Evaluation of Information System Development Method for Aiming at Management Efficiency

Toshimasa OZAKI [*] Teruhito MISHIMA [†]

Abstract

The information system is indispensable as an infrastructure of the society and enterprises today when informationization progressed. Especially, to secure competitive advantages, many expectations are sent to information systems in corporate organizations. However, the development enterprises that contribute to the introduction and the reform of the information systems are concerned with three problems, for example, the frequent occurrence of the specification change, the quality securing, and shortness of the delivery date.

In this presentation, development techniques were devised as a start to improve the production capacity of software, the water fall method, the RUP method, and the XP method. The development methods were evaluated in the next three steps. The first step was an evaluation of the development method by AHP by the trustee side based on the requirement definition from the employer side (user side). In the second step, the judgment concerning the acquisition of the know-how to the project risk of correspondence and the method were made and ANP was used to evaluate it from the side of the development methods. The last step was the overall evaluation that consisted of the first step and the second step by AHP. Moreover, it was able to be specified that the rate of profit was improved from 1.18% to 5.99% when applying to a certain enterprise. We were able to suggest that the development method be used for the problem of production rework, the quality securing, and shortness of the delivery date.

Keywords: AHP, ANP, Information System, Development Technique

1.Introduction

A lot of expectations are sent to the information system that supports competing domination in a corporate organization as a severe inter-enterprise competition progresses. The role of the software development industry that contributes to the introduction and reform is more important. However, three structural problems, the frequent occurrence of the specification change while developing, the quality securing, and shortening of the delivery date, might exert a substantial influence on the management of the software development enterprise.

The frequent occurrence of unforeseeable specification changes in development is caused by being not able to define the function requirement clearly. Therefore, the production rework within the re-design occurs frequently. Moreover, the difficulty in securing the quality is in mistakes that easily happen so that the information system development may accompany the human skill work, and that the advancement of the software skill exceeds the accumulation of know-how furthermore. The shortening of the delivery date is due to the customers' needs to use an information system that develops at the early stage and improves the operating effectiveness. Both sides, the employer and the trustee, foster these problems. When changes in specifications occur, a period of quality examination transpires so that making (production) may start again, and, as a result, the software that is of low quality security is delivered to the customer.

[*]Prf. NAGOYAGAKUIN UNIVERSITY, Nagoya, Japan. ozaki@ngu.ac.jp
[†]Department of Information Development, NTT APPLIE Nagoya, Japan.mishima@applie.co.jp

Moreover, a new technical introduction and a shift to the open system might make it return to the specification change. The reason is that they lack results of the stable operation. Furthermore, shortening of the delivery date complicates specifications change and quality security. Each is connected with each other, and these problems make finding a solution more difficult.

Recently, a new development method such as the Agile method used for the power of the organization with the individual is also worthy to pay attention to because these problems are difficult to solve by water fall (WF) method, a prior software development method. However, there are a lot of points where the judging criteria is uncertain to determine the adoption of these new development methods under the present conditions.

We propose the evaluation model of a new development method. We suggest the use AHP and ANP as a structural solution for the problems that the information system development holds as an example of D company of the mainstay information system development enterprise. Consideration of the evaluation results from the aspect of management could be referred to this case.

2. A problem with information system development

(1) The production rework by specifications change

In investigating the Ministry of Economy, Trade and Industry, the actual condition that "20% or more of the production rework rate" has reached 40% of the whole is clarified to "3.2% of no production rework". This refers to the frequency of re-design which makes specification changes in the areas of cause, re-coding, and a re-examination. In recent years, the scale of a mission critical system has increased. As well, the requirement definition and design have become more difficult, and the risk of production rework has also expanded.

The cause of the production rework by specification change is in the insufficiency of the organization by the side of the customer. The customer then becomes like a supervisorand checks and adjusts specifications, the problem of the lack of ability, and consensus with the participants of the system. Moreover, since the request of the customer in early stages of development tends to be abstract and vague, there is a tendency by the trustee to make an assumption in what is needed by using their experience and skill. When the customer sees the currently completed information system, they may request sudden changes to the specifications.

The production rework by specification change causes the delay in the schedule of entire project. Another problem that might develop is that time for the examination process may be comprimised because of delays in production rework. Under complicated and intense competition of change, the freeze of specification is actually impossible. Therefore, it is required to prepare the mechanism of reducing the frequency, although generating of production rework is permitted.

(2) Difficulty of quality reservation

It is theoretically possible to secure quality by checking the compatibility of design specifications and by using a program mutually in the stage of audit about the quality of an information system, although quantification is difficult. However, since much time and program technology is required in the stage of the audit which passed the development phase, this method is not practical. The classification of the review result and a review evaluation as the method of measuring an expedient quality must be taken into account. Furthermore, "ISO/IEC9126 "as a classification of the quality characteristic must also be considered. The formers are a measuring method of the stage of audit, and the latter has many abstracted items, making neither of the methods practical to use.

On the other hand, the shift to the open system also makes quality reservation difficult. That is, in the present open system, the operation of the software in a large area and the compatibility of an information technology are not perfect. Moreover, the results obtained of stable operation of software skill and the shortages of the degree of mechanical skill which may arise are also a problem. Moreover, few results of the stable operation of the software skill and the lack of the technological skill level are problems.

Hashimoto[(1)] has classified the system scale according to two factors, the complexity of management and technical complexity by setting up a scale of average information system development with $5 \sim 10$ persons and $10 \sim 15$ months. If conditions, such as "a member works by separating geographically" and "the novelty for development is very high", are involved, quality

reservation will become much more difficult, but this classification serves as a near standard of quality control. Rather than at the stage of the system audit, the method of performing quality reservation at the time of such development is searched for.

(3)Shortening of delivery date

In investigation of enterprise IT trend survey, the answer that the delivery date in the system development shortened reaches 61%.This result shows that the customer wants to correspond to changes in the business environment promptly from the viewpoint of securing a strong competitive advantage. However, the shortening of the delivery date makes the schedule of information system development tight. If production rework occurs, the system engineers will concentrate on protecting the delivery date, and the quality will not be secured. Since software development is labor-intensive, generally, the work load should be managed and covered by [persons] and the [months]. However, the situation may worsen further as F.Brooks[(2)] indicates, since "work to adjust" is not taken into consideration. Although the delivery date is determined at the estimate, even if the COCOMO (Constructive Cost Model) method and a function point method as a method to estimate is used, calculation of the time necessary for completion by an exact estimate is difficult. Therefore, the methodology of the flexible information system development on condition of the ability not to perform pursuit of estimated accuracy is needed.

3. Construction of Evaluation Model of Information System Development Method

3.1 Setup of Precondition

(1) The conditions of selection of the development method

In software development, use of the water fall method is common. If a new development method is suitably selected, the difficult information system (project) can be constructed because the method will give various choices to the achievement of the system function. Therefore, it is desirable to choose the development method according to consideration of a risk until the know-how of the development method is acquired, the feature of a project, or the strengths and weaknesses of the method in order to correspond to the difficulty of the production rework by specification change, quality reservation, and shortening of delivery date. The development methods to choose consist of the water fall method, the RUP method, and the XP method. The following conditions are set up in order to choose the development method for every development project.

Condition 1. The project is evaluated by two or more elements.

Condition 2. Two or more elements are evaluated by weight respectively.

Condition 3. The characteristic of the development method and the grade of know-how also are evaluated.

Condition 1 is not evaluated using a single element. It is, however, premised on the evaluation method by two or more elements for the know-how of quality, term of works, and method etc. Condition 2 differs in the importance of the evaluation element for every project, and also enables the trade-off between elements. The last condition presupposes that selection of the development method can be performed according to accumulation of know-how.

(2) Criteria

The element which fulfills condition 1 is set up as concrete evaluation criteria. From an unsuitable thing, the XP method makes a software large scale system development with important evaluation criteria first. Furthermore, shortening (quick delivery) of information system construction is also selected as evaluation criterion.

First of all, we make a software scale important evaluation criteria because the XP method is unsuitable for large scale system development. Furthermore, we also select the shortening (quick delivery) of the information system construction as an evaluation criterion. Moreover, there is also a development project for which new technology must be used in order to satisfy the requirements for the system. Or, in an existing technology, there is a project with a large development project to be able to confirm the validity of the processing method by coding it, and with technical uneasy element and risk (technical difficulty), too. In this case, since it is necessary to have to check the technological problems in the early stages of the project, it is of value to let technical difficulty be an evaluation

criterion. In addition, there is difficulty of the requirements as an element similar to technical difficulty. For example, when the business process is not in sight in an early stage, or when BPR (Business Process Reengineering) and the development project are developed simultaneously, the requirements for the system can not be clarified. Therefore, let requirement difficulty be criteria.

Furthermore, priority is given to reliability over what, when the information system is a social infrastructure or is a mission critical system. Then, in addition to evaluation criterion, high quality should also be a fifth evaluation criterion.

3.2 Frame of Evaluation Model of Development Method

(1) The 1st step

The development method is chosen from the feature of a development project using the evaluation criteria shown in Fig. 3.1. The trust side extracts the feature of a development system from the employer side (user side) by a hearing in the stage of a requirement definition, and makes a selection judgment of the development method based on the result. (Fig. 3.2)

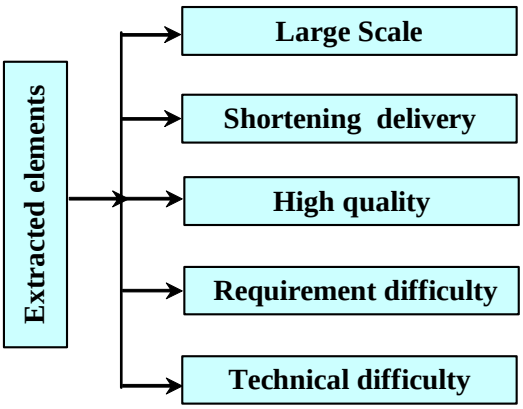

Fig. 3.1 Extraction of selection elements

Although priority of the development method can be performed from this result, even when a risk of a project going wrong is high, the development method without accumulation of know-how happens to be chosen. For example, when the trustee has only the know-how of the water fall method, the priority of the RUP method or the XP method may become high. Then the following step is added in order to cancel this unrealistic inconsistency.

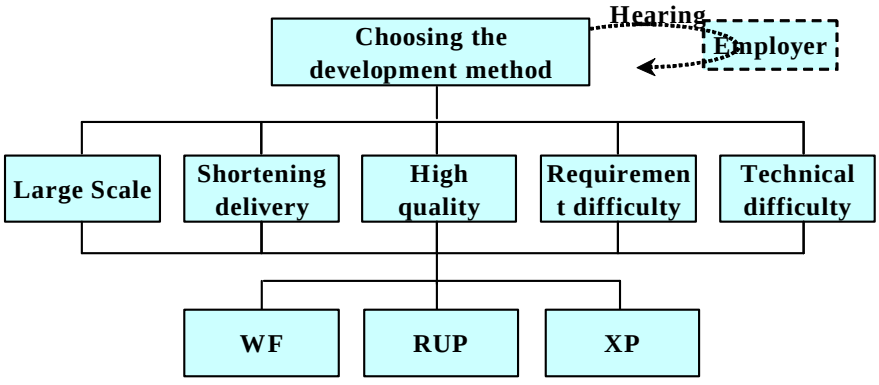

Figure 3.2 Layered structure to choose the development method from the feature of a project

(2) The 2nd step

Priority is given consideration to the risk of the project holding, or to the acquisition of know-how. Then, one of the development methods is chosen. Furthermore, ANP is used since evaluating also from the side of the development method is important (Fig. 3.3)

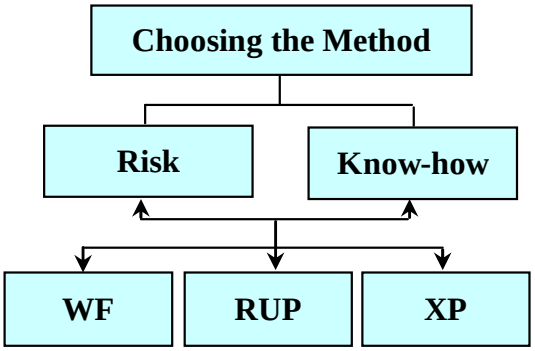

Figure 3.3 Layered structure to choose the development method

(3) The 3rd step

Judgment of both sides of the 1st step and the 2nd step is applied to AHP, and a synthetic judgment is made. (Fig. 3.4)

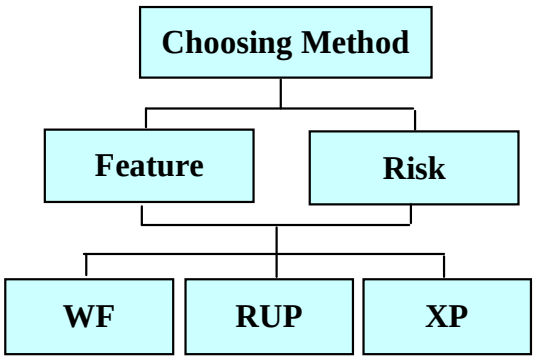

Figure 3.4 Layered structure to make a synthetic judgment

4. Example of Use of Evaluation Model

4.1 Financial Condition of D Company, and Setup in Question

(1) The financial condition of D company

Many of the software development companies became independent of the information section of the major company. D company is not an exception, either. D company is utilizing 200 or more external engineers per year in accordance with the period and scale of a development project. The ratio of the current profit which D company occupies in sales is 1.18%, and is inferior compared with the other company in the same trade. The factor with this low current profit efficiency has few competitiveness and strong points to the other company by technical capabilities or product power, and manufacture cost is at a large point. Therefore, strengthening of competitiveness and reduction of manufacture cost has been an urgent subject.

Table 4.1 Current profit efficiency

DMU	A	B	C	D	E	F	G	H	I	J
Value	0.742	1.000	0.123	0.097	0.236	0.168	0.537	0.098	0.065	0.026

(2) The setup in question

D company has been performing development by using the water fall method for years. However, if she has the opportunity, she wants to use the new development methods, such as the RUP method and the XP method, as a measure against the increase in a short-term development project. When new

information system development was requested from a certain customer and the requirement definition and the hearing were carried out, the feature of the project was as follows.

- Small-scale system
- High reliability is required.
- With no experience of the systems development which requirements resembled
- Systematization is possible with new technology.

4.2 Example Computation of Evaluation Model

(1) The 1st step

The eigenvector in the level 2 evaluation criteria shown in Figure 3.2 is requested. The consistency of the obtained weight is also good. (Table 4.2)

Table 4.2 Paired comparison between evaluation criteria

$\lambda max = 5.22$ $C.I = 0.055$

	Scale	Requirement	Technology	Quality	Delivery	Weight
Scale	1	1/2	1/2	1/2	2	0.155
Requirement	2	1	1	1	1	0.221
Technology	2	1	1	1	2	0.250
Quality	2	1	1	1	1	0.221
Delivery	1/2	1	1/2	1	1	0.153

Next, the paired comparison of alternatives (method) is repeated. The consistency of the paired comparison of alternatives is 0.15 or less, and the evaluation result is appropriate. Therefore, weight concerning the feature of the development project is requested by using the additivity of utility.

$$\begin{pmatrix} WF \\ RUP \\ XP \end{pmatrix} = \begin{pmatrix} 0.429 & 0.143 & 0.143 & 0.400 & 0.105 \\ 0.429 & 0.429 & 0.429 & 0.400 & 0.258 \\ 0.143 & 0.429 & 0.429 & 0.200 & 0.637 \end{pmatrix} \begin{pmatrix} 0.155 \\ 0.221 \\ 0.250 \\ 0.221 \\ 0.153 \end{pmatrix} = \begin{pmatrix} 0.238 \\ 0.396 \\ 0.366 \end{pmatrix}$$

The priority foreword based on the feature of the development project is

$RUP(0.39\ 6) > XP(0.366) > WF(0.238)$.

(2) The 2nd step

Shown in Fig. 3.3, the paired comparison between the criteria in level 2 is performed. Next, evaluation of each method for evaluation criteria occurs. The paired comparison of the evaluation criteria based on alternatives is further performed. When the weights of the criteria of the development methods are assumed to be super-matrix X

$$X = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0.125 & 0 & 0 & 0.167 & 0.125 & 0.125 \\ 0.875 & 0 & 0 & 0.833 & 0.875 & 0.875 \\ 0 & 0.659 & 0.109 & 0 & 0 & 0 \\ 0 & 0.156 & 0.309 & 0 & 0 & 0 \\ 0 & 0.185 & 0.582 & 0 & 0 & 0 \end{pmatrix}$$

And if $\lim_{k\to\infty} X^{2k+1} = X^*$

$$X^* = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0.133 & 0 & 0 & 0.133 & 0.133 & 0.133 \\ 0.867 & 0 & 0 & 0.867 & 0.867 & 0.867 \\ 0 & 0.182 & 0.182 & 0 & 0 & 0 \\ 0 & 0.289 & 0.289 & 0 & 0 & 0 \\ 0 & 0.529 & 0.529 & 0 & 0 & 0 \end{pmatrix}$$

The priority foreword based on the feature of the development project is
$XP(0.529) > RUP(0.289) > WF(0.182)$.

(3) The 3rd step

The first step is an evaluation by the feature of the project, the second step is an evaluation to the risk, and a final evaluation is done for these criteria.When we assume the weight of the selection criterion of the development method to be X,

$$X = \begin{pmatrix} WF \\ RUP \\ XP \end{pmatrix} = \begin{pmatrix} 0.238 & 0.182 \\ 0.396 & 0.289 \\ 0.366 & 0.529 \end{pmatrix} \begin{pmatrix} 0.750 \\ 0.250 \end{pmatrix} = \begin{pmatrix} 0.224 \\ 0.369 \\ 0.407 \end{pmatrix}$$

a synthetic priority is set to $XP(0.407) > RUP(0.369) > WF(0.224)$, and it is judged that the XP method is suitable in this project.

4.3 Influence on Management

(1) The example of application to a middle-scale system

Since there are actually many middle-scale systems, the possibilities of application of the new development method, such as the RUP method and the XP method, are explored in order to aim at improvement in competition predominance or productivity.

Problem setup

When a requirement definition and hearing of new information system development were carried out, the feature of the project is as follows and D company decided to adopt the water fall method. Is this judgment appropriate?

- Middle-scale system
- High reliability is required.
- With no experience of the systems development which requirements resembled
- Systematization is possible with technology with a development experience.
- Schedule conjectured to be appropriate although it is hard-pressed at time for

Table 4.3 Paired comparison between evaluation criteria

$\lambda_{max} = 5.29$ $C.I = 0.072$

	Scale	Requirement	Technology	Quality	Delivery	Weight
Scale	1	2	3	1	1	0.244
Requirement	1/2	1	1	1/5	1/3	0.086
Technology	1/3	1	1	1/5	1/3	0.080
Quality	1	5	5	1	1	0.325
Delivery	1	3	3	1	1	0.265

About the development method in the 1st step, by applying the addition sum of utility,

$$X = \begin{pmatrix} WF \\ RUP \\ XP \end{pmatrix} = \begin{pmatrix} 0.455 & 0.143 & 0.143 & 0.429 & 0.105 \\ 0.455 & 0.429 & 0.429 & 0.429 & 0.258 \\ 0.091 & 0.429 & 0.429 & 0.143 & 0.637 \end{pmatrix} \begin{pmatrix} 0.224 \\ 0.086 \\ 0.080 \\ 0.325 \\ 0.265 \end{pmatrix} = \begin{pmatrix} 0.302 \\ 0.390 \\ 0.308 \end{pmatrix}$$

is obtained.

The paired comparison between evaluation criteria is performed also in the 2nd step. We assume the weight of the selection criterion of the development method to be X,

$$X = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0.875 & 0 & 0 & 0.833 & 0.900 & 0.900 \\ 0.125 & 0 & 0 & 0.167 & 0.100 & 0.100 \\ 0 & 0.659 & 0.143 & 0 & 0 & 0 \\ 0 & 0.156 & 0.429 & 0 & 0 & 0 \\ 0 & 0.185 & 0.429 & 0 & 0 & 0 \end{pmatrix}$$

And if $\lim_{k \to \infty} X^{2k+1} = X^*$

$$X^* = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0.861 & 0 & 0 & 0.861 & 0.861 & 0.861 \\ 0.139 & 0 & 0 & 0.139 & 0.139 & 0.139 \\ 0 & 0.587 & 0.587 & 0 & 0 & 0 \\ 0 & 0.194 & 0.194 & 0 & 0 & 0 \\ 0 & 0.219 & 0.219 & 0 & 0 & 0 \end{pmatrix}$$

Evaluation about Step 3 is performed similarly.

$$X = \begin{pmatrix} 0.302 & 0.587 \\ 0.390 & 0.194 \\ 0.308 & 0.219 \end{pmatrix} \begin{pmatrix} 0.333 \\ 0.667 \end{pmatrix} = \begin{pmatrix} 0.492 \\ 0.259 \\ 0.249 \end{pmatrix}$$

Synthetic priority $WF(0.492) RUP(0.259) > XP(0.249)$ is obtained. Therefore, in this project, we can judge that the water fall method is suitable, and that the decision-making of D company is appropriate.

(2) The development method reform and its effect

These development methods are reform of business, and if there is neither preparation scrupulous for that purpose nor an understanding of the participants, the problem in connection with the delivery date or quality will occur. Therefore, it is necessary for D company to advance know-how accumulation by little small-scale practice, using this valuation modeling. Now, we will consider the concrete effect when advancing know-how accumulation and tailoring of a method.

In information system development, the person hour of a "design", "manufacture", "examination/synthesis examination", and "employment/maintenance" is the object of reduction, and reduction of 19% of person hour is shown by the FUJITSU communication system. Considering the skill of D company and assuming that person hour reduction can be carried out 25% as the minimum value, 30% of project makes the rate of the personnel expenses for person hour reduction 85% of sales among all projects from the results obtained of D company. The reduction rate of the personnel expenses from the whole D company becomes 6.8%, and current profit increases from 52 million to 262 million yen by reduction in expense. In addition, if the sales acquisition by a part for operation

reduction is presumed, 259 million yen will be expected and current profit will also increase by 18 million yen.

Synthetically, we can predict that current profit will be improved to 280 million yen from 52 million yen, and sales are improved from 4,415 million yen or 1.18% to 5.99% or 4,674 million yen as for a profit ratio.

Table 4.4: Current profit efficiency Presumed relative evaluation

DMU	A	B	C	D	E	F	G	H	I	J
Value	0.742	1.000	0.123	0.523	0.236	0.168	0.537	0.098	0.065	0.026

5 Examination of this Evaluation Model

(1) Evaluation method

Although selection of the development method is important decision-making for an information system development company, an evaluation method like this model has not been proposed. This evaluation model chooses the development method adapted to the feature of the development project, and concludes with an AHP evaluation of the 1st step. However, when the risk in the development method is high, or when know-how is insufficient, it is dangerous to adopt a development method based on the obtained evaluation. For this reason, whether the risk of a project is made preferential or future know-how accumulation is made preferential is judged at the 2nd step with AHP and ANP. Through the 3rd step, the weight of the 1st step and the 2nd step is judged and synthetic evaluation is performed.

A margin occurs in the time for delivery of the development project. If acquisition of the know-how of a new method is possible, and the risk is low etc, then the final evaluation is to choose the XP method, a new method. Although the priority is reversed in the 1st step and the 2nd step to the problem setup 1, this method can be called a prudent and safe valuation method.

(2) criteria

The evaluation criteria of the information system development method are decided by the situation and situation by the side of trust rather than are determined uniquely. Although this research was aimed at dissolution of three specific problems, it is thought that these problems are outcomes of production rework of specification change. It is natural that the development scale or the difficulty of the requirements for development, technical difficulty, and the high quality were extracted as evaluation criteria, respectively. Moreover, although time for delivery was directly made into one of the important criteria, this evaluation criterion should be fundamentally taken into consideration. Moreover, it is a premise that these five evaluation criteria are independent of each other, but absolute evaluation cannot actually be performed since it has mutual influence. Therefore, although a paired comparison value can be influential, AHP can estimate these criteria by grading with relative evaluation.

(3) Influence on management

It is natural that the software development enterprise wants to receive an order for a large scale system to secure the profit. Without experience, the risk of the project is large. Therefore, the software development enterprise wants to attempt the expansion of the profit for the leap of the enterprise by new development methods of the RUP method and the XP method, etc. However, the weight of risk is clearly high, as shown in Table 2.9. D company also took the risk of failure of this project into consideration, and chose to use the water fall method with know-how.

6 Conclusion

We were able to suggest that the development method be useful for the problem of production rework, the quality securing, and shortness of the delivery date. This model is simple and seems to be useful in securing a competitive advantage.

Reference

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