A Case Study of Team Learning Measurements from Groupware Utilization

A Proposal of Measurement Method for the Contribution Ratio of Knowledge

Ayako Masuda[1], Chikako Morimoto[2], Tohru Matsuodani[3] and Kazuhiko Tsuda[4]
[1]*FeliCa Networks, Inc., 1-11-1 Osaki, Shinagawa-ku, Tokyo, Japan*
[2]*Tokyo Institute of Technology, 2-12-1 Oookayama, Meguro-ku, Tokyo, Japan*
[3]*Debug Engineering Research Laboratory, 4-16-1 Hijirigaoka, Tama-shi, Tokyo, Japan*
[4]*University of Tsukuba, Tokyo Campus, 3-29-1 Ootsuka, Bunkyo-ku, Tokyo, Japan*

Keywords: Contribution Ratio, Team Learning, Groupware, Gini Coefficient, Software Development.

Abstract: In software development, there is a need to share a variety of knowledge; therefore, team learning (organizational learning) is required. As tools to support team learning, various groupware has been utilized. In groupware utilization, there is variation among development sites, which is suggested to reflect the maturity of team learning. Therefore, a case analysis on a team with a higher maturity of team learning was performed using groupware utilization as a measure of knowledge sharing. The Gini coefficient is used to represent the distribution of assets in economics. An inversion of the Gini coefficient was used to represent the groupware utilization and defined as the contribution ratio of knowledge. When the contribution ratio of knowledge is large, knowledge sharing is considered to be progressing. The contribution ratio of knowledge in this case study was observed to improve in proportion to the duration of the team. In future, we will expand the measurement range and continue to verify the measurement of team learning maturity using the contribution ratio of knowledge. This study measures the state of the team by analyzing their responses to the questionnaire. If this verification is successful, we would be able to measure the progress of team learning using the contribution ratio of knowledge, which can be measured more easily and objectively without resorting to the questionnaire.

1 INTRODUCTION

Most resources involved in software development are human resources; therefore, effective human resource management is critical to this industry. As software development becomes more complicated, the development of human resources with advanced knowledge of software technology and advanced information and communication technology (ICT) skills is required (MIT, 2009). In the development of human resources for advanced ICT, technical as well as comprehensive skills, for example, communication skills, problem finding, and solving skills, are particularly important (Takasaki et al., 2014). Within an actual software development site, it is difficult to devote resources for advanced training. Therefore, the development of human resources through real work, or on-the-job training (OJT), is required.

Organization, or team learning, was promoted by Peter Senge (Senge, 2006) and subsequently adopted by the software development industry, where the pace of technological change is rapid. In addition to basic knowledge such as domain-specific specifications, software development requires learning and sharing of expertise, for example, operating system (OS) and the use of the interface of a communication system. For team learning, communication and other various tools that comprise groupware are used. An example of a communication tool is mailing list (ML), and examples of groupware include Wiki and Moodle for groups.

The purpose of our study is to develop a method for measuring software development team growth and contribute to its efficiency. In this paper, the utilization of groupware as a tool for team learning and growth was assumed as an indicator of knowledge sharing, and its measurement was

Masuda, A., Morimoto, C., Matsuodani, T. and Tsuda, K.
A Case Study of Team Learning Measurements from Groupware Utilization - A Proposal of Measurement Method for the Contribution Ratio of Knowledge.
In *Proceedings of the 8th International Conference on Computer Supported Education (CSEDU 2016) - Volume 2*, pages 193-198
ISBN: 978-989-758-179-3
Copyright © 2016 by SCITEPRESS – Science and Technology Publications, Lda. All rights reserved

attempted. A software development team was selected for the case study. The quality of their products was highly evaluated, and members of this team were also actively involved in team activities. Therefore, some analytical results of team performance have been reported (Masuda et al., 2015a; 2015b). It is assumed that groupware utilization is at a high level and that this indicates a high level of team maturity.

Kitayama analyzed cases using the Lorenz curve and the Gini coefficient to measure the utilization of ML (Kitayama, 2009). In our study, the inversion of the Gini coefficient, which indicates the contribution to shared knowledge, was defined as the contribution ratio of knowledge (CRK). It is considered that when CRK is high, many members are providing knowledge.

In Chapter 2, based on previous studies of using the Gini coefficient for measuring ML utilization, the application to the measurement of groupware utilization is considered. In Chapter 3, the time-series change of CRK in this case is described. Chapter 4 presents the results of an analysis comparing the characteristics of the case team and other groups. In Chapter 5, the correlations between groupware utilization and CRK are discussed.

2 RELATIONSHIP WITH PREVIOUS STUDIES

It is considered that groupware utilization can be ascertained by the amount of information and the usage situation. The amount of information can be easily measured by the traffic per period. The usage situations are the ways in which members participate in groupware. There are various ways to measure usage situations. The Gini coefficient, as employed by Kitayama, focused on the distribution of senders in ML. This previous study showed a characteristic that can represent utilization with a single factor.

2.1 Lorenz Curve and Gini Coefficient

The Lorenz curve and Gini coefficient are common indexes used to analyze the distribution of household income (Gastwirth, 1972; Nakamura, 2005).

The Lorenz curve describes income distribution among households in order of income, with the cumulative of households on the horizontal axis and cumulative income on the vertical axis. When there is no income gap and all the income is the same, the Lorenz curve is a 45-degree line (Line of Perfect Equality). When there is a bias in the distribution of income and wealth, the Lorenz curve bulges downward (Line of Perfect Inequality).

The Gini coefficient is a representation of the downward bulge of the Lorenz curve and is expressed by the ratio of the area (A) and the areas (A) + (B) in Figure 1. The value of the Gini coefficient is between 0 and 1. Therefore, it can be said that when the value of the Gini coefficient is closer to 0, the income gap is small. In contrast, when the value of the Gini coefficient is closer to 1, the income gap is large.

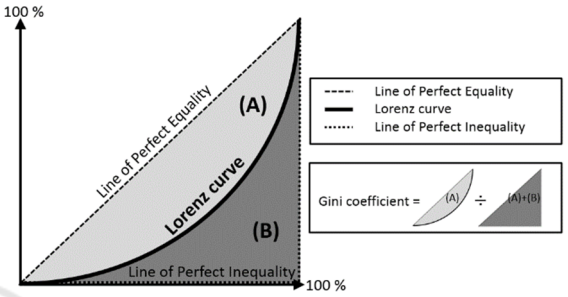

Figure 1: Lorenz curve and Gini coefficient.

2.2 Previous Research

Kitayama measured bias in the number of member transmissions in 29 MLs using the Gini coefficient and Lorenz curve. The Lorenz curve of each ML is lined up with the members in order of the number of transmissions, taking the cumulative number of people on the horizontal axis and cumulative number of ML transmissions on the vertical axis. The average Gini coefficient for 29 MLs was 0.69. As a result, the characteristics and utilization of each ML were captured by the Gini coefficient. The correlation coefficient of the ML scale (ML registration number) and the Gini coefficient value was 0.308. Although this value was a weak correlation, it indicates a tendency for the Gini coefficient value to increase when the number of people increases (Kitayama, 2009).

Kitayama's studies demonstrate that it is possible to compare the utilization of communication tools using the Lorenz curve and to represent utilization differences as a single factor using the Gini coefficient.

2.3 Application to Groupware

Our research focuses on the learning maturity of the team. It was considered that team learning maturity is advanced when the provision of knowledge frequently occurs among team members. In contrast,

it was considered that when team learning is immature, members provide only information related to their own role. Thus, team learning maturity is measured by groupware utilization among the team.

Groupware for team learning includes Wiki and Moodle, which in order to the sharing of professional knowledge. In this paper, the target groupware is distinguished from general groupware and called "groupware for team learning" (GWTL). The difference between GWTL and general groupware and ML is in its content. The burden of the contributor is larger when posting to GWTL in terms of quantity and quality than when posting to general groupware because the contributor is engaged with sharing their knowledge or contemplating current issues. Therefore, the number of posts is lesser than that with general groupware. For example, the Gini coefficient for e-learning with respect to teachers and students is close to 1. It is considered that as team learning matures, information exchange among members will increase and the Gini coefficient becomes smaller.

When the appropriate GWTL is selected and the Gini coefficient for the contributors is obtained, team learning maturity can be measured. Originally, the Gini coefficient represented "INCOME"; however, in this paper, the coefficient represents the "OUTCOME" of knowledge. These represent different characteristics; thus, CRK is defined as the Gini coefficient to avoid confusion:

$$\textit{The contribution ratio of knowledge} = 1 - \textit{the Gini coefficient}$$

For a group or organization, knowledge provided by members is regarded as the "income" of the Lorenz curve. Moreover, the inversion of the Gini coefficient in this Lorenz curve is defined as CRK (Figure 2). CRK is expressed by the ratio of the area (B) and the areas (A) + (B) in Figure 1. Therefore, when the value of CRK is closer to 0, the difference in the amount of knowledge provided by members is large. In contrast, when the value of CRK is closer to 1, the difference in the amount of knowledge provided by members is small.

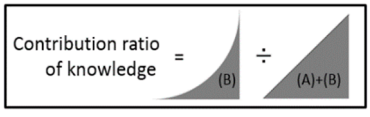

Figure 2: Contribution ratio of knowledge (CRK).

In the case of using groupware (GWTL) that satisfies the conditions as a tool for team learning, it is considered that the provision of knowledge from members increases as team learning matures. The aim of this paper is to indicate this situation as CRK. The groupware used by the team under study in Chapter 3 satisfies the conditions of GWTL. The details are described in the next chapter.

3 MEASUREMENT OF GWTL UTILIZATION

A software development team (Team X) actively engaged in team learning was chosen as the measurement target. Team X is one of the few teams to adopt Formal Methods to development in Japan. The groupware conditions required of GWTL were that it should be operated by members on a voluntary basis and exclusively for technical content. The measurements of GWTL utilization were the number of posts and number of contributors. Measurements were performed in two time periods to test whether team growth was affecting GWTL utilization. The measurement results and considerations are described in this chapter.

3.1 Case Overview

Team X is developing a chip-embedded software for which high security is required. Over several generations of development spanning 10 years, their products have encountered no serious problems in the market and have a high reputation. The number of members during the development period has been varied between approximately 60 from approximately 20 people. In addition, since the start of the project, team building activities have been incorporated aggressively (Masuda, 2014a; 2014b).

3.2 Time-series Changes

The numbers of posts and contributors were measured using data from the team's two GWTL platforms:

- GWTL2012:
  This platform was used from its start in 2012, mainly to share information on the impact of specification changes. It was operated using Wiki (Wikipedia, 2015).
- GWTL2014:
  This platform was used from 2014 to expand into information sharing for testing and maintenance. It was operated using Moodle, with an excellent user interface (Moodle, 2015).

The measurement results were analyzed using the statistical package *R* and are described below.

3.2.1 Lorenz Curve of GWTL2012

Figure 3 illustrates the Lorenz curve of utilization in GWTL2012.

In 2012, contributors represented approximately 25% of the total.

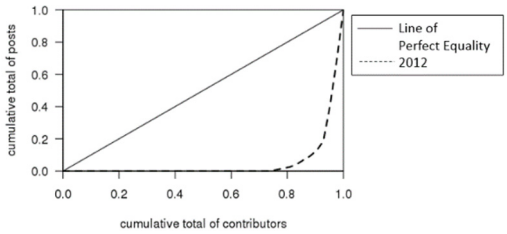

Figure 3: Lorenz curve of GWTL2012.

3.2.2 Lorenz Curve of GWTL2014

Figure 4 illustrates the Lorenz curve of utilization in GWTL2014.

In 2014, the number of contributors had risen to approximately 80% of the total.

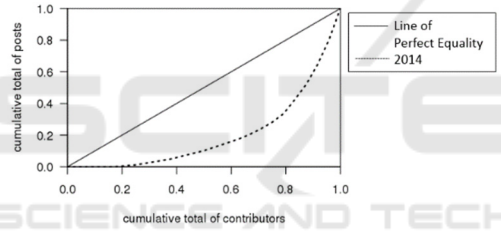

Figure 4: Lorenz curve of GWTL2014.

3.2.3 Comparison of CRK

Table 1 displays CRK in the cases of Sections 3.2.1 and 3.2.2.

Table 1: Comparison of contribution ratio of knowledge.

Case	CRK
GWTL2012	0.10
GWTL2014	0.40

As shown, the value of CRK grew from 0.10 in GWTL2012 to 0.40 two years later (GWTL2014).

3.3 Consideration of the Time-series Change

Figure 5 compares the Lorenz curves of utilization for GWTL2012 and GWTL2014.

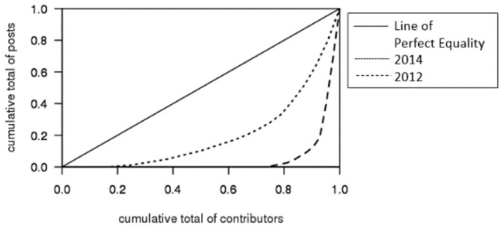

Figure 5: Lorenz curves of GWTL2012 and GWTL2014.

Differences in CRK shown in Table 1 verify that team learning had progressed, as represented by increased CRK.

Other studies that measure CRK of groupware utilization have not been found. The average value of the Gini coefficient of MLs in the previous study was 0.69 (Kitayama, 2009). When this value is converted to CRK, the value comes to 0.31. The CRK value of knowledge of GWTL2014 in this case was 0.40, which is greater than 0.31. This result indicates that knowledge sharing has advanced in Team X.

It was thought that in the course of promoting collaborative software development, members became actively involved in team learning; this has led to an increase the number of posts and contributors. If this hypothesis were correct, it is considered that the team performance of Team X should have become higher than that of the other teams.

To perform a preliminary verification, it was decided to measure the team performance of Team X and compare it with that of the other teams.

4 COMPARATIVE EVALUATION OF TEAM PERFORMANCE

It has been determined that Team X is in the mature stage of team learning. Team performance was then evaluated and compared with that of the other teams. These evaluations were performed using a previously validated survey instrument (questionnaire) (Matsuodani, 2014; Masuda et al., 2015a; 2015b). The evaluation results are described below.

4.1 Evaluation Overview

Team performance is evaluated on the basis of a plurality of factors that represent “performance”. These factors were determined by statistical analysis of the questionnaire responses.

The purpose of the evaluation is to demonstrate clear differences between Team X and other ordinary

software development teams using discriminant analysis.

4.2 Discriminant Analysis by Questionnaire Items

Twenty-two items from the 24-item questionnaire were used for discriminant analysis. The analytical result is presented in Table 2.

Table 2: Result of discriminant analysis of questionnaire items.

			Predictive Number		Total
		Result	group X	group Y	
Actual Survey Number	Frequency	group X	21	7	28
		group Y	2	97	99
	%	group X	75	25	100
		group Y	2	98	100

Each discrimination rate was 75% and 98%, and the total discrimination rate was 93%. As a result, discernible differences were found in responses between Team X and other data group (group Y).

4.3 Discriminant Analysis by Factors

Discriminant analysis was performed in the same way as that in Section 4.2 using the factors of team performance (Masuda et al., 2015a; 2015b). The scatter plot of discrimination scores obtained from the results is shown in Figure 6.

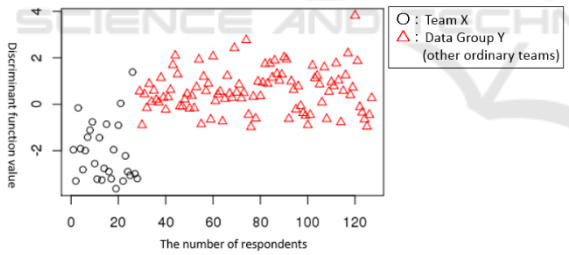

Figure 6: Scatter plot of discriminant analysis by factors of team performance.

Figure 6 clearly shows that the performance of Team X was different from the ordinary team data. It should be noted that the polarity of the graph does not represent the magnitude of the performance.

5 DISCUSSION

In this study, CRK was defined as a method for measuring the maturity of team learning; moreover, its measurement was verified. In this chapter, we summarize and discuss the results.

- Groupware utilization:
  Groupware utilization can be analyzed using the Lorenz curve as with ML utilization. However, because the Gini coefficient has a different meaning between ML and groupware, the inversion of the Gini coefficient was defined as CRK.
- Case evaluation of CRK:
  Team X's two groupware platforms (GWTL2012 and GWTL2014) were measured and analyzed.
- Comparative evaluation of team performance:
  It was established that Team X and other ordinary teams could be distinguished on the basis of a comparison of their team performance results. Indeed, in this case, high team performance can be confirmed by the evaluation of their products.

It is a challenge to analyze causality between increases in CRK and changes from GWTL2012 to GWTL2014. There is a need to investigate whether these changes are related to better proficiency in using the groupware tools or to the maturation of team learning.

6 CONCLUSIONS

This study focused on knowledge sharing among team members and its relation to team learning maturity. The Lorenz curve and inverted Gini coefficient were used as measures, with the inverted Gini coefficient defined as the contribution ratio of knowledge. The measurements were analyzed to generate the following results:

1) It is possible to demonstrate groupware utilization using CRK; thus, CRK can be used as a substitute for groupware utilization.
2) When team performance is high, CRK is also high.
   Because the number of samples was small, it did not reach the limits required of a statistical test; however, it is clear that the hypothesis cannot be denied from the time-series changes to CRK discussed in Chapter 3 and the comparison with other groups' performance in Chapter 4.

In future, we will expand the measurement range and continue to verify the measurement of team learning maturity using CRK. This study measures the state of the team by analyzing their responses to the questionnaire. If this verification is successful, we would be able to measure the progress of team learning using the contribution ratio of knowledge,

which can be measured more easily and objectively without resorting to the questionnaire.

ACKNOWLEDGEMENTS

This work was supported by Nomura School of Advanced Management.

REFERENCES

Kitayama, S., 2009. Social Network Analysis of Communities in Organization, *The Journal of Communication Studies* 29, 3-16.

Gastwirth, J. L., 1972. The Estimation of the Lorenz Curve and Gini Index, *The Review of Economics and Statistics* Vol. 54, No. 3 (Aug., 1972), pp. 306-316.

Masuda, A., 2014a. The Strengths of a team will grow people, and implementing the techniques: TIPS, which is obtained from nine years of activity, *Software Symposium* 2014.

Masuda, A., 2014b. Spread Team Culture that made with Team Building to Other Organizations: Effect we've continue to carry out team building, *Software Quality Symposium* 2014.

Masuda, A., Morimoto, C., Matsuodani, T., Tsuda, K., 2015a. Effect Measurement of Team Building Activities: Result of the Activity for 10 Years, *Software Symposium* 2015.

Masuda, A., Morimoto, C., Matsuodani, T., Tsuda, K., 2015b. A Trial of Team Performance Evaluation and Team Learning Evaluation in Software Development, *International Conference on Education, Psychology, and Social Sciences* 2015.

Matsuodani, T., 2014. Whether the "Genba-Ryoku" exists in the IT: Attempt of Evaluation and Measurement, *Software Symposium* 2014.

MIT (Ministry of Internal Affairs and Communications), 2009. The development of ICT human resources, http://www.soumu.go.jp/main_sosiki/joho_tsusin/joho_jinzai/ (accessed: 29-12-15).

Nakamura, K., 2005. Index for measuring the Income Gap: the Gini coefficient and the Lorenz curve , http://www.pref.toyama.jp/sections/1015/ecm/back/2005apr/shihyo/ (accessed: 29-12-15).

Moodle, 2015. The Moodle community, at: https://moodle.org/ (accessed: 29-12-15).

Takasaki, S., Igaki, H., Higo, Y., Kusumoto, S., 2014. TixRec: Task Recording Support for Retrospectives in Software Development PBL, *IPSJ Journal Vol.55 No.1* 199-209.

Senge, P. M., 2006. The Fifth Discipline: The Art and Practice of the Learning Organization, *Broadway Business*.

Wiki, 26 December 2015 23:07 UTC. In Wikipedia: The Free Encyclopedia. Retrieved from https://en.wikipedia.org/w/index.php?title=Wiki&oldid=696918561 (accessed: 29-12-15).

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS