Optimal Team Formation for Practical Software Development Exercise －Evaluating a Method for Team Formation Based on the Type of Project Manager－

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Abstract: - In the software development exercise for the third graders of the Shibaura Institute of Technology Department of Information Science and Engineering, students are assigned to each team with the capability to carry out a role, for optimization of team formation. In the team formation of 2006, each student who expected to play an active part for the success of exercise subject played an active part also in the actual exercise lesson in each team. As a result "all the teams achieved the exercise subject without any halfway dropouts", which Shirakawa, et al. [1] checked. However in the questionnaire results after the end of the exercise, it turned out that the low motivation of some students caused the shortage of communication of the members in the team.
Then, the authors built up the hypothesis that "each student's motivation is decided by whether the type of Project Manager (Project Manager is described as PM henceforth) and the PM type each member desire is in agreement. Each member has a role to play besides PM in the team for software development. The decision of the role assignment of each member demanded a substitute characteristic and an expression of relations with each role to express a role performance by a covariance structure analysis. Based on an expression of relations, decided assigned members according to the PM type and performed role assignment and the team formation of each member. As a result, the team formation of the students without the practice experience confirmed that high team formation of the cooperativeness between team members was realizable by considering a PM type.

Key-Words: - Optimizing Project Team Formation, Exercises in Units of Groups, Chi-Square test, Exercise for Software Development, Genetic Algorithm, Factor Analysis, Covariance Structure Analysis, Path Diagram, Maximum Likelihood Estimation

1. Introduction

In the software development exercise for the third graders of the Shibaura Institute of Technology Department of Information Science and Engineering, students are assigned to each team with the capability to carry out a role, for optimization of team formation. In the team formation of 2006, performed by Shirakawa, et al. [1] each student who expected to play an active part for the success of exercise subject played an active part also in the actual exercise lesson in each team. As a result "all the teams achieved the exercise subject without any halfway dropouts". However in the questionnaire results after the end of the exercise, it turned out that the low motivation of some students caused the shortage of communication of the members in the team. Therefore in order to solve this problem hypothesized that "it is decided whether the motivation of each student agree with the type of PM (management type or partnership type) and the type of PM desired by each member". In order to inspect the hypothesis for the target students (1st, 2nd grade) of Shibaura Institute of Technology, analyzed

"character suitable for PM", and applied the analysis results to the character of each student attending the lecture. By the results, it was judged that the students having aptitude of PM are of two types "management type" and "partnership type". Afterwards, it was found that a member is classified into two groups according to the type of PM, which (students other than PM) desires.

In the team for a software development exercise, each member has three roles, analysis/design in charge, coding in charge, and in charge of QA (Quality Assurance) to bear other than PM. In order to determine a role assignment of each member a substitute characteristic and an expression of relations with each role to express a role performance by a covariance structure analysis is requested. Based on an expression of relations, decide assigned members according to the PM type and perform role assignment and the team formation of each member. As a result, it is confirmed that the exercise subject is successful without halfway dropouts in any team and an ability difference between teams realized small team formation. Furthermore, in the team formation of the students without the exercise experience, it is confirmed that the high team formation of the sense of cooperation of team members respect to each other can be realized by considering a PM type.

2. Related research

Software development group exercise is unlike the usual lectures, and it has a large burden on an instructor. The frequent communication between students and an instructor is required as a reason for this. Because of this many systems, which support an exercise are proposed until now. For example, there are Chiken, et al.[2], Matsuura, et al.[3], Jang, et al.[4], etc. In Hazeyama[5], Hazeyama, et al.[6] the optimum group organization required in consideration of every student's individuality is described. However, as for the system having a function to support group formation for group exercise by a group exercise support system for software development, is almost none.

Iwasaki, et al.[7] are developing the system, which composes the study group as the foundation of group study at an elementary school. Iwasaki, et al. [7] compared a solution with the round robin method by the genetic algorithm. As a result, a solution by the genetic algorithm confirmed that it had enough effectiveness in practical use close to upper levels. Furthermore, it describes the advantage that time required for processing by using genetic algorithm for group formation can largely be shorten. Because there is no concept of the role necessary to accomplish a problem in these studies (because in other words it is group formation not team formation), and about the personal role assignment in the group is not considered.

Next, for research of group organization of software development exercise there is a need to consider a student’s individual skill. That is why there is a study of using the skill information of the individual student for group formation. Hazeyama[5], Hazeyama, et al. [6], and Hashiura, et al. [8] about the attributes information of the skill, collected system analytical abilities, concerns of the system development, future courses, abilities for leadership, communicative competence by a questionnaire. And considered them to be attributes information about the skill that a student had. And performed an experiment organizing a group based on the strategy how abilities difference

between groups becomes smallest while referring to these attributes information.

This study pays attention to the skill information of the individual student, but does not consider role assignment based on skill information. Besides, it uses evaluation values provided by the questionnaire that used an interval scale for personal attributes information (subjective value). Therefore the formation results may be controlled by the self-evaluation (subjectivity) of the student [9].

Moreover, the software, which was developed in software development training, Matsuura[10] has described it as "not only some students have to work but all the students tackle a subject by high motivation is important when raising a Software Design and Development Engineer is the point". There, Matsuura[10] is building the subject education used as premise knowledge, a suitable subject setup, the lesson design including evaluation criteria, and support environment, and is raising a student's wills.

We claim strongly that this research needs to use objective data for evaluation of the skill and aptitudes which need to consider roles assignment for organization of a project team based on an individual student's skill and aptitudes, and serve as the foundation of roles assignment. For this reason this research considers drawing optimum team organization using a multivariate analysis from the viewpoint of the human factors exerted on team organization by a software development exercise.

Up till now there existed a group, which was not able to attain the given subject during the half a year of lessons. In order to solve this problem if the student who has the capability more than a certain level for every skill is assigned in consideration of various skill (for software development) required for exercise subject achievement, the project team performs team formation based on a hypothesis to be able to achieve all problems.

The result of having judged the existence of the capabilities to carry out, which performs team organization based on the hypothesis that the project team can attain all the subjects, however the given role, based on objective data, is not necessarily in agreement with the judgment which students made themselves. Therefore the roles assignment drawn based on objective data in this research is not shown to students for this reason. Because, in the on-site software development, the reason is that there are many cases that play roles to a unit, and share a module than roles sharing skill to a base. Even if the roles are not shared that the people are originally good at as long as students with abilities to share roles gather, the reason is because thinking that the project succeeds by playing an active part in the form that the people supplement the place where lacking. In other words the reason is because it thinks that the software development project belongs to combination type by the classification of Steiner[11] (conjunctive).

Here, I want to see a related study from the viewpoint of the human factor. However, the range is too wide for the whole human factors, so there are Ezaki[12], Ezaki, et al.[13] besides Ezaki, et al.[14], Takahashi[15], Yamada [16], Yamada, et al.[17], and Yamada, et al.[18] in research by quality engineering approach when it extracts only to the human factor related to software development. In addition, for a study by the multivariate analysis there are Komiya, et al.[19], Komiya, et al.[20], Komiya, et al.[21], and Yamada, et al.[22]. As for these, there is difference in the technique, but it is a study about the human factors, which gives it the reliability of the software. Therefore,

even if it can analyze those factors from quality or reliability of the software, the study to lead the most suitable team formation with a multivariate analysis seems not to be yet done by the viewpoint of the human factor for team formation by the software development practice.

In this study, a sense of cooperation for each other in respect of members of the team and the motivation of the individual students can be raised in the team formation of students without experience of the software development practice by considering a PM type.

3. Measures of 2008 fiscal year

3.1 Research background

In the software development exercise, a project team consisting of 3-5 people is organized. The purpose of the exercise is to experience all making processes of software development from demand extraction to program development, and to learn knowledge and the technologies that are necessary for development. In addition, in this exercise all information of functions and the students such as communication support/result management support/project management support which were developed for work efficiency improvement of the students with automatic log information collection function of software development exercise lesson support environment (it is described as EtUDE Environment for Ultimate software Development Exercise henceforth) [23][24][25] is used. The project practice to learn here shares each role, and it is a form to cooperate, and to solve a problem. That is why the scale of a given problem is big, and the degree of freedom of the work of the attending individuals is big. Therefore in the project exercise, if the ability gap between teams is not made small there is unevenness of the result matters between teams. In addition, it is very likely not to achieve the problem within a period, if there is at least not one person in the team per role with the ability for role sharing. Optimization of the team formation that clarifies human factors is important for software development exercise to make project exercise of the software development an effective thing. The definition that Shirakawa, et al. [1] added a postscript to the factor of the depths to use to assign roles for conditions (limitation) of the team formation that Hashiura, et al.[8] established is Fig. 1.

Shirakawa, et al. [1] used structural equation model (Structural Equation Models, SEM henceforth) to contain covariance structure analysis (Covariance Structural Analysis) of one technique of the multivariate analysis. The relation of the criterion variables and the explanatory variable of the model are clarified and the criterion variables are expressed in the expression of relations of the explanation variables. After that by using genetic algorithm (Genetic Algorithm) in this expression of relations, performed the most suitable team formation automatically by applying system (Environment for Ultimate software Development Exercise/Group Organizer, EtUDE/GO hencforth)[26][27]. By this application, created the most suitable plan of the team formation. And performed the team formation of the exercise class based on the created, this most suitable plan. And performed the exercise class based on this team formation. As a result, it was possible to achieve the objectives that all teams finished the exercise problem by optimization of the team formation. Furthermore, it was expected if students with ability to share roles are assigned to each team without exception, students with the ability to share roles played an active part for

the exercise problem achievement. These students played an active part in the real exercise class as expected and confirmed that it was possible to achieve exercise problem without the halfway dropout of even one person in all teams.

C1:	The type of PM and the type of PM that each team member desires are coincided.
C2:	One or more students with the aptitude who can carry out roles are assigned to each team for every role, respectively. However, the 2 roles, the factor of the depths, which determine the capability to carry out various roles are made into "the special skill (henceforth described as Skill) of software development", and "the analysis ability for software development (henceforth described as Capability)" have performance capability. Skill: Capability of special skill, such as programming in software development, which become high by study or experience Capability: Capability required for software development analysis / reasoning logically
C3:	The capability gap between teams is made as small as possible.
C4:	The number of people difference between teams is assumed to be less than 1 people.
C5:	Even the students who do not fit to accomplish any roles are assigned to any one team by all means. (Educational consideration).

Fig. 1 Team formation conditions definition

However, the measured alternative characteristics were insufficient in research of Shirakawa, et al. This changed into the hypothetical model, which extracts two factors (role performance capability) from the hypothetical model of four factors (role).

In this research, devised four factors (role) and a secondary factor hypothetical model with the latent variables of more than the same numbers. This hypothesis model is the hypothesis model that considered recognition of PM type and the PM, which students have as clarified by Shirakawa, et al. [1]. In addition, it is assumed on the conditions that it will not deviate from the original hypothesis when changes are made to this model.

In addition, the roles required for a software development exercise in research of Hashiura, et al.[8], Shirakawa, et al. [1] consider that four roles of PM in charge (project manager), analysis/design in charge, coding in charge, and QA in charge (Quality Assurance) are enough. In other words the roles of each member in a project are the following four.

(i) PM in charge: Mainly take responsibility for the progress management of the project, the presentation of the progress reports, the presentation documents making. There is much work to manage so that a project advances smoothly to check how much work has been completed with assigned levels. Therefore the work such as design/analysis have to be entrusted to other members.

(ii) Design/analysis in charge: As a person in charge of the use Case diagram/use Case description making/Class diagram and sequence making diagram, take responsibility of making each diagram or its description, and presentation.

(iii) Coding in charge: Take responsibility of concluding assignments of the allotment of the coding and the presentation of the coding results.

(iv) QA in charge: Mainly takes charge of creation of test cases, and coding. As a person in charge of QA take responsibility to perform test cases creation, conclude assignments of tests implementation, debugging and presentation of test cases, and test results.

Further, the students targeted for exercise environment are shown in Table 1 and Table 2.

Table 1 Exercise environment

Exercise Term	Half year
Lecture number of times	15 tims(180min/time)
Number of Objective Students	50 students
Number of lecturers	1 professor, 7 TAs
Number of Team Members	4 to 5 students

Table 2 The targeted students

Students	the third graders of the Department of Information Science and Engineering
Software development experience	Inexperienced person
Skill of programming	Students who can understand a sample program in the C language

3.2 Research measures

The authors carry out a questionnaire for students of enrollment-in-school of the Shibaura Institute of Technology department of information engineering to grasp the PM image that students have. Performed a discrimination analysis with these questionnaire results to decide substitute characteristic (personality trait) and an expression of relations to derive the quality that is necessary for PM. After the start of the exercise, apply the substitute characteristic of the person of study to an expression of relations from the questionnaire results, and makes PM candidate, the student who judged that a distinction result turns to PM. Next by increasing the knowledge degree of skill and the software engineering of the JAVA of the person of study, arrived at expression of relations to calculate analysis/design in charge, coding in charge, role in charge of QA by a second factor hypothesis model of the SEM which added improvement to the hypothesis model of Shirakawa, et al.[1]. Apply this expression of relations to EtUDE/GO after appropriate time. By this, generate the most suitable plan of the team formation automatically. After that, students suitable for each role are chosen by automatically created team formation and confirm that is the team formation without the capability difference between each team. Perform exercise class based on this and half year after the end of exercise, use exercise results and the questionnaire results of the persons of study and evaluate the team formation method that considered a PM type. As a result, in the team formation of the students without the exercise experience, high team formation of the cooperativeness between members is realizable by considering a PM type. (Fig. 2)

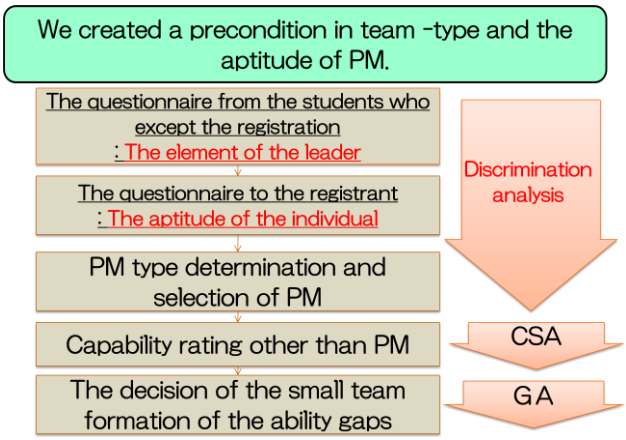

Fig. 2 The verification method for evaluations

4. Analysis method

4.1 PM candidate's selection method

PM as for project team "concentrate on means to achieve targets" and demand the answer to "can targets be achieved?" On the other hand, the leader "defines results to be expected" and finds the answer to "what we want to achieve?"[28] PM by this exercise can be referred to as close to the role of the leader instead of the business capability currently searched for in the actual world. Enforcement of the prior questionnaire for PM candidate selection was done for 207 students of 1st and 2nd grade of this school who understand the leader's concepts. In addition, used the expression by the questionnaire as "a leader" and not "PM" because the targeted persons did not have a concept of PM. PM which the persons of study evaluate, and the alternative characteristic (character data) actually acquired from the study persons are considered based

on this questionnaire and the remarkable students of PM execution capability are selected.

4.2 Analysis for selecting PM

The authors used rating of nine abilities (1~4 linear measure) and ten variables of the PM type (dummy variables) as a result of questionnaire that investigated the PM image by the students and performed a discrimination analysis.

The aptitudes of PM which were able to be found from this discrimination analysis, relatively the students with a large numerical value of X_3, X_4, and X_5 and non manageable (X_{10}) PM type suitable for (1:PM) was understood as in Table 3. In addition, the data used for this analysis is 39 data, which had "yes" reply for the question "are you active?" of the questionnaire.

Table 3 Classification function coefficient (1:PM suitable)

No	Aptitude for a PM	0	1
X_1	Energetic character	4.152	3.773
X_2	Creative approach	6.851	3.414
X_3	Take the initiative and set a good example for others	0.591	0.609
X_4	Form an operational control framework	2.716	3.071
X_5	Assert one's firm belief	2.867	3.070
X_6	Give a concise explanation to someone's question	3.989	1.054
X_7	To demand detailed explanation from a person	6.742	6.369
X_8	Engage in an active debate	-4.068	-1.615
X_9	Approach someone with an authoritarian stance	4.590	2.986
X_{10}	One's own style (PM type: management)	4.370	1.759
	Intercept	-40.872	-28.264

* Right people for PM: $Y_0 < Y_1$

$Y_0=\sum\alpha_{0n}*X_n+\beta_0$, $Y_1=\sum\alpha_{1n}*X_n+\beta_1$ (n=1～10)

Table 4 Classification results of discrimination analysis

Classification results	Assessment		Prediction 0	Prediction 1	Total
Original data	Freq.	0	0	39	39
		1	3	3	0
	%	0	0	100	100
		1	100	100	0
Cross-validation	Freq.	0	1	39	38
		1	1	3	2
	%	0	2.6	100	97.4
		1	33.3	100	66.7

As validity of the coefficients of Table 3, from the classification results of discrimination analysis Table 4, 100% of PM characteristics are correctly classified among the grouping of original cases. Further from Table 5, confirmed whether the coefficient of the items which students consider "important" is larger or the coefficient of "PM suitable" is larger. In addition, the "important" and "not important" correlation coefficient is -0.911, and there was no difference of the important items by PM type.

Table 5 Items "Important" and "Not Important" which students consider (multiple answers)

No	Important (%)	Not Important (%)
X_3	133(21.8)	22(3.6)
X_1	98(16.1)	60(9.8)
X_9	84(13.8)	46(7.5)
X_8	70(11.5)	56(9.2)
X_2	61(10.0)	79(13.0)
X_5	53(8.7)	89(14.6)
X_4	50(8.2)	63(10.3)
X_6	49(8.0)	75(12.3)
X_7	12(2.0)	120(19.7)
Total	610(100.0)	610(100.0)

4.3 PM type determination and selection of PM

Each student's PM type determination was by adding the numerical values of (linear rating measure 1-4 from X_1 to X_9) of the questionnaire results and

classified types by average marks (neglecting the decimal parts) of all the persons of study. As a result by classification of the students with bigger than average marks "management type", and the students with lower than average marks "partnership type", there were 32 persons and 13 persons in each.

Selection of PM, based on coefficients of Table 3 and on the reply of each question (from X_1 up to X_{10}) of the questionnaire, total of two coefficients "1:PM suitable" and "0:PM non-suitable" was demanded. As a result of the calculation the students with the larger numerical value of "1: PM suitable" are selected. By the calculation result of all the students, a total of 12 persons, 7 persons of management PM and 5 persons of partnership PM were selected.

Therefore as a result of considering students other than candidates with PM expectations (18 management types, 15 partnership types) and a team with condition of four numbers, there are 6 persons of management type and 5 persons of partnership type. In addition, this time 11 students to play the role of PM were selected.

4.4 Capability rating other than PM

Performance capability other than PM conducts analysis by SEM based on skill of persons of study, and the data of aptitude.

SEM is the analysis method into which verification factor analysis was developed further as how to find out a true factor [29].

The procedure of analysis by SEM is as follows.

(i) The structure of a question is modeled using a Path diagram (illustration).
(ii) By referring to a Path diagram, the relation of three, a latent variable, an observed variable, and an error variable is expressed by a regression equation.
(iii) By checking the applying condition of SEM hypothetical model by examination of χ^2 (chi-square), SEM hypothetical model is improved.

4.5 Automatic generation and a check of the optimum proposal of team formation

It requests for the relation between an alternative characteristic and a true factor, and expresses a latent variable with the expression of relations of an observed variable. Next it substitute a alternative characteristic for EtUDE/GO(Fig. 3) in an expression of relations and use the expression to demand the value of the latent variable from the observation data of the alternate characteristic and generate the most suitable plan of the team formation automatically. Then it is confirmed if the most suitable plan of team formation generated then satisfies condition (C1) - (C5) which Shirakawa, et al. defined. In addition by confirmation of condition (C3) it is checked that the multiple comparison, which does not use an analysis of variance and F statistics, there is no difference in the capability between teams. The other conditions are confirmed manually. After checking all, team formation based on this optimum proposal is performed, and exercise is done by assigning students to each team.

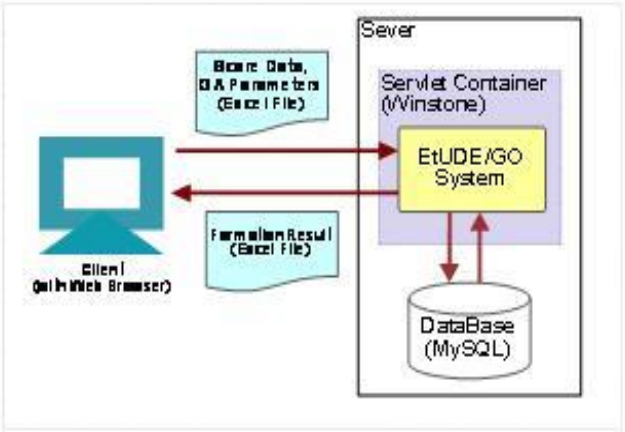

Fig. 3 Composition of EtUDE/GO

4.6 The process which evaluates the effect of team formation optimization

After the software development exercise end, it is analyzed that the influence that optimization of the team formation gave to exercise class, and by optimization of the team formation, these students play active parts as expected and confirm whether, as a result, all teams were able to achieve the exercise problem. In the exercise class, discriminate analysis is used to prove that the team formation optimization was effective. In software development practice, the professors including TA (Teaching Assistant) of the exercise class judge whether each student really played an active part by seeing the log information of the students, which EtUDE acquires automatically.

5 Collection and evaluation of data

AMOS (Analysis of Moment Structure), which can check and correct a hypothetical model visually is used.

5.1 Narrowing down of the alternative characteristics used for analysis

Acquisition of alternative characteristics considers seven variables the skill (JAVA1, JAVA2, JAVA3, PGM1), which can be quantified and knowledge of (PM, a test, an analysis design) which Shirakawa, et al. used by newly added 2 knowledge data to five data (value of an alternative characteristic), the definition of each variable is as follows.

JAVA1:	The definition problem of the operator currently used by JAVA
JAVA2:	The knowledge problem of a JAVA language
JAVA3:	The fundamental grammar problem of JAVA
PGM1:	The problem which measures programming capability
Test:	The problem about the test coverage
PM:	The problem of scheduling using the PDM method
Analysis/ Design:	The problem which creates a Class diagram and a Sequence diagram based on a robustness figure

5.2 Collection of data

The data to use for team formation acquired an alternate characteristic to measure the role capability of the persons planning study at the time of the class for the first time. They are basically the skill of the JAVA program before the exercise class and the software engineering knowledge. For the reliability measuring method of the alternative characteristic, reliability statistic α coefficient was used by Cronbach. The reliability statistic α of seven variables of Fig. 2 using a coefficient is 0.561, beyond the minimum standard ($\alpha > 0.5$)[30].

Furthermore, for inspection method whether or not an observation variable is independent of each other, there is a diagnosis of collinearity characteristics used for the multiple regression analysis that is a low-ranking model of the SEM. Further, as validation of whether an observed variable is mutually independent a distributed expansion factor (described as VIF Variance Inflation Factor henceforth) is used for the index which investigates the state(1).

$$VIF = tr|\sum|^{-1} \quad \cdots (1)$$

The VIF value of observed variables are JAVA1=1.509, JAVA2=1.368, JAVA3=1.367, PGM1=1.509, test=1.690, analysis design =1.314, and PM=1.625. Since all the VIF values are lower than the criterion value (VIF<10), each observed variable may be considered mutually independent.

5.3 The Web system for data collection

This section describes the configuration of the questionnaire system carried out this time, and the outlines of the technologies introduced.

This system was implemented by Web application mounted described in the Java language[31]. It is possible to acquire the questionnaire without depending on the platform of the client by using the Web application. Clients can access using the web browser (Internet Explorer or Safari) preinstalled in OS. For this reason there is no necessity of installing special software.

Moreover, when the questionnaire is filled out, simultaneously the total is completed, so this can reduce the labors for making total. Further it was based on Java Servlet 2.4 specifications[32] and JSP 2.0 specifications[33]. By this if it is the Web application server corresponding to Java Platform and Enterprise Edition[34] based standards, it is possible for this system to operate without the hardware requirement used this time.

When using the system, it is necessary to input the data of the questionnaire into the system that questionnaire creators want to acquire.

But if questionnaire contents are written directly in application each time when acquiring the questionnaire, the source code must be rewritten and must be recompiled. So, in order to ease a questionnaire maker's burden adopted the XML file as an interface file. By this it became possible to take multiple questionnaires in one application system. Further the result of a questionnaire is saved by CSV format and can be downloaded.

For the screen of this time, the Web application was made as a part of the studies to grasp the specifications of the questionnaire (it becomes necessary to acquire it). Furthermore, for this data collection used this Web system and made a questionnaire.

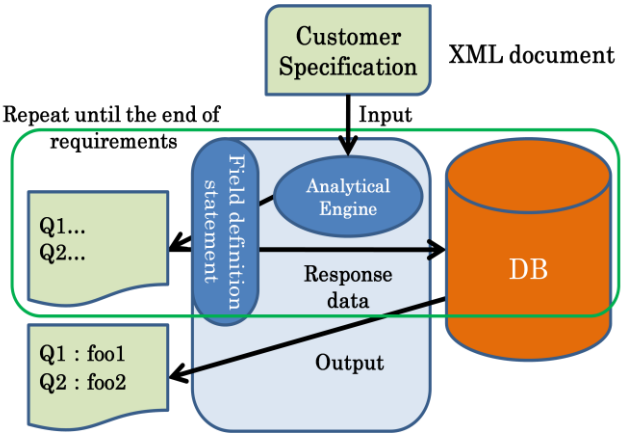

Fig. 4 Outlines of a prototype system

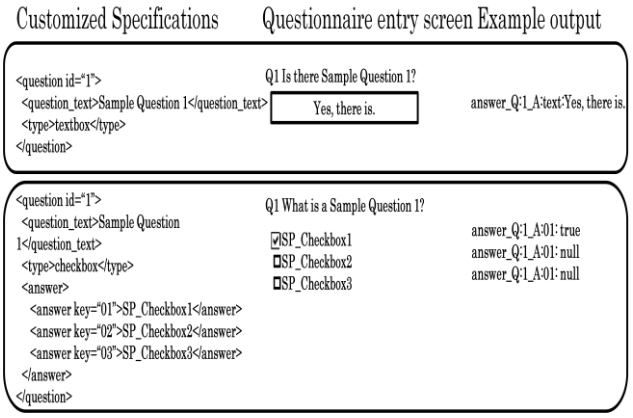

Fig. 5 Specification for customizing

5.4 Decision of the model based on a hypothesis

Devised the hypothetical model of the human factors, which has an influence on the team formation for a software development exercise. Fig. 6 is a model of some factors (a true factor: not measurable factor) showing the capability, which carries out each role required for software development from some alternative characteristics.

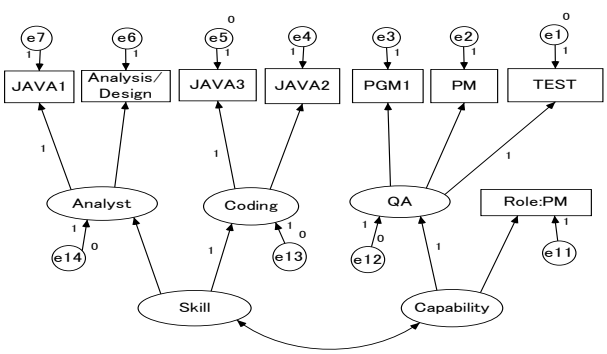

Fig. 6 The causal relationship model of a role and an alternative characteristic

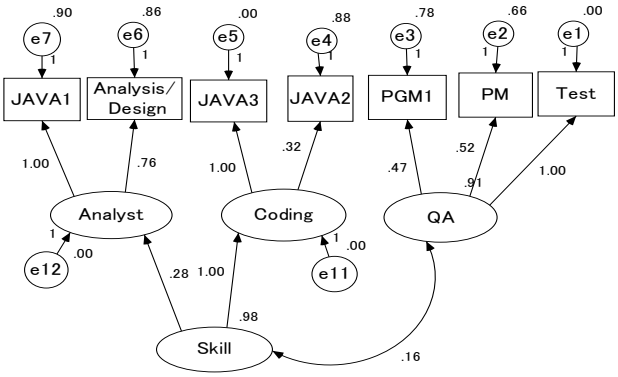

Fig. 7 The causal relationship model of the role and alternative characteristic except PM

When asking for four latent variables, according to the limits of Lederman, it decides upon the hypothetical model of the role (analysis and a design, coding, QA) except PM with six or more alternative characteristics.

$$Number\ of\ Factors = \leq \frac{(2p+1-\sqrt{8p+1})}{2} \quad \cdots (2)$$

However, since PM is already finished with selection, from the hypothesis model of Fig. 6 performs the analysis of the hypothesis model Fig. 7 excluding the factor Capability of the depths and the role of PM.

Table 6 Evaluation of the model by fix index

	GFI	AGFI	RMSEA	AIC	CFI
Model	0.918	0.847	0.063	43.537	0.920

Roles other than PM are as follows.

$$\left.\begin{array}{l} \text{Design/analysis} = 0.76 \times \text{Analysis design} + 1.00 \times \text{JAVA1} \\ \text{Coding} = 0.32 \times \text{JAVA2} + 1.00 \times \text{JAVA3} \\ \text{QA} = 0.47 \times \text{PGM1} + 0.52 \times \text{PM} + 1.00 \times \text{Test} \end{array}\right\} \quad (3)$$

In the official approval result of this hypothetical model χ^2=17.537, freedom degree=15, and probability level ($p < 0.05$) are lower than theoretical value 24.996, therefore the hypothesis was not rejected (it cannot be said that the model is non-conformity type).

6 Evaluation of team formation and validity

6.1 Team formation

Team formation determined the 1st PM and divided the selected PM into two PM types from the character trait.

The collected alternative characteristics were substituted for the obtained expression of relations, and classified the aptitude other than the PM role for each student. Then classified it according to PM type each student demand except PM and the role assignment and team formation based on the classification were performed.

Since there were 45 persons in the exercise study, composed 11 teams in all with 4-5 members in each team. According to the type of PM, made 6 management type teams, and 5 partnership type teams. So that the par capability value of a team may become equal according to PM type by system EtUDE/GO using a genetic algorithm (GA: Genetic Algorithm), generated the team formation proposal so that distribution of average value is the minimum (Table 7).

Table 7 Calculation of the genetic conformity degree

P1	The calculation of the role performance capability in the individual (Expression 4) $y_{il} = \sum_{j=1}^{p} \alpha_{ij} x_{jl} + c_i \quad \cdots(4)$ *i*: Role performance capability number, *j*: Subject number y_{il} :Students' role performance capability , α_{il} : Coefficients of role performance capability x_{il} : Students' score, C_i: Constants
P2	Number of Team Members: 4 to 5 students The arrangement of the student above the average (0) of each role performance ability (The procedure of the arrangement follows the choice of GA, intersecting, a mutation).
P3	A calculation of the mean capability (Expression 5) $O_k = \frac{1}{n_k \gamma} \sum_{k=1}^{n_k} \sum_{i=1}^{\gamma} w_i y_{il} \quad \cdots(5)$ O_k: Capability of team *k* (Average), *Wi*: Importance of role performance capability *i* in team *k*, y_{il} : Ability of role performance capability in student *l*, n_k : Number of Students in team *k*, γ :Number of role performance capability
P4	A calculation of the variance value among teams : Preservation of the team formation of the smallest variance (Expression 6) $O = \min\left[\frac{1}{m}\sum_{k=1}^{m}(O_k - \overline{O})^2\right] \cdots(6)$ o: The objective-function, $\overline{o}$: The mean of the capability of all the teams, *k*:Team *k*, m: Number of teams
P5	The parameter of GA: The number of repetition The computation repeats a procedure from P2 to P4.

The result of this team formation is an exercise summary as in Table 8.

Although there were students who were absent during the study registration, since judgment of whether to abandon one's rights to an exercise did not stick, it assigned having assumed that they participated in the exercise study, and were considered as the candidates. However, one exercise absentee appeared from persons with role.

Although one person did team formation exercise registration among 45 exercise schedule persons, since he abandoned immediately after team formation, 1 team of three persons was made.

Table 8 Outlines of an exercise, 2008 fiscal year

Exercise Task	Development of the bookselling system
Exercise Term	September 18th, 2008 to January 15th, 2009
Number of Objective Students	44 students
Number of Team Members	3 to 5 students
Number of Teams	11 teams

6.2 Equability evaluation of the team formation by an analysis of variance

Evaluation of analysis of variance, which verifies the equability about four roles, PM, analysis/design, coding, and QA, using an analysis of variance is done.

Table 9 Analysis of variance (Single factor) Results

Team No.1~6

Source of Variance	SS	df	MS	F	P-value	F cnt
Between Groups	0.148	5	0.030	0.003	1.000	2.773
Within Groups	194.848	18	10.825			
Total	194.996	23				

Team No.7 ~11

Source of Variance	SS	df	MS	F	P-value	F cnt
Between Groups	1.099	4	0.275	0.030	0.998	3.056
Within Groups	138.419	15	9.228			
Total	139.518	19				

As for the evaluation of the analysis of variance (Single factor), P the probability of the critical region which value < experimenter sets up, and F boundary value < the observed variance ratio of "rejecting a null hypothesis" and the probability of a critical region is 5%.

7 Validity evaluation of the team formation optimization after the end of the exercise

7.1 Method of judgment

The instructors containing TA evaluated the contribution to the subject achievement in all exercise lessons participants' teams after the end of the exercise based on the presentation of middle and the last announcement, and the log information which the last product and EtUDE of the exercise acquired.

Validity evaluation of the team formation classified by PM type is performed by "evaluation of the product according to team", and "the questionnaire result after an exercise."

7.2 Validity evaluation of team formation optimization

In this team formation, carried out equalization of capability according to the type of the team. Therefore it was judged that there is the difference of capability between the team type M (Management) and the team type P (Partnership), when seen from the team type point, but evaluation was judged with no gap.

Therefore it was proved that evaluation became equal by considering the type of the team rather than the method to make capability equality simply.

The correlation coefficient of evaluation of the product according to PM type and team capability, the capability numerical value calculated by evaluation of a team and analysis became -0.644. Since role performance capability is taken into consideration in team formation even if the capability of a team is low, it is good evaluation Fig. 8).

Table 10 Results of the Independent Samples T Test

Group Statistics

	Team	N	Mean	SD	SE
Capability	M	6	1.350	0.356	0.145
	P	5	-1.600	1.056	0.472
Evaluation	M	6	-0.333	0.983	0.401
	P	5	0.380	0.983	0.440

Independent Samples T Test

Levine's test for equality of variance		F	Sig.
Capability	Equal variance assumed	11.488	0.008
	Equal variance not assumed		
Evaluation	Equal variance assumed	0.285	0.607
	Equal variance not assumed		

t-test for Equality of Means						
t	df	Sig. (2 tailed)	Mean Difference	SD Difference	95% Confidence Interval of the Difference	
					Lower	Upper
6.475	9	0.000	2.950	0.456	1.919	3.981
5.970	4.761	0.002	2.950	0.494	1.660	4.240
-1.198	9	0.261	-0.713	0.595	-2.060	0.634
-1.198	8.642	0.263	-0.713	0.595	-2.069	0.642

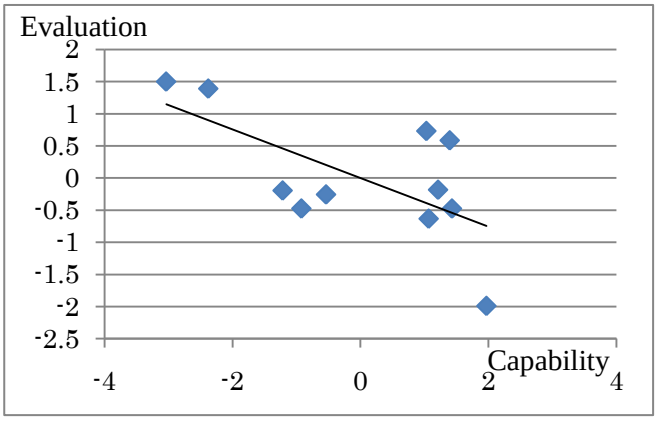

Fig. 8 Product evaluation and team capability

8 Conclusion

8.1 Result of Research

In order to analyze the human factors, which affect on team formation by a software development exercise worked out a secondary factors hypothetical model, performed the analysis procedure of SEM and inspected SEM hypothetical model. As a result of role

performance capability was able to consider it as the true factor (criterion variables), and was able to demand for the expression of relations between seven alternative characteristics (explanatory variable). Applied those expression of relations to EtUDE/GO, and generated the optimum team formation proposal. Made a team formation based on this proposal, and performed an exercise lesson of students. After an exercise class of a half- year, analyzed the influence that optimization of the team formation brought on exercise class.

According to the type of PM decided position members and performed role allotment and the team formation of the members. As a result, was able to realize team formation with small capability difference between teams, and confirmed was able to achieve exercise problems without one halfway dropout in all teams. Furthermore, by this inspection, the team formation of the students without the exercise experience was able to realize the high team formation of the sense of cooperation of team members respect to each other by considering a PM type. PM allots the work to the team of the management type by result units, and a tendency to be able to leave to each person is in particular strong. But the unevenness was big, and PM confirmed that the team of the partnership type made results for every WBS by cooperating with all the members.

In evaluation comparison of the degree of fullness of the cooperativeness and the exercise in this time and the team of 2006, "it was very substantial" became 31.1% in 2008 from 12.3% in 2006, and "all the members cooperated" became 60.0% in 2008 from 47.4% in 2006.

There was no clear difference in the degree of fullness according to PM type carried out this time, and evaluation of cooperativeness. (Table 11).

Table 11 Fullness degree and cooperativeness according to type of PM

	Fullness degree(%)		Cooperativeness (%)	
	Type1	Type2	Type1	Type2
Strongly Agree	25.0	42.1	58.3	68.4
Agree	62.5	52.6	16.7	26.3
Disagree	12.5	0.0	25.0	5.3
Strongly Disagree	0.0	5.3	0.0	0.0
Total	100.0	100.0	100.0	100.0

In addition, in a team "what is necessary to redevelop it with the same members" regardless of team type (M: Management type, P: partnership type), the thing which each demanded from team members of good evaluation and bad members team became the same results Table 12).

Table 12 Things PM demands from team members

What is necessary to redevelop it in the same members?	Team type (Respondent : PM)	Evaluation
(requirements of PM)	M	1.499
(i)The skill of the requirements analyses	P	1.390
(ii)Clarification of the work allotment	P	0.731
(iii)Schedule management	P	0.585
	M	-0.183
	P	-0.195
	P	-0.256
(i)Adhere rigidly to the rules	M	-0.475
(ii)Report of the progress	P	-0.475
(iii)Communication	P	-0.633
	P	-1.989

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