. Boehm [1] suggests that COCOMO II model provide phase effort distribution percentage which must be considered same for developing a software considering various situations. Further Boehm [2] also conveys that COCOMO 81 model provides and accurate and systematic way of handling phase distribution during software development considering design, coding, integration and testing. Chatzoglou and Macaulay [9] in their research work proposed and developed a new model called MARCS which was used to provide predictions for resources required during software development process. Additionally, a team-building model for the software projects [33] as well as effort estimation models [34] [35] have also been proposed by the researchers.

III. METHODOLOGY

For research study we collected data from software project documentation prepared by final year students of Master Degree level course. The time period of these software project developments was six months. The documentation was collected from college library.

We scrutinized and evaluated 84 large software project documentations of softwares developed during a period of the academic year 2014 – 2015 to the academic year 2016 – 2017. During the examination process followed by us, we studied the Time Line Chart showing effort distribution of software projects. The Time Line Chart was available in the documentations and included to depict the plan and actual progress of the software development. As each project was exclusively diverse from other projects, this investigation was repeated for each of the 84 project documentation. Initially, the first step was to identify and extract the software development phases followed by students as well as task done during software development. These phases and corresponding tasks are mentioned in Table III.

Table-III: Phase and Task for Software Development

Sr. No.	Software Development Phase	Tasks Done
1	Learning & Planning	Learning of Technology, Preparing a plan
2	Requirement Analysis	Gathering, analysis and prioritizing requirements
3	Designing	Module, user interface design
4	Coding	Providing code to the software
5	Testing	Performing various test with test data
6	Documentation	Documenting software phases

Further, after identification of these phases and tasks next step was to study effort distribution data represented in software project documentation. For this procedure set of characteristics having quantitative values and can be used as metric for measuring effort distribution were considered and presented in Table IV.

Table-IV: Set of Quantitative Characteristics

Sr. No.	Metric	Unit	Description
1	Requirement Phase	Team Size and work completed week wise	Requirement Model
2	Design Phase	Team Size and work completed week wise	Design Model
3	Code Phase	Team Size and work completed week wise	Working System
4	Test Phase	Team Size and work completed week wise	Tested Software
5	Process Model	Software Development Model used	Waterfall
6	Team	Team Size	Maximum size of the team
7	Documentation Phase	Team Size and work completed week wise	Software Project Documentation

In the present work, we considered academic projects from 2014 – 2015 to 2016 - 2017 hence effort distribution for each phase in weeks are presented in tabular format in Table V (a), (b) and (c). It is noteworthy that for all the three sub-tables of Table V, the process model was 'Waterfall' model. Also, 'Req. Analysis', 'Doc.' And 'Mgt.' stand respectively for 'Requirements Analysis', 'Documentation' and 'Management'. From Table V (a), (b) and (c) we observed that there were 28 software projects developed during the academic year 2014–2015, 31 software projects during the academic year 2015 – 2016 and 25 software projects during the academic year 2016 – 2017. The next section presents finding and analysis.

IV. FINDINGS AND ANALYSIS

From a total of 84 software projects, 28 software projects were developed during the academic year 2014 – 2015 whereas 31 software projects were developed during the academic year 2015 – 2016 whereas 25 software projects were developed during the academic year of 2016 – 2017. The foremost observation found that all 84 software projects were developed using the Waterfall process model. Further, maximum, minimum and total average time spent for development of these said software projects in units of weeks are presented in Table VI.

From Table VI, maximum efforts given by students during software project development was requirement analysis at the highest, coding at second highest whereas design at the third highest. Whereas minimum effort was given to documentation of software project development. Further, overall phase effort distribution in percentage is presented in Table VII.

Table VII represents that percentage wise there is consistency in phases such as requirement analysis, design, code and testing. Whereas, during the year 2016 – 17 there was a huge increase in effort distribution (percentage) in documentation phase. Now the next procedure was to examine the differentiation of individual phase distribution with the software project developed by students for each individual academic year in consideration with COCOMO II, we compare the effort distribution (percentage) with the COCOMO II following waterfall distribution magnitude and present the same in Fig. 1(a) to Fig. 1(c).

As revealed in Figure 1 (a), (b) and (c) distribution similarities were found in the Design phase. But large amount of divergences are found among two datasets which shows that: (a) A larger prominence on Requirements Analysis phase is found for all 3 academic years (22.08%, 17.6% and 26.91%) which is only 7% stated in COCOMO II; (b) Coding phase is severely found to have lowest effort again for all 3 academic years (24.91%, 18.18% and 19.45%) correspondingly as compared to COCOMO II projects (33% in average); (c) Same pattern was observed for testing phase having significantly a smaller amount of effort distribution for all 3 academic years 12.01%, 9.24% and 12.73% respectively as compared to 25% in COCOMO II; and (d) As academicians, the researchers found that mostly the students devote their efforts even in preparation of documentation and the same is been observed from the Time Line Chart presented in software projects documentation which in itself is not a good practice nor we suggest to follow it. In real sense of the software development, the documentation is and should be a parallel activity to be done during or immediately after the completion of the individual phase. This is truer when the Waterfall model is followed as it provides with almost sequential flow of activities during the software development process. From the observations, we explored and analyzed that the effort in preparation of documentation for the 3 academic years was 7.14%, 5.72% and 8.73%, respectively.

Table-V(a): Week-wise Phase Effort Distribution for The Year 2014–15

Sr. No.	Project Definition	Req. Analysis	Design	Code	Testing	Doc.	Team Size
1	Organization Mgt Information System	2	4	8	1	2	1
2	Human Resource Mgt System	3	3	4	4	3	3
3	Production Monitoring System	8	4	5	4	1	1
4	Social Networking	4	2	8	4	2	1
5	Online Shopping Portal	3	2	8	1	4	2
6	Book my Class Room	3	1	5	3	2	2
7	Yeboshop	8	3	4	3	2	3
8	Advance Pizza Ordering System	4	2	3	2	3	1
9	Alumni Website with Cloud Computing	5	1	2	2	1	2
10	Android Applications	6	2	5	2	2	2
11	A to Z Directory Search Engine	8	4	5	3	1	3
12	Know your School	4	2	8	3	2	1
13	AdRelease	6	5	8	3	1	1
14	Online Auction System	3	4	3	1	1	2
15	Student Mgt Information System	7	4	3	2	1	2
16	Online Ethnic wear Shopping Store	5	4	6	3	1	3
17	Tourism Mgt	3	3	4	1	1	2
18	Work Flow Mgt System	5	2	3	2	1	2
19	Online Hostel Mgt System	2	2	6	1	1	2
20	Online Food Ordering System	7	5	5	3	1	2
21	Online Matrimonial Site	3	3	6	4	1	2
22	Customer Relationship Mgt	7	3	4	2	1	2
23	I am Educate	5	5	7	3	1	2
24	ShipDeal	7	5	5	4	1	2
25	Employment Exchange	4	3	7	4	2	2
26	Online Library Mgt System	5	3	7	3	2	3
27	Online Transport Mgt System	4	5	4	3	2	1
28	Online Examination System	5	4	6	3	1	1

Table-V(b): Week-wise Phase Effort Distribution for The Year 2015–16

Sr. No.	Project Definition	Req. Analysis	Design	Code	Testing	Doc.	Team Size
1	Inventory Mgt System	5	3	4	2	2	3
2	Online Food in Railway	5	3	4	2	2	1
3	Rental Application	4	3	5	2	1	1
4	Car Pooling System	4	2	3	2	1	1
5	Join Us System	3	4	6	3	2	2
6	Inventory & Supply Chain Mgt System	4	2	3	2	1	1
7	Garage Mgt System	3	4	6	3	2	1
8	Online Grocery Store	4	2	4	2	1	1
9	Security for U	5	3	5	2	1	1
10	Salon Center	3	3	3	3	1	1
11	Visa Consultancy Mgt	4	2	3	2	1	2
12	Student Information System	5	5	2	1	1	3
13	Online Book Store	1	3	2	2	1	1
14	Weight Loss All In-1	4	1	2	1	1	1
15	Digital Campus	5	3	4	2	1	1
16	Teacher and College Rating System	4	2	3	2	1	1
17	Q-Buy	6	3	4	2	1	1
18	Mall Locator	4	4	4	2	2	3
19	Milk Distribution	4	2	4	2	1	2
20	Online Job Portal	4	7	4	2	2	2
21	Information Mgt System	4	4	5	2	1	1
22	Online Shoe Store	5	7	4	2	1	1
23	Online Car Auction System	4	4	4	2	1	3

24	Electricity App.	4	7	6	2	1	3
25	Treasury Online Shop	4	4	5	2	1	1
26	Online Review System	3	4	4	2	1	3
27	Restaurant Mgt System	3	2	3	2	1	2
28	Yellow Cabs	3	3	4	2	1	1
29	Online Food Ordering System	3	4	4	2	1	2
30	Liquor Store Mgt	3	2	4	2	2	1
31	School Mgt System	3	4	6	2	2	2

Table-V(c): Week-wise Phase Effort Distribution for The Year 2016–17

Sr. No.	Project Definition	Req. Analysis	Design	Code	Testing	Doc.	Team Size
1	APMC Mgt System	8	4	4	4	2	2
2	E-Shop	8	4	4	4	1	1
3	Jewellery Catalogue App	7	3	4	4	3	1
4	Online Jain Traders	6	4	3	3	1	1
5	Mineral Water Supplier	5	2	4	2	2	2
6	JMSC POS System	8	4	4	3	4	2
7	A to Z GIS Map App	4	3	3	2	2	1
8	Gym Mgt System	8	4	4	3	2	1
9	Lakshya Blood Bank	8	4	4	3	3	2
10	Online Multistore Portal	5	5	5	2	1	2
11	Business to Business Market Place	5	3	3	2	2	3
12	Yogeshwar Sarees	4	5	4	3	1	3
13	Sarvasva Goat Farming	6	4	6	2	3	3
14	Material Management System	7	3	4	4	3	1
15	Online Project Tracking	4	7	4	2	2	2
16	E – Library	4	4	5	2	1	2
17	On line Exam	5	1	2	2	1	2
18	Online Shopping Portal	6	5	8	3	1	2
19	Transport Reservation System	5	5	5	2	1	2
20	Softcom Office Help Desk System	3	3	4	4	3	3
21	Property Advertise Portal	8	4	4	4	1	2
22	Pavitra Rishta Matrimonial	7	3	4	4	3	2
23	Recruitment Management System	6	3	4	2	1	2
24	Network Management System	5	5	5	2	1	2
25	Leave and Event Management Module	6	4	6	2	3	2

Table-VI: Year–wise Maximum, Minimum and Average Time Spend (in Weeks)

Sr. No.	Phases	Maximum Efforts			Minimum Efforts			Total Average Time Spend		
		2014 – 15	2015 – 16	2016 – 17	2014 – 15	2015 – 16	2016 – 17	2014 – 15	2015 – 16	2016 – 17
1	Requirement Analysis	8	6	8	2	1	3	4.86	3.87	5.92
2	Design	5	7	7	1	1	1	3.21	3.42	3.84
3	Coding	8	6	8	2	2	2	5.32	4	4.28
4	Testing	4	3	4	1	1	2	2.64	2.03	2.8
5	Documentation	4	2	4	1	1	1	1.57	1.26	1.92

Table-VII: Year–wise Overall Average Phase Effort Distribution (Percentage)

Sr. No.	Phases	Overall Average Phase Effort Distribution		
		2014 - 15	2015 - 16	2016 – 17
1	Requirement Analysis	21.34	20.87	28.67
2	Design	15.47	16.01	17.13
3	Coding	20.52	18.18	18.18
4	Testing	10.98	10.33	12.94
5	Documentation	6.94	6.82	9.44

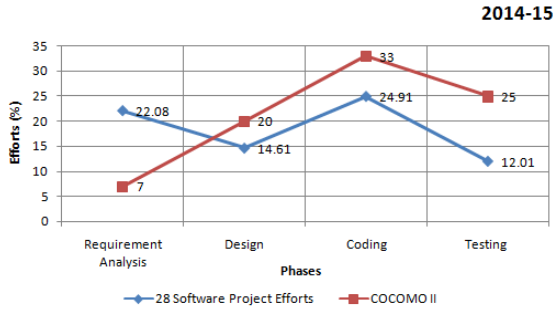

Fig. 1(a). Comparison of 28 software projects with COCOMO II model (Waterfall Distribution Magnitude) for academic year 2014 – 15

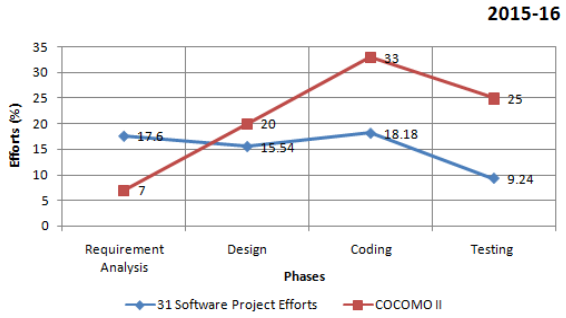

Fig. 1(b). Comparison of 31 software projects with COCOMO II model (Waterfall Distribution Magnitude) for academic year 2015 – 16

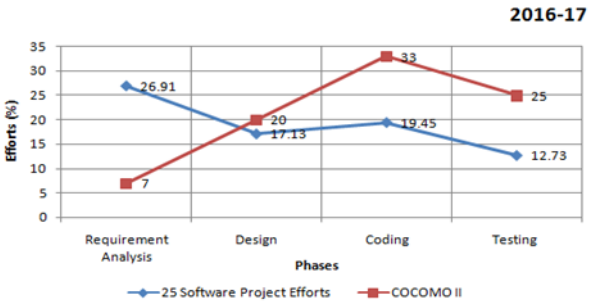

Fig. 1(c). Comparison of 25 software projects with COCOMO II model (Waterfall Distribution Magnitude) for academic year 2016-17

V. CONCLUSION

In the present work we considered 84 large software project documentations which were used to explore effort distribution in different stages of academic software development. Further we tabulated various phases and corresponding task performed during these phases. Also we calculated week wise effort distribution for these individual 84 software project documentations using Time Line Chart. The basic objective of computation of effort distribution was to verify whether appropriate and accurate amount of effort is devoted by students in various phases of software development. To justify the work minimum, maximum and total average of time devotion was calculated along with overall phase effort distribution. Further, comparison of overall phase effort distribution for all the 3 academic years was done with COCOMO II model which provides waterfall distribution quantities. The experimental results showed that while comparing two data sets, software project phase effort distribution (percentage) and COCOMO model II similarities was found only in design phase. A vast variance among other phases was found. Hence through this experiment we found that students who are future IT professionals fail to accurately distribute their efforts in software project development having adverse consequences such as non-completion of software project on stipulated time duration, missing functionalities and so on. Considering the same we believe that academic domain dealing with software project development oriented streams should focus, consider and provide guidelines as well as approaches, models regarding effort distribution in software project development.

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