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Suggestion for Collaboration-Based UI/UX Development Model through Risk Analysis

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Abstract

An attractive user interface (UI) design with a clear user experience (UX) is the key for the success of applications. Therefore software development projects require very close collaboration between SI developers and front-end service developers. However, methodologies for software development only exist with inadequate development processes or work standards for collaboration. This survey derived 13 risk factors in developing UI/UX from 113 risk factors of IT projects through a questionnaire and factor analysis and proposed a collaboration-based UI/UX development model that can eliminate or mitigate six risks with high weights and reliability. To extract risk factors with high reliability, factor and reliability were analyzed to extract 13 major risks, and based on the expert opinions and the results of correlation analysis, UI/UX development stages were classified into planning, design, and implementation. The causal relationships between risks were verified through regression analysis. This study is the first to expertly analyze major risks based on collaboration in UI/UX development and derive a theoretical basis that can be used in project risk management. These findings are expected to provide a basis for research on development methodologies for higher levels of front-end services and to construct rational collaboration systems between SI practitioners and front-end service providers.

Keywords

Collaboration, Front-end, Project Management, UI, UX, UI/UX

1. Introduction

During the design of mobile apps, websites, or products, the user interface (UI) refers to the means by which the user will interact with the product by visualizing it externally, such as the shape, size, color, and layout. User experience (UX) design, a user-oriented approach, refers to the collective design of experiences such as the reactions and behaviors of users when they directly or indirectly use a product, system, or service [1]. As software is being developed in size and complexity because of the fourth industrial revolution, customers expect fast and new technological innovations, and the time-to-market of new products has been shortened [2]. UI and UX, in particular, are the main components of front-end services, and an attractive UI design that provides a clear UX is becoming an important component of software quality and a key success factor to applications [2,3]. Therefore, numerous companies are devoting efforts to provide a UX that can enhance user satisfaction through collaboration with front-end

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service providers. These providers are represented by digital agencies who specialize in UI/UX development for creating services such as mobile apps and websites. Front-end service providers offer services such as business consulting, creative design, and information technology needed to creatively and progressively develop and operate websites based on the Internet. Generally, UI/UX development tasks are difficult to efficiently integrate with SI project-centered development processes, and UX designers tend to make decisions in terms of aesthetics or creative design elements in the UX design process. In contrast, developers make judgments in terms of the feasibility of implementing a function within a certain period. This difference between the designer's creative ideation-centered thought process and the developer's functional feasibility-centered thought process sparks conflicts between individuals or organizations. This becomes a major cause of risks for the entire SI project and consequently degrades the productivity and quality of the project. Furthermore, if various stakeholders or decision makers have very different preferences for design templates, there are too many changes in requirements or too many requests for changes, thereby delaying the project. Therefore, to provide optimal UI/UX services that satisfy user requirements in line with recent trends, it is vital to first identify the difficulties and problems of UI/UX development for front-end service providers and SI practitioners, who are the main agents of collaboration. This is because difficulties and problems in UI/UX development are likely to become major risk factors for SI projects.

Despite the numerous studies on UI/UX, research on collaboration systems between front-end service providers and SI practitioners for UI/UX development is insufficient. Moreover, although studies have presented reference models for UI/UX development and guidelines in terms of the UI/UX development process, these are only general software development methodologies for SI practitioners or focus on UI/UX tasks for only front-end service providers. There is therefore an urgent need for research on task procedures based on collaboration between the organizations of two stakeholders and the research for models and procedures at the IT project management level.

This study derived risk factors in UI/UX development through a questionnaire, identified the characteristics of major risks through analytical techniques and expert opinions, and designed an optimized UI/UX development model based on a collaboration system that can reduce or mitigate risk.

The various analytical results of this study and the proposed collaboration process can provide a basis for enhancing collaboration systems when planning and implementing UI/UX projects or SI projects with a high proportion of UI/UX development. In addition, the findings and proposed process can also be used as indicators for practical judgments. Therefore, this study not only contributes to enhancing the rational collaboration systems for SI performers and front-end service providers in UI/UX service development projects but also provides a theoretical basis for the inherent risks in UI/UX development, thus enabling the establishment of preemptive risk prevention strategies. This will ultimately help firms provide high-quality UI/UX services more effectively and quickly in response to customer needs, thereby significantly contributing to improving business satisfaction.

Section 2 describes the preliminary research on the characteristics and development methodology of UI/UX development and then describes previous literature. Section 3 outlines the research procedure and survey process for the various problem factors in UI/UX development. Section 4 describes the analytical results of UI/UX development risk factors and correlation and regression analysis results for major risk factors, and then, proposes a collaboration-based improvement process reflecting the analytical results. Finally, Section 5 concludes the study.

2. Preliminary Research

2.1 Changes in UI/UX Development Model and Development Methodology

This study discusses the environmental characteristics of UI/UX development and examines the related research to accurately investigate the concepts of the waterfall model, the most widely used development methodology, the recently-introduced agile model, and the lean startup-based UX process, which is applied to the improved process here.

2.1.1 UI/UX development model

The Agile methodology was introduced in mid-2000 primarily in web-based service companies; however, it is only known through typical success cases and has insufficient diffusion among a wide range of UX overall. Most SI projects require step-by-step outputs following sequential development. Moreover, the vertical development of organizational systems of companies makes it difficult to apply lightweight development methodologies. The standard process for UI/UX development comprises processes goal definition to project planning, requirement definition, design and implementation, testing, distribution, and management are defined as follows [4,5].

In the goal definition stage, the goals and scope of the UI/UX development are defined and reflected in the overall project plan. In the project planning stage, the needs of the expected target audience are defined in the form of a profile, after which a UX differentiation strategy is established based on market conditions and user survey results. In the requirement definition phase, personas, which are "users with common experience characteristics", are defined for user analysis, and their behaviors, motivations, needs, and attitudes are defined. In addition, through a to-be model, a conceptual model is defined for visualizing and examining how users can use a system. After examining the collected requirements, a representative screen is designed, and then, a mood board or draft is created to describe the visual concept of the screen design. In the design and implementation stage, the detailed design stage is conducted based on the UI design draft, and a full-page screen is designed using a GUI style guide and template design. In the testing stage, a plan for evaluating the usability of the software is established; test scenarios and cases are created, and actual usability tests are conducted based on the test plan. In the distribution and management stages, a manual creation guide for software distribution and management is developed. Feedback is continuously collected to implement improvements in the distributed software.

2.1.2 Agile and Lean methodologies

When a problem is discovered, the waterfall process [1,6] returns to the stage that caused the problem and the task is performed again. This requires extensive resources and time for modifications when requirements change. To address these disadvantages, in 2001, Kent Beck and 16 others presented the agile methodology through the agile manifesto [7]. The agile methodology values each individual member and the interactions between them, the implemented software, and cooperation with users. It is a software development methodology that places more value on changing plans than on adherence to plans. The development stage is divided into several segments; whenever one stage is completed, it is immediately opened, and this process is repeated until the entire development is completed [8]. After developing a software run through quick releases, customers can provide feedback and suggestions for improvements while viewing the work output. This agile-based UI/UX development method places a psychological burden on designers to present unfinished work output to customers. Lean UX methodology was proposed to remove wasteful elements of the UX methods originating from this traditional methodology, formulate hypotheses from faster investigations, and launch a minimum viable product (MVP) to the market based on these hypotheses. It is essentially a cyclic process of planning, production, and measurement. The lean startup UX process originating from the competitive environment of startups is a cyclic learn-build-measure process. It was designed to quickly achieve maximum efficiency in a startup environment, which contains uncertainty [9]. The key to the lean startup UX process is to measure user responses and swiftly make the next product by reflecting these results. Another lean UX application methodology is lean UX comprising the cyclic think-make-check process presented by Cooper [10]. In addition, Gothelf [9] proposed a lean UX methodology-based process that comprises a cyclic assumption publication-MVP production-test-feedback process.

2.2 Previous Research

Previous studies on UI/UX primarily focused on proposing efficient collaboration methods and procedures. First, in terms of previous research on efficient UI/UX development based on collaboration methods, Lee [11] defined four conceptual changes in moving the existing UX process to agile-based UX and argued for the necessity of openness in UX design processes and the ability to collaborate with developers. Kikitamara and Noviyanti [12] presented a specific collaboration process to integrate the UX process into Scrum, an agile process framework. Because it is difficult to develop and verify new designs within a single sprint in Scrum, the researchers proposed a track progress format in which design and development parts run in parallel after the sprint “0” stage. A more comprehensive UX integration framework was proposed based on the processes presented by Pillay and Wing [13]. Its main feature is that the project’s UX vision is shared with all team members so that the team does not lose sight of the big picture as the project progresses through the validate, sketch, present, and critique stages. Kim and Lee [14] created a toolkit that enables designers, developers, and planners to effectively use the lean UX methodology and communicate quickly and easily in a startup environment, which requires fast and close collaboration. Nudelman [15] presented UX communication strategies for introducing lean UX to enable success even in large organizations with a distributed environment. In contrast, Bruun et al. [16] regarded defining clear roles for UX experts as a more important factor in integrating UX processes into the agile methodology. Kashfi et al. [17] conducted interviews to investigate the difficulties faced by organizations when integrating UX principles and practices into the existing development processes and presented findings on risks that companies should avoid and lessons learned in terms of changes due to integration.

In a study on improving UX processes, Ohashi et al. [18] presented a two-step procedure using metrics that enables even non-experts of UX to identify the importance and characteristics of UX-related requirements to derive effective points of improvement. Cheng [19] presented the mobile app usability inspection (MAUi) framework for verifying the suitability of the MVP, which is a key element of the verification stage of lean UX, and proposed a verification checklist. Lee and Lee [20] analyzed the use cases of lean UX of Korean mobile app developers and presented a lean UX process for minimizing failure factors. Kim [21] presented limitations and strategic utilization methods when introducing lean UX and lean processes in large IT companies. In a study on the quality measurement and evaluation stage of UX, to raise the awareness of UX quality measurements, which had been often ignored in the past, Law et al. [22] emphasized the necessity of UX modeling based on theories linked with empirical quality, as well as developing and distributing high-quality measurement tools. Studies on user-centered design according to usability analysis in various newly emerging services can also be examined. Liew et al. [23] investigated the effects of the voice avatar service in e-commerce and found higher levels of non-preference in female users than in male users. Shtykh and Jin [24] emphasized that an essential part of information search activities in user-centrism is considering not only the individual scope of the user but also expanding this to the user's community. Leftheriotis et al. [25] investigated the collaborative usability of multi-users on large displays and proposed a design method based on multi-touch interaction.

As examined above, to provide high-quality UI/UX services, researchers have been studying close and flexible processes and organizational operation for swiftly responding to market and customer requirements. These methods relate to the necessity for a near real-time collaboration system across all stages of the development process, including planning, design, and distribution. Moreover, industry practitioners are also devoting efforts to maximizing the collaboration and reducing wasteful elements in existing UX development processes by introducing flexible agile methodologies and the value of interactions. However, research on development models that mitigate risks and problems in the development process in terms of collaboration to support successful mobile UI/UX development is still insufficient.

This study recognizes UI/UX development as an SI project in a large framework, derives problems inherent to collaborative UI/UX development projects, employs statistical techniques to determine the root causes of these problems, and then, applies a risk management approach to solve them. The importance and relationships of the risks derived through this process are then analyzed, and a collaboration-based UI/UX development model based on causal relationships between the risks is derived. This approach has never been attempted thus far. The proposed collaboration process can provide a basis for enhancing collaboration systems when planning and implementing SI projects in which UI/UX development is important. In addition, the findings and proposed process can also be used as an indicator for practical judgments.

3. Research Procedure and Questionnaire

3.1 Research Procedure

To increase the success rate of UI/UX development, this study derives important risk factors distinct from general SI projects that practitioners must strategically manage and analyzes these results to provide collaboration processes that must be strategically managed or improved. Thus, the objectives of this study are to derive the risk factors of UI/UX development projects and analyze characteristics of risks to propose a collaboration-based development process that can minimize these risks. To this end, as shown in Fig. 1, risk factors in the UI/UX development process are selected from risk factors of IT projects, and the major risk factors are extracted. For each risk factor, the risk is classified through factor analysis, and for each classified risk, the importance of each risk factor is evaluated. Exploratory factor analysis, reliability analysis, and correlation analysis are also performed, and for the correlations of major risk factors, their causal relationships are defined through regression analysis. The analytical results are then combined to measure the effectiveness of each factor and the core common risk groups in the UI/UX development stage, and procedures or techniques for mitigating or eliminating each risk are presented.

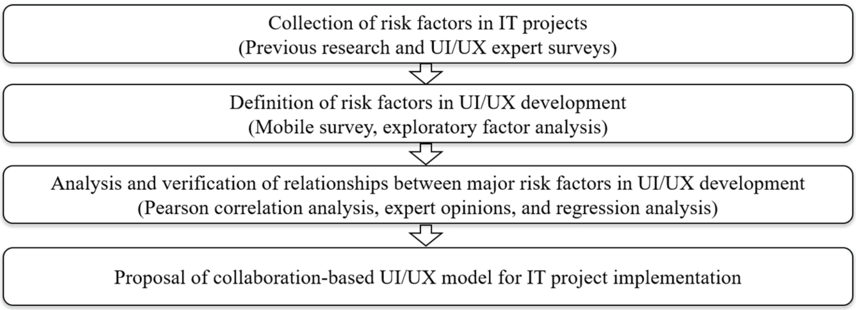

Fig. 1. Research process.

3.2 Risk Factor Collection

Because UI/UX development is performed based on SI projects, this study utilized the findings of research on risk management for SI projects. Accordingly, UI/UX risks are extracted from the risk factors of IT projects derived in the research of Kim [26,27]. Kim collected 520 risk factors from 77 related studies and derived 131 risk factors from these through a classification process based on expert opinions. This study utilizes these results for risk factors inherent in UI/UX development.

3.3 Survey of Risk Factors in UI/UX Development

A group of Korean UI/UX experts completed a questionnaire on problem factors in UI/UX development, through which the major risk factors were derived. The questionnaire comprised 117 questions based on project risks and process characteristics in UI/UX development. The impact of each risk factor on UI/UX development was rated on a 7-point Likert scale. The questionnaire was administered online to the employees of a Korean digital agency, UI/UX consultants, and SI developers who have primarily collaborated with digital agencies. As a result, a total of 45 questionnaires were collected. In terms of survey participant composition, digital agency employees comprised 40% of the participants, SI company employees 42%, and general company employees 13%. In terms of work experience, at least 71.1% of the participants had 10 years of experience or more, indicating that many long-time practitioners participated in the survey. In terms of field of work, 46.7% were business managers or project managers, 20% were planners, and 22% were designers. Table 1 shows details of the participant composition.

Table 1. Survey participant composition

Category	Sub-category	Number (%)
Company type	SI developer	19 (42.2)
	Digital agency	18 (40.0)
	UX-specialized company/consulting	1 (2.2)
	General company/other	6 (13.3)
	Freelance contractor	1 (2.2)
Field of work	Business manager/project manager	21 (46.7)
	Planner	4 (8.9)
	Designer	9 (20.0)
	Developer/publisher	10 (22.2)
	Other	1 (2.2)
Years of experience	Less than 5 years	5 (11.1)
	5 to less than 10 years	8 (17.8)
	10 to less than 15 years	11 (24.4)
	15 to less than 20 years	18 (40.0)
	20 years or more	3 (6.7)

4. Collaboration-Based UI/UX Development Model

4.1 Analysis of Risk Factors in UI/UX Development and Reliability Analysis

To identify the major risk factors recognized as the highest risk factors in UI/UX development, the averages were first analyzed. The average score of all risk factors was 5.15 out of 7. Table 2 lists the top 10% items with the highest risk factors in order of the highest score, the average of which is 5.99 out of 7. The areas of IT project management include communication management, stakeholder management, scope management, change management, and human resource management. UI/UX experts regard communication management as the greatest risk factor in development. In particular, they highly emphasized the input of PMs with suitable project capabilities for minimizing risk factors during the planning stage. An exploratory factor analysis was performed to reduce the large number of risk factors in UI/UX development derived from the expert survey and extract the important common factors. Under the premise that there is no correlation between the factors, principal component analysis was conducted using varimax factor rotation to ensure no problem of multicollinearity between the factors arose. This study only selected questioned items with an eigenvalue of 1 or more and a factor loading (item weight) of 0.4 or more. As a result, a total of 26 common factors were extracted. These were limited to common factors with 3 or more measurement variables, and a common factor analysis was performed. As shown in Table 3, a total of 13 major risk factor groups were derived. For each common factor group, a new risk name to represent the measurement variable was defined, and codes were assigned. In addition, Cronbach' α for each of the 13 common factors was derived, and the reliability was analyzed.

R1 was 0.954, R2 was 0.913, and R3 was 0.900, indicating very high reliability. Generally, a Cronbach' α value of 0.6 or more indicates that the variables constituting the factor are reliable and that they accurately represent the factor. As such, all 13 derived risk factors were highly valid in terms of reliability. This value can also be utilized as a weight for each risk factor in practical terms.

Table 2. Top 10% items with highest average risk factors in UI/UX development

Item #	Average	Survey description	Management area
Q4	6.29	Excessive changes in requirements and implementation scope can be a risk factor in UI/UX development.	Scope
Q32	6.2	Ambiguous and inconsistent requirements can be a risk factor in UI/UX development.	Scope
Q45	6.16	Insufficient communication with stakeholders can be a risk factor in UI/UX development.	Communication.
Q85	6.16	Inappropriate PM and leader input in the project can be a risk factor in UI/UX development.	Human resource
Q56	6.07	Misinterpretation of customer requirements can be a risk factor in UI/UX development.	Communication
Q36	6.02	Insufficient communication within the project implementation team can be a risk factor in UI/UX development.	Communication
Q77	5.89	Insufficient decision-making abilities of decision makers can be a risk factor in UI/UX development.	Communication
Q38	5.84	Performing development with undefined requirements can be a risk factor in UI/UX development.	Scope
Q54	5.82	A large number of stakeholders can be a risk factor in UI/UX development.	Stakeholder
Q62	5.82	Poor project change management can be a risk factor in UI/UX development.	Change
Q103	5.8	Excessive changes due to the power of suppliers or customers can be a risk factor in UI/UX development.	Stakeholder
Q109	5.8	Conflicting customer requirements can be a risk factor in UI/UX development.	Scope

4.2 Correlation Analysis between Risk Factors in UI/UX Development

To identify major risk factors recognized as the highest risk factors in UI/UX development, the averages were first analyzed. To examine the scope of the most important factors required for UI/UX development projects, a scree-test was conducted using the eigenvalues. As a result, R1, R2, R4, R3, R6, and R7 were derived as shown in Fig. 2. To investigate the relationship between the major risks derived through exploratory factor analysis, Pearson correlation analysis was performed on the six major risks, the results of which are shown in Table 4. Generally, a correlation coefficient of 0.3 or more indicates a correlation between variables. A value of 0.9 or more indicates a "very high correlation" between the variables, 0.7 to less than 0.9 indicates a "high correlation", 0.4 to less than 0.7 shows a "somewhat high correlation", and 0.2 to less than 0.4 indicates a "low correlation". R1 and R2 were shown to be highly correlated at 0.702.

Table 3. Varimax principal component analysis and reliability analysis results

Code	Risk name (redefined)	Description	N	Question #	Weight factor	Cronbach' α	Eigen-value	Variance explanation power (%)
R1	Insufficient basis for overall project planning and implementation	Risks due to overall inadequacies throughout the project planning and development phases, such as project planning/ security/implementation environment/infrastructure platform, insufficient management interest and strategic support/unstable collaborative environment /erroneous contracts	24	Q72	0.809	0.954	13.379	11.435
				Q101	0.798			
				Q59	0.773			
				Q60	0.771			
				Q81	0.719			
				Q70	0.715			
				Q73	0.710			
				Q90	0.670			
				Q65	0.635			
				Q92	0.622			
				Q98	0.589			
				Q29	0.571			
				Q74	0.557			
				Q68	0.554			
				Q76	0.539			
				Q83	0.496			
				Q69	0.487			
				Q39	0.458			
				Q61	0.454			
				Q99	0.434			
				Q67	0.431			
				Q107	0.419			
				Q41	0.410			
				Q82	0.409			
R2	Insufficient project leadership due to inadequate knowledge management	Risks due to insufficient knowledge and experience management of the organization and insufficient leadership and work performance due to inadequate information sharing/utilization	10	Q85	0.745	0.913	7.841	6.702
				Q87	0.680			
				Q111	0.674			
				Q110	0.635			
				Q108	0.629			
				Q100	0.602			
				Q54	0.551			
				Q88	0.541			
				Q77	0.508			
				Q53	0.488			
R3	Lack of standard processes and insufficient project control	Risks due to inefficient control resulting from inadequate standardization (processes, technologies, information standards, low quality standards, culture)	9	Q33	0.827	0.900	6.379	5.452
				Q23	0.603			
				Q56	0.587			
				Q34	0.579			
				Q89	0.568			
				Q91	0.521			
				Q94	0.496			
				Q15	0.490			
				Q44	0.449			

Table 3. (Continued)

Code	Risk name (redefined)	Description	N	Question #	Weight factor	Cronbach' α	Eigen-value	Variance explanation power (%)
R4	Inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams)	Risks due to constantly changing requirements resulting from inadequate stakeholder coordination and process control due to insufficient expertise (technology, experience, process, inappropriate teams)	8	Q8 Q24 Q9 Q55 Q38 Q10 Q12 Q104	0.843 0.809 0.720 0.694 0.685 0.599 0.531 0.474	0.897	7.333	6.268
R5	Insufficient information (vision) regarding the business, low customer loyalty for the organization, insufficient work capability, and high resistance to change	Risk of delays in deriving accurate and specific requirements due to low customer member loyalty to the organization, insufficient work capability, and inadequate input information for defining requirements and resistance to change	8	Q115 Q64 Q51 Q47 Q114 Q46 Q112 Q66	0.828 0.634 0.581 0.480 0.445 0.421 0.419 0.414	0.862	4.712	4.027
R6	Application of inappropriate new technologies and information systems	Risks due to the application of unfit information technologies (interconnections / new technologies/multiple providers/process, etc.) and the indiscriminate adoption of service trends that do not fit the organizational culture	7	Q14 Q22 Q13 Q17 Q5 Q97 Q113	0.849 0.793 0.761 0.685 0.514 0.491 0.460	0.883	6.061	5.181
R7	Unfair performance measurement and allocation	Risk of performance and compensation arising from inadequate measurement procedures and unclear evaluation criteria for performance	5	Q50 Q43 Q49 Q42 Q102	0.865 0.837 0.637 0.636 0.420	0.833	5.836	4.988
R8	Team conflicts and lack of communication	Risk of degraded work competitiveness due to various types of conflicts and unfit communication methods within the customer company	5	Q25 Q36 Q40 Q35 Q37	0.768 0.594 0.479 0.416 0.411	0.859	3.496	2.988
R9	Inaccurate business scope and resource forecasting	Risks due to unclear development strategies and inaccurate budget, schedule, personnel/work requirements in project planning	4	Q26 Q7 Q75 Q31	0.881 0.745 0.501 0.403	0.791	4.454	3.807
R10	Excessive size/schedules/work complexity/ stakeholders	Risk of management and control due to excessive project size/complexity/ schedule management/ stakeholders in the implementation	4	Q1 Q3 Q2 Q6	0.899 0.627 0.574 0.536	0.764	3.962	3.387
R11	Products or services that do not meet customer requirements	Risk of unclearly defined customer intentions and requirements due to insufficient participant motivation and interest	3	Q96 Q95 Q86	0.778 0.753 0.535	0.811	4.400	3.761
R12	Insufficient systems and procedures that can reflect customer requirements	Risk due to lack of work processes or change procedures that can implement changes reflecting requirements and work characteristics by users	3	Q57 Q62 Q20	0.741 0.642 0.542	0.662	3.196	2.731
R13	Ambiguous project vision and R&R definition	Risk of internal conflict due to inadequate presentation of organizational strategic vision and inappropriate definitions of roles	3	Q11 Q30 Q52	0.730 0.568 0.442	0.772	3.031	2.590

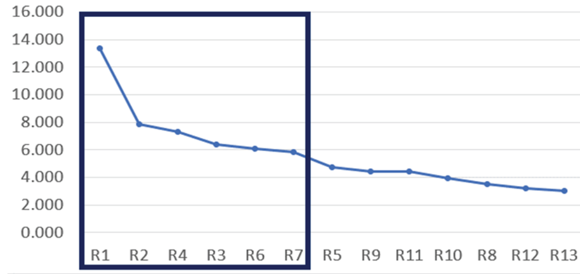

Fig. 2. Scree table graph using eigenvalues.

Table 4. Results of correlation analysis between risk factors

Code	Eigen-value	R1	R2	R4	R3	R6	R7	R5	R9	R11	R10	R8	R12	R13
R1	13.379	1												
R2	7.841	0.702**	1											
R4	7.333	0.424**	0.461**	1										
R3	6.379	0.605**	0.525**	0.610**	1									
R6	6.061	0.323*	0.150	0.223	0.327*	1								
R7	5.836	0.523**	0.532**	0.309*	0.346*	0.140	1							
R5	4.712	0.611**	0.511**	0.523**	0.613**	0.167	0.401**	1						
R9	4.454	0.519**	0.383**	0.529**	0.600**	0.227	0.436**	0.476**	1					
R11	4.400	0.474**	0.538**	0.384**	0.477**	0.141	0.515**	0.404**	0.468**	1				
R10	3.962	0.213	0.218	0.402**	0.315*	0.378*	0.046	0.115	0.095	0.122	1			
R8	3.496	0.594**	0.521**	0.498**	0.570**	0.126	0.426**	0.538**	0.525**	0.429**	0.134	1		
R12	3.196	0.444**	0.299*	0.371*	0.447**	0.216	0.290	0.558**	0.238	0.276	0.031	0.453**	1	
R13	3.031	0.527**	0.420**	0.480**	0.504**	0.044	0.440**	0.658**	0.591**	0.443**	0.012	0.569**	0.505**	1

*$p<0.05$, **$p<0.01$.

4.3 Test of Differences by Experience, Work Type, and Company Type

A Kruskal–Wallis non-parametric test was performed to identify differences by experience, work type, and company type for the 13 factors. For the analysis, years of experience were classified into “5 years or less”, “5 to less than 10 years”, “10 to less than 15 years”, “15 to less than 20 years”, and “20 years or more”. Work types were classified into “developer/publisher”, “planner”, “designer”, “business manager/ project manager”, and “other”. Company types were classified into “SI developer”, “digital agency”, “general company/other”, and “freelance contractor”. Generally, a p-value of less than 0.05 indicated a significant difference. According to the analysis, in the average difference test according to experience, although the p-value of R6 was the lowest, it was still greater than 0.05 at 0.113. In the difference test according to work type, the p-value of R1 was the lowest, although it was greater than 0.05 at 0.096. In the difference test according to company type, the *p*-value of R10 was the lowest, although it was greater than 0.05 at 0.109. The main causes of R10 are scope, schedule, business complexity and stakeholder management. These are all perceived as inherent risks for IT projects.

According to Kim [27], this inherent risk is highly related to project planning, project implementation, and project technology risk. Therefore, it can be seen that R10 has the smallest difference between industries than other risks, but is recognized as a major risk in all industries. Therefore, there were no significant differences found in the perception of risk factors for all items by experience, work type, and company type.

4.4 Regression Analysis of Major Risk Factors

A regression analysis was performed to analyze specific methods in terms of how processes should be improved for the major risks derived from the correlation analysis. First, the development stage was based on the UI/UX standard development framework, as specified in Section 2.1.1 of the preliminary research. However, there was an expert opinion that in order to clearly distinguish the causality of risk factors related to UI/UX development, it is necessary to group steps according to similarity of work. Therefore, the goal definition stage, project planning stage, and requirements definition stage of the UI/UX standard development framework were grouped into project planning stages, and later unified into the design and implementation stage with significant SI development characteristics; the testing stage and distribution and management stages were excluded. The experts were then asked to map six risks to each of the planning, design, and implementation stages, after which the risks regarded to have a causal relationship were connected by lines. The risks were then marked for each stage as shown in Table 5.

Table 5. Mapping between risk factors by UI/UX development stage and stage of occurrence

Code	Risk	UI/UX development stage	
		Planning (α)	Design and implementation (β)
R1	Insufficient basis for overall project planning and implementation	●	●
R2	Insufficient project leadership due to inadequate knowledge management	●	●
R4	Inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams)	●	●
R3	Lack of standard processes and insufficient project control	●	●
R6	Application of inappropriate new technologies and information systems		●
R7	Unfair performance measurement and allocation	●	

Next, to mathematically verify the accuracy of the mapping information of causal relationships based on expert opinions, regression analysis models were designed, as shown in Table 6.

As the planning stage takes place before all UI/UX development, all factors shown in the planning stage are causative factors in the regression analysis, i.e., independent variables. For example, assuming that the regression model is designed based on risk R2 in the implementation stage, the regression model checks how risk R2 in the implementation stage is related to risks R1, R2, R4, R3, and R7 in the planning stage. This was simplified for the purposes of this study. The regression models are expressed as {H1:α.R1→β.R2}, {H2:α.R4→β.R2}, {H3:α.R4→β.R2}, {H4:α.R3→β.R2}, {H5:α.R7→β.R2}. The arrow (→) indicates the direction of the causal relationship; the risk factor to the left of the arrow is the independent variable of each regression model, and that to the right is the dependent variable. Thus, hypothesis H1 means "risk R1 in the planning stage causes risk R2 in the implementation stage". The regression models {α.R2↔β.R6}, {α.R4↔β.R6}, and {α.R7→β.R6} were excluded during design, reflecting the relationships of {R6, R2}, {R4, R6}, and {R6, R7} which showed low significance based on the correlation analysis results in Table 4. Table 6 shows the results of regression analysis using the final derived regression models. Model 12 {R7→R4}, Model 16 {R7→R4}, Model 17 {R7→R4}, and Model 18 {R7→R4} exhibited p-value significance levels less than 0.05, and the *p*-values of the other models were all less than 0.01. This demonstrates that the derived risks have very high causal relationships, indicating that the expert opinions are statistically significant and that there are no problems with the regression model. Furthermore, due to the nature of regression models, their inverse models are also significant, which means that there is a causal relationship between the risk factors. Through these analytical results, risk factors with a causal relationship can be more clearly identified in collaboration-based UI/UX development projects. Due to these strong causal relationships, by investigating alternatives for avoiding or mitigating risks in UI/UX development reflecting these findings, an optimized collaboration process for UI/UX development in SI projects can be developed.

Table 6. Correlation test results for each risk factor through regression analysis

Model	Analysis path		Path coefficient					Durbin–Watson	Regression model		Remarks
	Independent variable	Dependent variable	B	β	S.E.	*p*-value	Adj. R^2		*F*-value	*p*-value	
1	F2	F1	0.781	0.702	0.121	0.000	0.492	1.915	41.666	0.000	Inverse model of model 5
2	F4		0.393	0.424	0.128	0.004	0.180	1.562	9.428	0.004	Inverse model of model 9
3	F3		0.610	0.605	0.123	0.000	0.365	1.802	24.762	0.000	Inverse model of model 13
4	F7		0.435	0.523	0.108	0.000	0.274	1.554	16.217	0.000	
5	F1	F2	0.630	0.702	0.098	0.000	0.492	1.994	41.666	0.000	Inverse model of model 1
6	F4		0.384	0.461	0.113	0.001	0.213	1.777	11.613	0.001	Inverse model of model 10
7	F3		0.476	0.525	0.118	0.000	0.275	2.137	16.335	0.000	Inverse model of model 14
8	F7		0.397	0.532	0.096	0.000	0.283	1.949	16.962	0.000	
9	F1	F4	0.458	0.424	0.149	0.004	0.180	1.740	9.428	0.004	Inverse model of model 2
10	F2		0.554	0.461	0.163	0.001	0.213	1.877	11.613	0.001	Inverse model of model 6
11	F3		0.665	0.610	0.132	0.000	0.372	1.743	25.479	0.000	Inverse model of model 15
12	F7		0.277	0.309	0.130	0.039	0.096	1.950	4.540	0.039	
13	F1	F3	0.599	0.605	0.120	0.000	0.365	2.365	24.762	0.000	
14	F2		0.578	0.525	0.143	0.000	0.275	2.621	16.335	0.000	
15	F4		0.560	0.610	0.111	0.000	0.372	2.127	25.479	0.000	
16	F7		0.285	0.346	0.118	0.020	0.120	2.219	5.845	0.020	
17	F1	F6	0.353	0.323	0.158	0.031	0.104	2.511	4.998	0.031	
18	F3		0.361	0.327	0.159	0.028	0.107	2.541	5.152	0.028	

4.5 Discussion of Collaboration-Based Improvement Model Reflecting Analytical Results

A total of 13 risk factors were derived through a factor analysis and reliability analysis of major risks in UI/UX development, and their weights were derived through a correlation analysis. In addition, through a scree test, this study analyzed and verified the causal relationships between 6 major risks in planning, design, and implementation in UI/UX development. Based on this, a collaboration-based improvement model for UI/UX development is proposed that can provide high-quality services and reduce risks in UI/UX development when conducting SI projects.

4.5.1 Informatization strategy planning in UI/UX sector through UI/UX experts

According to the top 10% average values of the risks in Table 2, the greatest risks in UI/UX development include not only communication issues between stakeholders, customers, and project teams, but also insufficient decision-making ability of decision makers and other risks in communication management. In addition, according to the principal component analysis and reliability analysis results of the risk factors in Table 3, the largest risk factors were identified as follows: insufficient basis for overall project planning and implementation in the planning stage (R1), insufficient project leadership due to inadequate knowledge management (R2), inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams) (R4), and lack of standard processes and insufficient project control (R3). Accordingly, to mitigate risks in the planning stage, which is the initial stage of SI projects, risks must be resolved during the stage of establishing the organization's informatization strategy, which takes place before implementing the SI project. To establish an informatization strategy at the organizational level, however, an informatization strategy plan (ISP) or informatization strategy master plan (ISMP) is generally implemented before performing the SI project. This determines the organization's informatization vision and strategy, success factors, business scope, and scope of technology and standards. Therefore, it must also include strategies, development technology applications, and standardization directions for UI/UX at the company level. In practice, however, when executing ISP and ISMP projects in most organizations, the UI/UX development department is regarded as a sub-part of the standardization department; as a result, standardization experts rather than UI/UX experts often establish the UI/UX development strategy. Moreover, regardless of whether UI/UX is excluded from or included in the informatization strategy establishment item, it is often performed formally. When performing large SI projects, UI/UX experts are often first input in the analysis and design stages rather than the project launch and planning stages. For these reasons, it is also common for standards managers to make several changes during UX design and implementation through simple planning, with no strategic preparations or specific development direction based on UI/UX or SI project experts. This results in delays and confusion when confirming the UX design template in information system development projects, and after development is completed, this can negatively affect user satisfaction in the information service and efficiency of use. As shown in the analytical results, current procedures cause problems in scope, communication, and stakeholder management in the entire project. There are also a very large causal relationships in the planning and implementation stages for UI/UX development. In practice, at the beginning of large development projects, the UI/UX development standards and prototype development process repeat the planning and implementation stages, which leads to severe project-level problems such as delays in the entire project schedule and the omission of UI/UX standards.

In the conventional waterfall process, the designer was only in charge of creating drafts and prototypes in the analysis and design stages based on screen design, which is the output of the planning stage that reflects customer requirements. However, the role of designers has been recently expanding, necessitating a swift and lightweight UX process customized for customers. That is, roles are changing in which the planner focuses on defining customer requirements and functions, and the designer leads the establishment of the UX vision by directly visualizing the service functions and creating wireframes. A wireframe is a two-dimensional figure [28] of a webpage interface that shows the allocation of space, content prioritization, available functions, and intended behavior. It can be referred to as a visual design of the user experience. UI/UX experts are therefore placed in an environment where planning, design, and design implementation are conducted nearly in parallel with the sequential process of planning, design, and design implementation, and face the challenge of delivering prompt results.

To respond appropriately to these changes in the environment, for SI projects with a large proportion of UI/UX, the UI/UX expert has the authority to establish a vision and strategy for UI/UX when devising the informatization strategy and master plan, and a process that ensures the technology is clearly defined is proposed. Based on this, in the SI project, the UI/UX expert accurately and concretely implements specific requirements within a certain period of time using their authority and influence in the UI/UX field, and by performing usability tests on customers or users, the development outcomes can be clearly verified. In addition to producing highly competitive outcomes that improve both the organization’s UI/UX strategy and usability satisfaction, this also ultimately contributes to the organization’s business competitiveness.

Furthermore, servant leadership for UI/UX is proposed in relation to R2, R4, and F3, which indicate that the PM's leadership and expertise are crucial, and R7, the risk of unfair performance measurement and allocation. When applying the characteristics of servant leadership, the PM of the SI project respects the independence and expertise of the UI/UX expert, based on a clear understanding of the UI/UX strategy and direction at the project level, and promotes fair performance. The servant leader also becomes an assistant who actively supports communication channels to derive UI/UX requirements. The PM can thus prevent delays and confusion in UI/UX development by making swift and accurate decisions and coordinating with stakeholders through servant leadership.

4.5.2 Proposal of collaboration-based model of design/implementation stage in planning

As shown in Table 2, the UI/UX experts regarded communication management among stakeholders, customers, and project team members as the greatest risk, in addition to ambiguous and changing scope management. According to Table 3, the following are also present in the implementation stage and have a causal relationship with the planning stage: insufficient basis for overall project planning and implementation in the planning stage (R1), insufficient project leadership due to inadequate knowledge management (R2), inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams) (R4), and lack of standard processes and insufficient project control (R3). Hence, risks in the planning stage continue to negatively impact the project up to the design and implementation stages. Indeed, inadequate knowledge and experience management in IT project organizations influences the inadequacy of personnel expertise, and personnel with inadequate expertise create a vicious cycle in which they cannot positively contribute to the internalization of knowledge in the organization. As confirmed by the results, insufficient personnel expertise, lack of standard processes, and insufficient knowledge (experience) internalization management are the most prominent risk factors in actual UI/UX development. Even for front-end service providers who are the most well-versed in UI/UX, rather than performing a single SI project externally, they are partners of the SI project in charge of UI/UX. As a result, it is very difficult to apply a collaborative process appropriate for the entire SI development methodology. Most of these providers are small- and medium-sized enterprises who internally face difficulties in fostering expert personnel based on knowledge management due to high turnover and unfavorable management conditions. Thus, a UI/UX collaboration improvement system is proposed which reflects these characteristics of the IT industry to minimize risks in communication management, scope management, stakeholder management, and change management, as well as achieve optimal collaboration with SI project entities from the planning stage.

(1) First, this is a change in the team communication system using the lean UX methodology and agile Scrum implementation principles.

This can be enhanced into a collaborative environment by creating a smooth flow of information and swiftly responding to project changes by shifting to an environment and system of open communication between members. Therefore, improvement measures are proposed using the lean UX methodology and agile Scrum implementation principles.

First of all, key members who make major decisions for each department should be arranged in the same space when performing the project. This enhances the project concentration and makes it easy to share the project status, contributing to empathy in terms of setting priorities and improving colleagues' sense of intimacy from a project risk management-perspective [9]. In addition, the implementation principle of "work output disclosure" can be naturally achieved. This is a key implementation principle in lean UX in which members share their work progress through monitors, whiteboards, post-its, etc. to keep everyone updated regarding the team's progress [9].

The strategic division of Scrum daily meetings is suggested to enable smooth communication between practitioners. Scrum meetings are short daily meetings among project members that last up to 15 minutes [29]. Generally, participants concisely and transparently share their ongoing work with the objective of quickly eliminating problems in their work. Intimate and highly practical communication can be achieved by conducting these meetings in a comfortable atmosphere over short periods of time.

This method therefore provides a number of Scrum meeting rooms within the same time frames and allows members to select and participate in them to maximize the advantages of Scrum meetings. For example, one can specify the same Scrum meeting time and post a clear topic in front of the meeting room, while the members can select a Scrum topic that interests them. This increases participation and interest in the meetings and facilitates exchange of opinions. For Scrum meetings related to UI/UX development, for example, a strategy can be considered that divides them into a Scrum meeting for review and a Scrum meeting for issue resolution. This can address the problem in which the topic of Scrum meetings becomes blurred because of the free sharing of opinions. For more effective UI/UX scrum meetings, the results related to the topic are shown first before conducting the meeting. As such, the use of tools to help participants more accurately and easily understand the content related to the review or issue can be considered. This method can maximize the advantages of autonomy while focusing on functions and problems during a scrum meeting.

(2) Second, knowledge management and collaboration improvement measures using tools are proposed.

The following were risk factors identified throughout the entire software life cycle: insufficient project leadership due to inadequate knowledge management (R2), inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams) (R4), and lack of standard processes and insufficient project control (R3). At their core, they share commonality of insufficient understanding due to communication problems. Therefore, a measure for improving communication methods is proposed that uses tools to make communication between the PM and team members more accurate and easier to understand. Particularly in a collaborative environment, communication and information management based on clear information sharing are essential to attain organizational goals and enhance productivity. Tools can also be utilized to eliminate work inefficiencies due to excessive documentation of project outputs. As a result, knowledge management required for the work processes of collaboration-based projects can be efficiently performed, and knowledge management and utilization using tools based on efficient work performance are essential. However, as indicated by the risk of inappropriate application of new technologies and information systems (R6), it is crucial to ensure that tools appropriate for the organization's goals are introduced.

For example, as a method for smooth knowledge management and communication and efficient documentation in relation to UI/UX development, an issue tracker-based project management tool and collaboration software using a wiki can be considered. These tools enable the production of output required in project implementation in various types of documents and data and can be applied as knowledge assets of the organization or company through viewing and archiving functions based on permission settings. Various prototyping tools have recently been used to collect real-time feedback between customers and team members. Adobe XD provides CASE tools for directly checking CSS code and collecting feedback on prototypes. Prototyping is performed as needed to verify the intentions of UX design. Typically, UX planners and designers judge the suitability of the communication target and development stage and select either a Lo-Fi (fidelity) wireframe or a full-skin Hi-Fi wireframe to create the prototype. Lo-Fi is a simple sketch-based prototype to verify the basic UX design concept and interaction intention. Hi-Fi, a part of the designer creation stage, is a prototype close to the real service that clearly reflects the detailed expression and design vision of UI elements [30].

These diverse collaboration and prototyping tools are utilized for efficient implementation and are vital in SI project execution. Therefore, when establishing an ISP, detailed reviews should be performed according to the goal of introducing the tool while including the UI/UX department. When these prerequisites are met, knowledge management within the project in line with company-wide knowledge management and organizational judgment using this become possible, as well as the ability to determine clear requirements. This can also be utilized for generating reports and work output of various forms which can be shared, ultimately enhancing collaboration and development productivity.

(3) Third, the introduction of two-step design sprint is proposed.

As an improvement measure for the lack of standard processes and insufficient process control (R3), this study proposes the use of a two-step design sprint centered on prototyping. Developed by Google Ventures [31,32], a design sprint is a time-constrained design workshop process with quick decision-making. Even if the waterfall development process is being adopted during project implementation, a design sprint can be partially used based on the analysis, design, and implementation stages. Expertise in UI/UX development can be found in the design and implementation of user experiences optimized for services. The specialized knowledge and experience of UI/UX experts, designers, and front-end developers is essential for implementing high-quality UX. Even if these conditions are met, however, if there is insufficient understanding of the customer's business objectives and direction or of layout, interactions, etc. in terms of application between UX design and key users, then it becomes significantly more difficult to implement high-quality UI/UX services. This is due to the confusion of inappropriate tasks and collaboration required to execute them. This study therefore proposes the introduction of a two-step design sprint using lean UX and Scrum processes. The first step is planning, and the second step is design and implementation. The objectives are divided for each period. In the first step, through business workshops, UX workshops, and user research [33], the development goals, scope, and strategy are clarified, requirements are collected, a design template that reflects the UX vision is determined, and customer approval is obtained. This is repeated in short sprints of approximately two weeks. In the second step, a detailed screen design is implemented according to the design template. This consists of extended sprints of approximately 3 to 4 weeks and is repeated with feedback from usability verification results.

The greatest advantage of this two-step design sprint is that it enables flexible response to changes by dividing tasks into units of sprints. Thus, in step 1, it facilitates response to feedback or customer change requests for establishing the UX design vision, and in step 2, this can be embodied to verify the usability of the detailed screen design using the template determined in step 1.

Second, prototyping can be actively used as communication method to quickly and specifically check customer and user feedback and reduce design errors between project participants. This is a method for analyzing customer requirements based on work output, which is important in agile methodology, as well as an improvement measure that incorporates the advantages of identifying user needs through an MVP, as proposed in lean UX. As such, change requests can be minimized by clearly visualizing the customer's requirements through prototyping. Finally, at the end of the sprint, a retrospective meeting [31] is held based on the outcomes; the scope of the next sprint is defined and opinions on usability and lessons learned are embodied. The objectives of the next sprint are clearly defined through this process, which can reduce the risk of uncertainty and conflicts in future projects. Fig. 3 shows the collaboration-based UI/UX development model including the contents presented thus far.

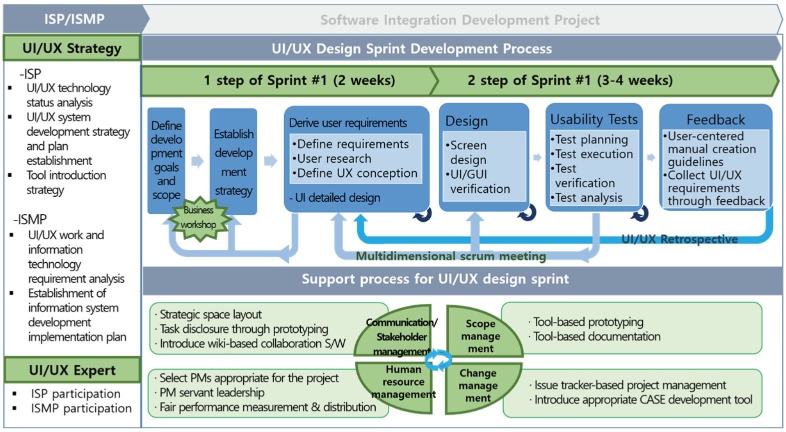

Fig. 3. Improvement model of collaboration-based UI/UX development.

First, before developing the information system, when implementing the ISP/ISMP project, it is necessary to classify the UI/UX into one independent department and input experts to analyze the status of the technology or provide a development strategy or tool introduction strategy. Next, this study proposed dividing the information system development stage into a UI/UX design sprint development process and a support process for managing it. In the first UI/UX two-step design sprint development process, planning is repeatedly performed in the step 1 sprint, and design and implementation are repeatedly performed in the step 2 sprint. Business workshops are also held to clarify the objectives and directions of the software to be developed, and multidimensional Scrum meetings differentiated from conventional meetings are held within each sprint activity. For the process to support the design sprint development process, in terms of communication management, including stakeholder management, this study proposed strategically arranging spaces in an open structure so that key personnel can easily communicate, as well as disclosing tasks through prototyping and introducing a wiki-based collaborative software. Regarding scope management, this study proposed a tool-based prototyping and tool-based documentation and management process. In terms of human resource management, this study proposed selecting PMs with capabilities appropriate for the project, in addition to servant leadership-based project operation considering the characteristics of the front-end service and expertise. Moreover, fair performance measurement and allocation were proposed. Finally, in relation to project change management, this study proposed introducing issue tracker-based project management and appropriate CASE development tools. The four support processes in the project management area must be continuously managed and controlled to ensure smooth UI/UX development in project execution.

5. Conclusion

An attractive user interface design that provides a clear user experience is a key success factor for applications. As such, using UI/UX specialists in SI project implementation, many companies are devoting efforts to enhancing quality in terms of functionality and usability and improving aesthetics to maintain steady usage of the app. However, there are no development processes or standardized methodologies that support efficient collaboration between all project practitioners and UI/UX development organizations for performing SI projects. This study therefore proposed a UI/UX development model based on collaboration with SI practitioners. For this purpose, the risk factors inherent in UI/UX development when performing IT projects were derived, and reliability, correlation, and regression analyses were conducted to present a UI/UX development model optimized for collaboration with SI practitioners. According to the analysis, the main risk management areas were found to be stakeholder management, communication management, human resource management, and change management. In addition, a total of six major risks were derived in relation to these: insufficient basis for overall project planning and implementation in the planning stage, insufficient project leadership due to inadequate knowledge management, inadequate control and coordination of requirements due to insufficient expertise (technology, experience, process, inappropriate teams), lack of standard processes and insufficient project control, application of inappropriate new technologies and information systems, and unfair performance measurement and allocation. To derive improvement requirements to avoid or mitigate risk, a regression analysis was conducted for the derived risk factors to determine their causal relationships, through which specific improvement models and activities were derived. The improvement measures were divided into the ISP/ISMP stage and the information system development stage. This study proposed dividing the information system development stage into a two-step design sprint development process and a support process for managing it. First, UI/UX experts must participate in the establishment of an informatization strategy and master plan, which precedes the informatization development project, and the organization's UI/UX governance strategy should be based on an understanding of the organization's strategy and business characteristics with UI/UX separated into an independent work department. Next, a collaboration-based development model was proposed for informatization development projects, which includes changes in the team communication system such as strategic space layouts, business workshops, and multidimensional Scrum meetings. In addition, this study proposed improvement measures for knowledge management and collaboration using appropriate tools and the introduction of a two-level design sprint, as well as a collaboration-based UI/UX development model that reflects all improvements derived from this study.

With the rising importance of UI/UX services, many studies have presented reference models for UI/UX development. This study is different in that it has expertly analyzed the major risks in UI/UX development and presented a collaborative-based UI/UX development model that can eliminate or mitigate the risks for the six risks that have been finally validated through regression analysis. In addition, a theoretical basis was derived that could be used as a weighting factor for actual project risk management. These findings can also be used as a reference when constructing rational IT project collaboration systems between expert organizations and SI practitioners to apply the existing UI/UX model. Finally, this study provides a basis for research on optimization of UI/UX development methodologies to provide higher levels of front-end services. Meanwhile, future studies will apply the proposed model to actual collaboration-based UI/UX development projects to verify its effectiveness. The effectiveness of the model is expected to be verified by measuring the UX quality before the application of the project and the UX quality after the application. Therefore, quantitative evaluation indicators for UX quality measurements to be applied in this verification procedure will be given first. Furthermore, by analyzing the causal relationships between complex risk factors and presenting an improvement model using the 13 derived risk factors, future research will involve investigating processes for a wider scope of optimized front-end development.

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