International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 01, January – 2017, PP – 58-65

AN EMPIRICAL STUDY TO FIND OPTIMAL TEAM SIZE FOR INSPECTION PROCESS

Sumaira Nazir[1], Nargis Fatima[2]

[1]*Department of Engineering,/ National University of Modern Languages,IslamabadPakiatan,*
[2]*Department of Engineering,/ National University of Modern Languages,IslamabadPakiatan,*

Abstract: Software development artifact needs regular quality assessment. Software inspections helps to assess the quality of software through defect detection. The effectiveness and efficiency of inspection process may vary with respect to the number of factors such as inspection procedure, reading techniques and team size etc. This study focuses on identifying the effect of varying team sizes on the effectiveness and efficiency of inspection process. An experiment is conducted to find the optimal team size for inspection process. The experimental results shows that the effectiveness of the inspection process increases with the increase in team size but it gets steady at specific team size. The efficiency of the inspection process decreases with the increase in the team size.

Key Word: Quality; Inspection process; Artifact; Team size; Effectiveness; Efficiency; Defects.

1. INTRODUCTION

Software Engineering is field that is devoted to cost effective timely developments of high quality software [25].Software quality refers to the conformance of the functional and nonfunctional requirements defined by the stakeholders of the software. Software quality can be measured by number of bugs, defects rate (# of defects/size unit), reliability and the degree to which the product is compliant with the requirements. Software inspection is a process during which a software artifact is inspected by a team member [26].It provides a number of benefits in software development. Software inspection proves to be significant to improve the quality of software artifact such as requirement document, design document, source code etc. [22],[27]. Software inspections are important to find the defects and their root causes [16]. The most important payback of the inspection is that they reduce the rework cost by early defect detection because as software development phases progress the amount of rework and its cost increases. For example if development cost at requirement stage is 6%, then the rework cost at this stage is 1%, but if the defects identified in later phases i.e. in preliminary design or detail design phases, then rework cost at these phases increases to 4% and 8% respectively. The author of the artifact have to perform more rework if the defects are not identified in the early phases of development and the cost of rework almost doubles in the later phases of development, so the use of the inspection process can reduce the rework and cost of rework by detecting defect at initial phases [3].

The generic inspection process involves activities like planning, overview, preparation, meeting rework and follow up [7].Results of inspection process depends upon a number of factors such as inspection procedure, training, inspection material, and team size etc. Team size refers to number of human beings involved in an inspection process. The number of team members involved in inspection process drives the process [9]. Success and failure of the process depends upon the involved team members [18]. Different researcher had tried to find out the effective team sizes. Effective inspection team size may increase the error detection rate. Selecting the right number of team members to perform the defect detection task is very important for the inspection process to be successful [24].

This research focuses on finding the optimal team size of inspection process for effective defect detection. The study assesses the effect of varying team sizes on the effectiveness and the efficiency of the inspection process.

The paper is organized as section one provides the introduction of software inspection, section two highlights the related work details, section 3 discusses the experiment design, section four covers the experimental finding and section five provides conclusion and future work details.

2. EFFECTIVENSS FACTORS OF INSPECTION PROCESS

Effectiveness refers to as percentage of defects identified in a inspection process or it also refers to as total number of defects found [20].The effectiveness of inspection process depends upon number of conditions [24]. Effectiveness factorswhich affect the inspection process found in literature are as follows.

2.1 Software Inspection Procedure

Software inspection procedure is defined as an involved activates, stages or phases which are required to run the process [1],[13]. The sequence and arrangement of these phases have impact on the inspection process. Different researchers have introduced different activities or phases in different inspection processes

2.2 Team Structure

Team structure refers to the composition of team i.e. the members who participate in an inspection process. Team structure can be clearly defined through sub factors i.e. number of reviewers selected to compose a team, description of roles with associated responsibilities and individual expertise level. All these sub factors of team structure have impact on team structure which in turn contributes to the effectiveness of the inspection process. The sub factors are defined in the sub sections.

2.2.1 Team Size

Team size indicates to the number of members involved in an inspection. The number of team members involved in aninspection process drives the process [9]. The success and failure of the inspection influence by involved members. Results of the inspection depends on the inspection team members [18].

2.2.2 Team Roles

Roles are another most important influencing factor of the team structure. Roles and their associated responsibilities are defined varyingly in different inspection processes [16]. They can be explicit or implicit.

2.2.3 Individual Expertise

Individual expertise refers to the capability and expertise level of the individuals. Individual expertise can be defined in terms of technical skills, domain knowledge and experience.

2.3 Defect Discovery Method

It is defined as the steps which guide the reviewers to get good understanding of artifact for detection of defects. The defect detection techniques help and guide the reviewers to easily find out the defects from the artifact [10]. Using defect detection technique is an important activity for individual defect detection [2]. The more effective defect detection technique results in more efficient inspection process. The defect detection techniques can be systematic for example perspective base readings and can be non-systematic for example adhoc or checklist base.

2.4 Review Rate

Review rate refers to speed at which the inspection process progress. Some researchers believe that slow rate can be effective [1],[8],[19]. Gilb & Graham suggest that review speed should be 150 lines per hour. Laitenberger & DeBoud suggest 200-300 lines within 2 hours [11]. Review rate can affect the inspection process effectiveness. If review rate is fast then the quality of review will be lower and if the review rate is slow then it can waste the time of reviewers. Review rate effect the inspection process normally in situation where group based defect detection is done.

2.5 Interaction Mode

Interaction mode refers to the way in which the inspection team members interact with each other. The mode of interaction can be synchronous or asynchronous. In Synchronous mode of interaction the inspection team members interact with each other in impersonal face to face meeting while in asynchronous mode of interaction the inspection team members does not interact with each other impersonally or in a face to face meeting. They use some other means of interaction e.g. telephone, online tools etc.[16]. Different researchers have suggested different mode of interaction for inspection processes.

2.6 Advanced Preparation

The purpose of the advanced preparation is to understand the artifact individually to easily detect the defects. It is also an important factor that has impact on the inspection process. Many inspection processes having group based defect detection favors the advance preparation with understanding purpose. In this case the reviewers efficiently prepare themselves before attending the group meeting for defect detection. It results in time saving and better outcome. If the process emphasizes on individual defect detection and group base collection then there is dual purpose of advanced preparation i.e. understanding and defect detection. According to Laitenberger if reviewer has large time for preparation he can effectively contribute to the effectiveness of the inspection process by thorough understanding of artifact and keenly finding defects [9].

3. RELATED WORK

Team size is one of the most important inspection process influencing factor. Software inspection process involves a team which works together to find defects from the artifacts. Team work has lots of benefits like quality of product improves as it is reviewed by different members having different expertise [11]. Few researchers have worked to estimate the effect of team size on the inspection process. According to Fagan the most optimal team size is three to five members [6]. Bisant and Lyle have suggested team having two persons.Reason for suggesting two person team size is that if the team size is large, most dominant and experienced persons can actively participate and the less experienced members hesitate to give their suggestions, this suppresses their ability [4].

Martin & Tsai recommendedseveral teams to review the similar artifact, according to them a single team is not as productive as many small teams. They argued that the multiple small teams performed parallel and independent reviews of same artifact which reduces the possibility of missing defects [14]. Weller like Fagan believes that there should be four members in a review team [21]. Madachy et al., and Bourgeois suggested to have 3 to 5 people in a inspection team [5], [12].

According to Wheeler et al., the effective team size should consist of four to five members. This team size agreed with Fagan and Weller [22]. The most important work done in this context is by McCarty, Adam porter and Votta [15].They conducted experiments to analyze the effect of various team sizes on inspection process. As a result of their experiment they find that two or more than two persons team is most effective than a single person. However they do not find out any difference in effectiveness of two, three or four person's team. According to them these team sizes equally benefit the inspection process but they also suggested that the team size has large effect on inspection process with respect to meeting arrangements i.e. schedule and location planning, management for distribution of artifacts, defect detection, defect collection etc.

Large team sizes may delay the development because of delay in inspection process arrangements and their results gathering. Owens suggest five to six persons in a inspection team because according to him multiple people reviewing the product can be more effective and beneficial [17]. It is also believed by some researchers that large number of people are not more effective because all of them are never efficient at the same time. Laitenberger et al., has the same idea as of Porter & Votta that two reviewers can be more effective than single one, they suggested team size of two people as suggested by Bisant and Lyle. Laitenberger et al also believes that larger team size is better because large number of people can detect large number of defects [9].

4. EXPERIMENT DESIGN AND EXECUTION

This section provides the detail of necessary preparation performed to conduct the experiment i.e. details related to the subjects involved in the experiment, the review material provided during the experiment etc.

The experiment was performed with 27 subjects divided in to 6 teams with different team sizes. The subjects were voluntarily selected on the basis of knowledge of artifact which is to be reviewed. Top 27 students with respect to GPA was selected for experiment. The aim of the study was to find the optimal team size for inspection process. Review material provided to the subject for review consists of three pages of the requirement document of hospital information system. The experiment was conducted with 20 seeded defects in the artifact to be reviewed. The defect report forms were also provided to all the subjects individually. Each member have to identify defects, fill defect report form individually and discuss the identified defects in the meeting. Fagan inspection process was followed in the experiment for defect detection and collection [7]. "Table 1" shows the team division of subjects that vary with respect to team size.

Table 1. Team division of the subjects

Group #	Team Size
Team Z	2
Team Y	3
Team X	4
Team W	5
Team V	6
Team U	7

4.1 Training

Students were provided the training related to the aims and objective of the experiment, general procedure of the experiment and the inspection process. Brief overview of the Fagan inspection process and artifact to be reviewed was provided to all the teams. They are also briefed about how to fill the defect report forms. The training session continues for one hour. All the students were prepared for the experiment in one lecture.

4.2 Research Questions

Following research questions are design to conduct the study.

RQ1. Which team size is effective with respect to defect detection?
RQ2. How the efficiency of the inspection process varies with the change in the team size?

In research question one the aim is to identify that which team size detect large number of defects. The research question two aims to study the change in the total review time with varying team sizes.

4.3 Variables

There are two types of variables defined for the experiment i.e. independent variables and dependent variables. The aim of the study was to change the independent variables and study their effects on the dependent variables. Independent variable is team size whereas dependent variables are inspection process effectiveness and inspection process efficiency. Inspection process effectiveness refers to the percentage of defects identified during inspection process. Inspection process efficiency is defined as the total number of defects detected per hour.

4.4 Validity Threats

Validity threats are factors that affect the results of inspection process. They can be internal or external. Validity threats for the experiment are discussed in next section.

4.4.1 Internal Validity Threat

The internal validity threats for the experiment are selection of team member, instrumentation effect and exchange of information.

4.4.1.1 Selection of Team Members

It is related to difference in performance of human beings involved in the experiment. Every individual has his/her own characteristics for example proficiency in reading, understanding of English Language etc. This threat was controlled by selection of subjects from the same class level.

4.4.1.2 Instrumentation Effect

Instrumentation effect deal with the problem of differences in result of inspection process which may occurs due to difference in review material provided to the subjects. We have overcome this threat by providing the same requirement specification document to all the reviewers**.**

4.4.1.3 Exchange of Information

Exchange of information is great threat for the experiment results especially when conducted in academic environment. This threat was controlled by monitoring the performance of the reviewers all the time.

4.4.2 External Validity Threat

External Validity threats for the experiment is representative subjects.The most important threat for the experiment is use of students as the subjects, because most of the subjects did not have professional experience and domain knowledge that an industry reviewer could have. We had not considered that threat as much as critical because many researchers had investigated the use of students as a subject in experiment and they had provided argument both for and against them. Wohlin et al. had not identified any difference in their efficiency [23].

5. DATA COLLECTION AND ANALYSIS

Data of the experiment was collected very carefully. It was checked that all team members had filled the defect form. Once the data was collected the detailed analysis of data was performed. The effectiveness and efficiency of inspection process was calculated. Inspection process effectiveness refers to the percentage of defects identified during inspection process whereas inspection process efficiency is defined as the total number of defects detected per hour.The formulas for calculating the effectiveness represented by Effe and efficiency represented by Effi are given below.

$$\text{Effe} = \frac{\text{Number of defects identified}}{\text{Total number of defects in artifact}} * 100$$

Effi) = $\frac{\text{Number of defects identified} * 60}{\text{Total review time+Meeting time}}$

Total time = Total review time+ Meeting time

Total time to review the artifact consist of the time spent by each reviewer during preparation plus the time spent on meeting. Total Review time is calculated by summing up the preparation time of all the reviewers.

Total Review Time = RT1 + RT2+…..+RTn where RT stands for the review time by the individual reviewer.

"Table 2" shows the number of defects identified and missed by each team.It shows the answer of RQ1 that is "Which team size is effective with respect to defect detection?". "Table 2" shows that team with size 2 detect 11 defects, team with size 3 detect 14 defects and team with size 4,5,6,7 detect equal number of defects that is 16.

Table 2. No. of defects identified and missed by each team

	Team Z	Team Y	Team X	Team W	Team V	Team U
Team Size	2	3	4	5	6	7
Defects detected	11	14	16	16	16	16
Defects not detected	9	6	4	4	4	4

"Figure 1"compares the number of defects identified and missed by each team. It shows that the team with team size 4 and greater than 4 is effective in defect detection.

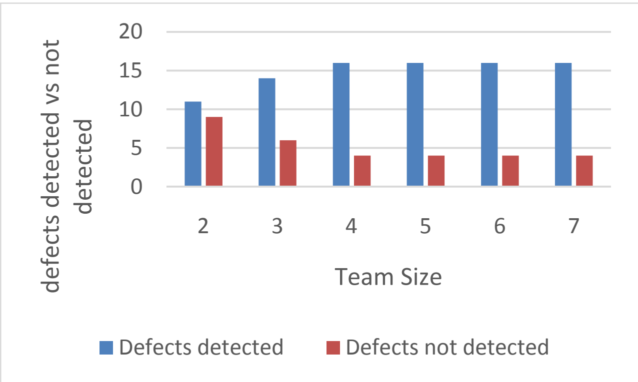

Figure 1. Comparison of identified and missed defects by each team.

"Table 3" shows the total time spent by each team to review the artifact. The total time is calculated by adding the total review time for each individual and the meeting time. Team with team size two utilizes minimum time resources as compared to teams with size 3 and greater than three."Table 3" answers RQ2 that is "How the efficiency of the inspection process varies with the change in the team size?"

Table 3. Time Spent by team to review the artifact

	Team Z	**Team Y**	**Team X**	**Team W**	**Team V**	**Team U**
Team Size	2	3	4	5	6	7
Total review	60	120	180	240	300	360

time (min)						
Meeting time (min)	60	60	60	60	60	60
Total time (min)	120	180	240	300	360	420

"Figure 2" describes the total time spent by each review team to identify the defects. It shows that the team with minimum number of persons is efficient for defect detection as it utilizes minimum time resource.

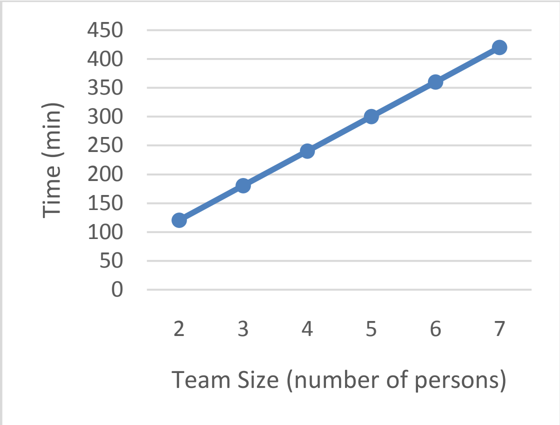

Figure 2. Time spent by each team for defect detection.

"Table 4" shows the effectiveness and efficiency of each team. It shows that team with 2 members have 55% defect detection effectiveness, team with 3 members have 70% defect detection and team with sizes 4,5,6,7 have same percentage of defect detection effectiveness that is 80%. "Table 4" also shows that team with 2 team members' detected maximum numbers of defects per hour that is 5 while team with team size 7 detected minimum defects per hour that is 2.2.

Table 4. Effectiveness and efficiency for each team

	Team Z	Team Y	Team X	Team W	Team V	Team U
Team Size	2	3	4	5	6	7
Effe	55%	70%	80%	80%	80%	80%
Effi	5.5	4.6	4	3.2	2.6	2.2

"Figure 3" describes the effectiveness percentage of each team.It shows that team with 4 and greater than 4 members is effective for defect detection .

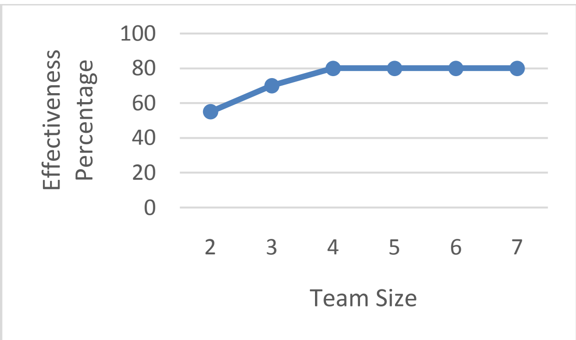

Figure 3. Effectiveness percentage of each team.

"Figure 4" describes the defect detection efficiency of each team.It show that the defect detection efficiency of team size 2 is higher than team with team size 7.

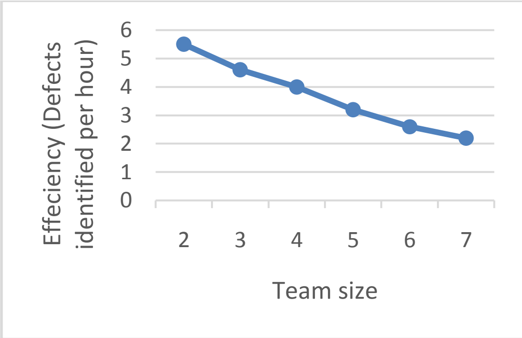

Figure 4. Defect detection efficiency of each team.

Data analysis shows that the effectiveness of the review process increases with the increase in the inspection team size and at specific team size the effectiveness gets steady. Regarding inspection process efficiency the experiment results shows that the efficiency decreases with the increase in inspection team size. The study shows that effectiveness of inspection process with team size = 2 is 55% with team size = 3 is 70% and with team size >= 4 is 80%. The review process efficiency with team size = 2 is 5.5 with team size = 3 is 4.6 with team size =4 is 4 with team size = 5 is 3.2 with team size = 6 is 2.6 and with team size =7 is 2.2. According to the experimental results we suggest that optimal inspection team size is 4.

6. CONCLUSION AND FUTURE WORK

The study contributed in the field of software inspections. There are number of effectiveness factor that can directly or indirectly effect the effectiveness and efficiency of software inspection. In this study we have focused on the effectiveness factor team size for the experiment. Inspection team size is important influencing factor for effective defect detection as well as efficient execution of inspection process. This study aims to find the variation of defect detection effectiveness and efficiency with varying team size. It is concluded from the study that effectiveness and efficiency of inspection process changes with different inspection team sizes. According to the findings the effectiveness with team size 4 and higher than 4 is 80%. The effectiveness gets steady when team size increases from 4 to 5 and so on.The efficiency of the inspection process degrades with increase in team size that is 5.5 for two team members and 2.2 for seven team members.It is suggested that inspection team size with four members is optimal. In future more empirical studies can be performed and other influencing factors discussed in the paper may be verified to assess the inspection process effectiveness and efficiency.

7. REFERENCES

[1]. A. Aurum, H. Peterson, and C. Wohlin. "State-of-the-Art: Software Inspections after 25 years*,"* *Software Testing, Verification and Reliability*, vol. 12, no. 3, pp. 133-154, Sep 2002.

[2]. V.R. Basili, "Evolving and Packaging Reading Technologies". *Journal of Systemsand Softwar*e, 38 (1), 3-12, 1997

[3]. V.R. Basili, S. Green, O. Laitenberger, F. Lanubile, F. Shull, S. Sorumgard, S., and M. Zelkowitz. 1996. "The Empirical Investigation of Perspective-based Reading".*Empirical Software Engineering*, 1,133-164,1996

[4]. D. B. Bisant, and J.R. Lyle, J.R." A two-person inspection method to improve programming productivity," *IEEE Transactions on Software Engineerin*g, vo. 15, no. 10, pp. 1294-1304, 1989

[5]. K.V. Bourgeois. "Process Insights from a Large-Scale Software Inspections Data Analysis". Cross Talk, *The Journal of Defense Software Engineering*, 17-23, 1996

[6]. E.P. Doolan, "Experience with Fagan's Inspection Method," *Software-Practice And Experience, John Wiley and Sons*, Ltd , vol. 22, no. 3, pp. 173-182, 1992

[7]. M.E. Fagan, " Design and Code Inspections to Reduce Errors in Program Development," *IBM Systems Journa*l, vol. 15, no. 3, pp. 182-211, 1976

[8]. T. Gilb, and D. Graham, " *Software Inspection*." Addison Wesley, P. 471, 1993

[9]. O. Laitenberger, T. Beil, and T. Schwinn. " An Industrial Case Study toExamine a Non-Traditional Inspection Implementation for RequirementsSpecifications". *Empirical Software Engineerin*g, 7(4), 345-374, 2002

[10]. O. Laitenberger, and J.M. DeBaud. " An Encompassing Life Cycle Centric Surveyof Software Inspection". *The Journal of Systems and Softwar*e, 50, 5-31, 2000

[11]. O. Laitenberger, and J.M DeBaud. "Perspective-based Reading of CodeDocuments at Robert Bosch GmbH". *Information and Software Technology*, 39(11), 781-791, 1997

[12]. R. Madachy, L. Little, and S. Fan. "Analysis of a successful Inspection Program". *Procceding of the 18th Annual NASA Software Eng. Laboratory Workshop*, 176-198, 1993

[13]. K.K. Marri. "Model for evaluating review effectiveness"**.** *3rd Annual International Software Testing Conference, 2001*

[14]. J. Martin, and W.T. Tsai. "N-fold Inspection: A Requirements Analysis Technique".*Communications of the ACM*, vol. 33, no. 2, pp. 225-232, 1990

[15]. P. McCarthy, A. Porter, H. Siy, and J.R. Votta. " An experiment to assess cost-benefits of inspection meetings and their alternatives: a pilot study". Proc. *Int. Metrics Symp., Berlin, IEEE Computer Society Press*, 100–11, 1996

[16]. S. Nazir, N. Fatima, and S. Malik., "Effective Hybrid Review Process," *International Conference on Computer Science and Software Engineering, IEEE Computer Society*, 763-771, 2008. DOI 10.1109/CSSE.2008.1417

[17]. K. Owens. "Software Detailed Technical Reviews: Findings and Using Defects". *Wescon'97, Conference Proceedings*, 128-133, 1997

[18]. A.A. Porter, and P.M. Johnson. "Assessing software review meetings: results of a comparative analysis of two experimental studies", *IEEE Transactions on Software Engineerin*g, 129–145, 1997

[19]. G. Russel. "Experience with inspection in ultralarge-scale developments."*IEEE Software* 8(1) 25-31, 1991

[20]. T. Thelin, P. Runeson, P., and B. Regnell, "Usage-Based Reading - An Experimentto Guide Reviewers with Use Cases". *Information and Software Technolog*y, 43(15), 925-938, 2001

[21]. E.F. Weller, "Lessons from Three Years of Inspection Data."*IEEE Software*, 10(5), 38-45, 1993

[22]. D.A. Wheeler, B. Brykczynski, and R.N. Meeson,. " Peer Review Process Similar to Inspection. Software Inspection: An Industry Best Practice". *IEEE Computer Society* Press,USA. ISBN 0-8186-7340-0, 1996

[23]. C.Wohlin, P. Runesson, M. Host, M.C. Ohlsson, B. Rangnell, and A. Wesslen, " Experimentation in Software Engineering: An Introduction." *Kluwer academic publisher, 2000*

[24]. Y.Wong. "An Exploratory study of software reviews in practice". Faculty of Information Technology, University of Technology, Sydney, Australia, 2003

[25]. B.H. Bharahate. Software Inspection Improves Quality of Software Product. *Special Issue of International Journal of Computer Science & Informatics*, (18)1, 2016, 44-48.

[26]. A. Güzel, Ö. Aktaş and K. U. Birant. Peer Review in Software Development: A Survey. *International Journal of Computer Science and Software Engineering* , 5(1), 2016.

[27]. P. Thongtanunam. *Studying Reviewer Selection and Involvement in Modern Code Review Processes. Graduate School of Information Science Nara Institute of Science and Technology,* 2016