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Development of Design Information Framework for Interactive Systems Design

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Abstract

Multi-disciplinary design environment in interactive systems development requires integration and sharing of design knowledge across different disciplinary viewpoints. This research focuses on introducing a common information platform to support consistency and accessibility in design information management over multiple views of design through different phases of the design process. In order to develop the common information platform, Design Information Framework (DIF) is introduced as a shared language that enables designers effectively to organize, generate, evaluate and communicate their knowledge. The evolution history of design information accumulated in the form of DIF can also be readily traceable through the design process. In this regard, DIF functions as an infrastructure that stores all the design knowledge acquired and produced through the design process. The framework also provides an environment in which prototypes or scenarios can be readily created according to their purposes. Through the development of DIF based on theoretical and empirical studies of design processes and knowledge, the followings are achieved: (1) identification of the basic design knowledge elements and relations among them, (2) the representation and modeling of extracted design information, and (3) the implementation of a computer-based design environment that embeds this conceptual framework.

1 Introduction

Research on managing design information has supported increasing design productivity, automating some part of design process, and understanding complex design issues. Communicating among development team members has also become one of the primary concerns in this research area because design requires the integration of multidisciplinary information to satisfy the diverse requirements of interactive systems. Designing even a simple device needs diverse sources of information from different disciplinary viewpoints. As the products are becoming more complex, they deal with a large amount of information flow, and one system consists of multiple products. In addition, as the sophisticated design information structure grows in organizations or business areas, it becomes even more important to create an effective knowledge-intensive design environment that reinforces our capability of accessing, exchanging, capturing and generating knowledge in design activities (Owen 1998 and Veer et al 1995).

What arises are the following issues: how to trace accumulated design information throughout the whole process, how to archive and organize the accumulated design information in an effective form, how to share different viewpoints generated by multi-disciplinary teams, and how to make all design activities coherent throughout the process.

These issues are the primary driving forces of research for the development of DIF. There are several existing research areas related to these issues: knowledge-based design systems which attempt to support automated design decision making, research for design knowledge itself, design rationale to trace reasoning activities in the design process (Moran et al 1996), and framework development for guiding design activities. These frameworks are developed based on the set of elements of design information that is empirically believed to best represent the content of design thinking. This approach is effective for making the quality of design information consistent and sharable among development teams. One of existing examples of frameworks is a format used in Structured Planning method (Owen 1998).

This development attempts to bridge between different

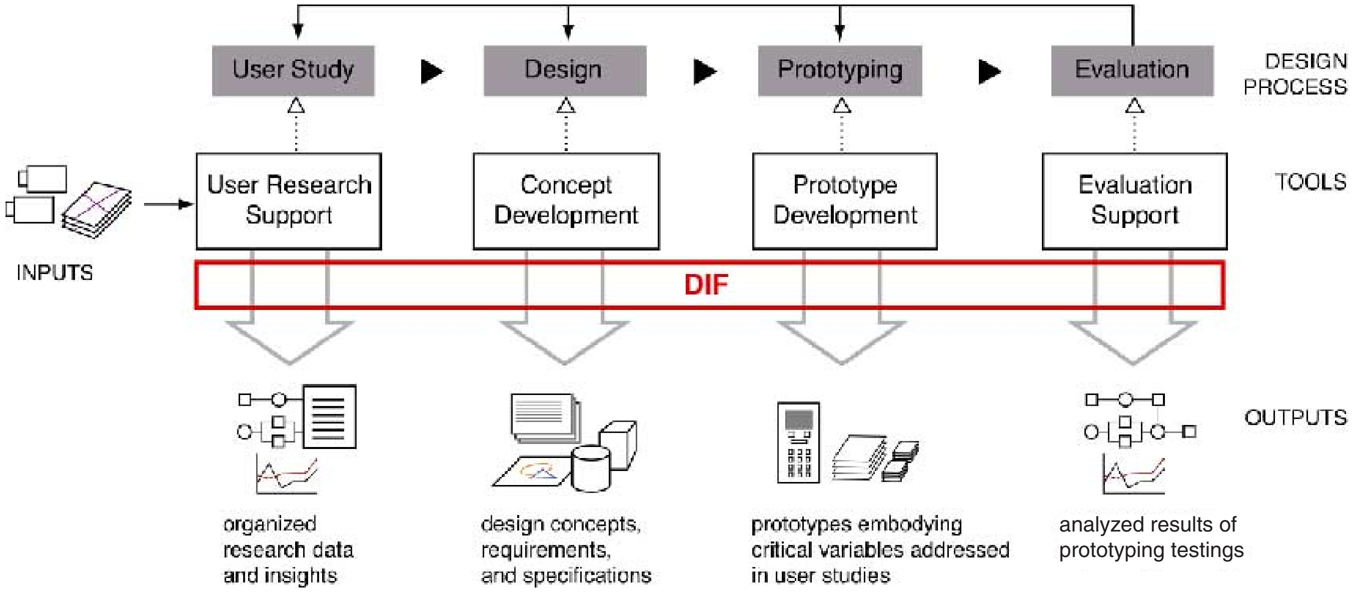

Figure 1 DIF as a foundation through the whole design process

disciplinary viewpoints, different activities in the design process, and different representations of design information by introducing DIF as a common information platform for design activities.

2 Design Information Framework (DIF)

DIF is used as a platform for archiving all accumulated information elements in design activities (Figure 1). To support the effectiveness of the full use of DIF, a computer-based design environment has been developed, embedding DIF as a mechanism for the representation of design information.

Design knowledge can be categorized into two classes. One is fact-based design knowledge that is equivalent to declarative knowledge in the human cognition model, and the other is process-based design knowledge equivalent to procedural knowledge (Coyne et al 1990, 29). This concept provided the fundamentals for organizing design information in DIF. DIF is composed of basic design information elements representing concepts of information commonly used in design. It defines the fact-based design knowledge with the design information elements and the process-based design knowledge with the relationships among the elements.

DIF consists of two different organizations. One is the organization of design information elements that define the nature of each information. The other is the organization of design information primitives that are the basic descriptors of design information such as users, behaviors, objects, and etc. The design information elements can be described by a combination of several design information primitives (Figure 2). For example, the information about user's action that is one of the design information elements can be described by: a user, a behavior that performs the action, objects involved in the action and etc., which are the design information primitives.

Through this organization, DIF provides a foundation for design thinking and design activities such as organizing data from user studies, developing insights, generating design concepts, and prototyping and evaluating design concepts.
It is difficult to enumerate all possible design information elements in DIF. Therefore, DIF should have open structure to accommodate any additional concepts and relations as necessary. In this research, a set of design information elements was introduced as a subset of DIF by focusing on the information of user-system interactions (Figure 2). Through its open structure, new information elements can be added to the predefined DIF, or only necessary information elements can be selected from the DIF. For example, the concepts of functions or performance can be added as design information elements in DIF if they are required for particular design activities.

2.1 Basic Design Information Elements

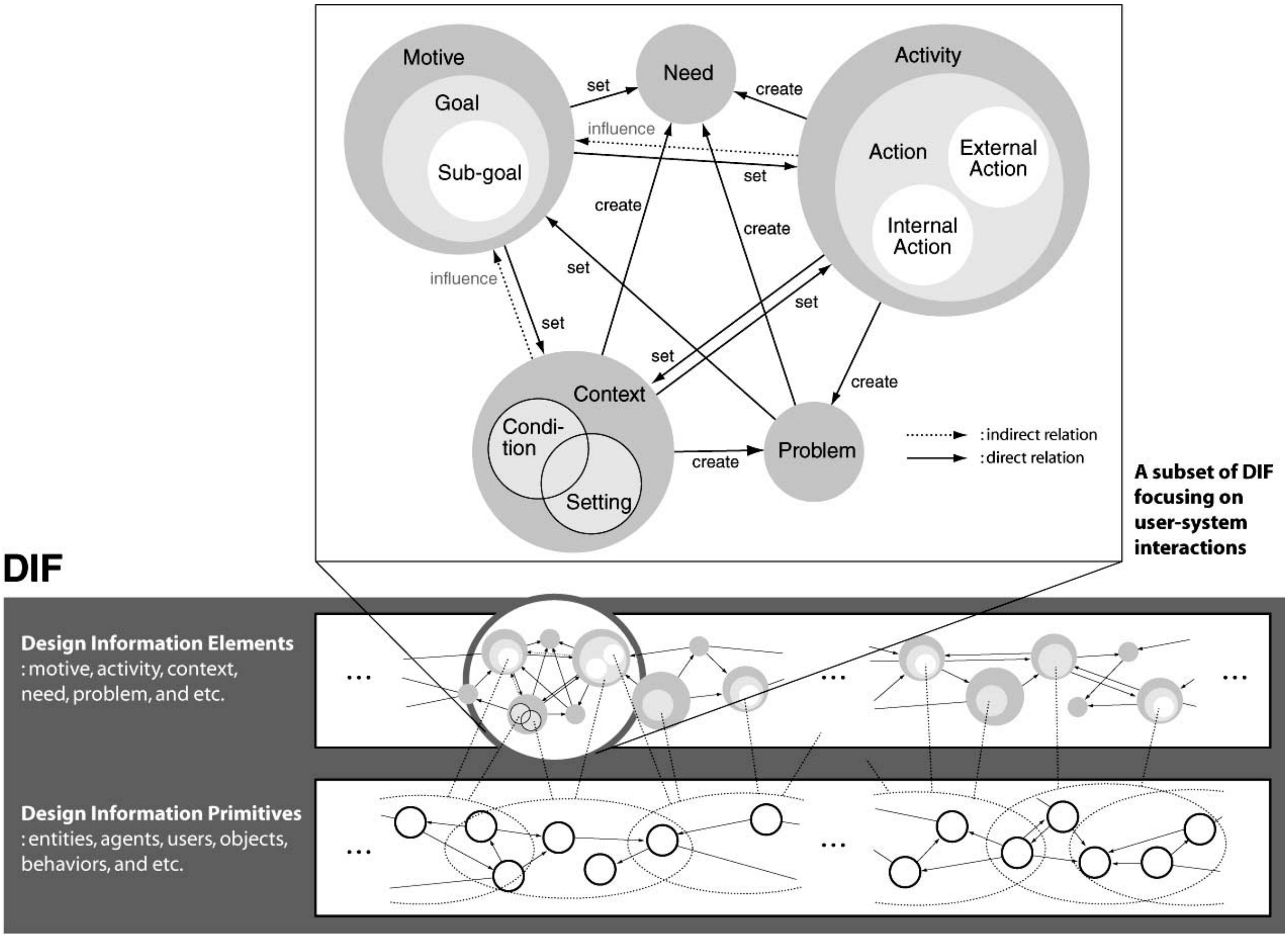

Figure 2 Relationship between the elements and the primitives of design information in DIF

DIF defines what each design information element means and how the elements are related with each other. As Figure 2 shows, one subset of DIF from the case studies consists of the five information elements: user's Motive, user's Activity, Context of use, user's Need, and Problem defined by users. These design information elements are defined as follows.

- Motive: It is the basic need to satisfy users themselves. It is brought out based on users' daily experiences or context. Motive initiates the Activity which is in the highest level. In the sub-level of Motive, Goal is made up to achieve a specific step in the process of using an interactive system (Schank 1977). It changes over situations (the circumstance of a setting). Actions are carried out to achieve Goals.

- Activity: Activities consist of Actions or chains of Actions (Nardi 1996, 30), which in turn consist of External Actions and Internal Actions. It proceeds to satisfy the Motive. Action is what users do with specific objects to achieve a Goal. Actions can be performed by users or systems. External Actions indicate the actions that are expressed externally so that they can be observed like physical actions. Internal Actions indicate the actions that are proceeded internally so that they cannot be observed directly like human mental actions. External Actions and Internal Actions have interactions between each other.

- Context: Context can be described by Setting and Condition. Setting describes some relative positions of objects, the environment where the users is, and etc. (Carroll 1998, 47). Condition is a kind of setting, but it describes detailed situations that affect user's actions in using a system.

- Need: It is what a user wants for system functions. Needs guide Actions toward the achievement of a Goal.

- Problem: It is defined as undesirable states that interfere or obstruct Actions for achieving Goals and Motives.

Design Information Elements		Sources of Information: User Studies		
		Video-Observation only	Observation w/Interview	Interview only
Motive		*Motive cannot be captured directly. It could be inferred by an observer.*	"I received the request for a software project that should be completed in six weeks" *It could be captured by the interview part by asking questions in the use context.*	
Goal			"I need to test the usability of new concept" *It could be captured by the interview part by asking questions in the use context.*	
Activity		"Completing a software project"		*These elements cannot be captured only by the interview because it doesn't capture the use context.*
Action	External Action	"Programming a module", "Arranging a meeting" or "Using operating system commands"		
	Internal Action	*Mental Action cannot be captured directly. It could be inferred by an observer.*	"Realizing that the schedule for meetings should be modified" *It could be captured by the interview part by asking questions in the use context.*	
Context	Setting	"Mary sits in front of the laptop computer in the meeting space. This is the meeting time with his co-workers."		
	Condition	"Three MS Word documents are open, and they all are minimized."		
Need		*These elements cannot be captured directly. They could be inferred by an observer.*	"He wants some kind of an automatic function that shows previously and frequently recorded words when users fill in something into a field."	"I want this bottom part to be more round."
Problem			"John usually forgets the way of writing a certain letter when using Palm Pilot."	"He needs to stir food around a lot to cook well in using this frying pan."

Table 1 Examples of design information elements according to different categories of user study methods and user-system interactions

These elements can be captured and identified through user studies in the design process. There are various kinds of user studies such as video observation, interview-combined observation, and interviews. Each user study method deals with different design information elements. Furthermore, the different categories of user-system interactions such as single user interaction and multiple user interaction also determine what design information elements should be captured. The examples of the design information elements in DIF are shown on the Table 1 according to the different kinds of user studies.

2.2 Basic Design Information Primitives

Each element of information is described by design information primitives. There are ten design information primitives for describing design information elements of user-system interactions. They are critical information factors in all design activities and also for building a design knowledge base. By organizing the information recorded based on DIF, it can be described as various kinds of representation, so it becomes a communicable and sharable resource among development team members and also an organizing mechanism for the design information database. By storing the information elements of DIF into a computer database and automating core operations on the DIF, re-use, manipulation, and trace of previous data can be achieved more readily.

The ten design information primitives are defined as follows.

- Entities: all the elements that include agents, objects, and spaces.
- Agents: the active performers of behaviors or interactions. They include the artifacts that are the part of system components and users for human agents.
- Users: the active human performers of behaviors or interactions.
- Objects: any kinds of Entities that are targets of Behaviors or receive something through the Behaviors.
- Spaces: physical spaces that define areas or three-dimensional spaces involved in the domain of concerns.
- Behaviors: routines performed by Agents.
- Locations: any geometrical positions involved in the domain of concerns.
- Attributes: descriptions of structurally fixed properties

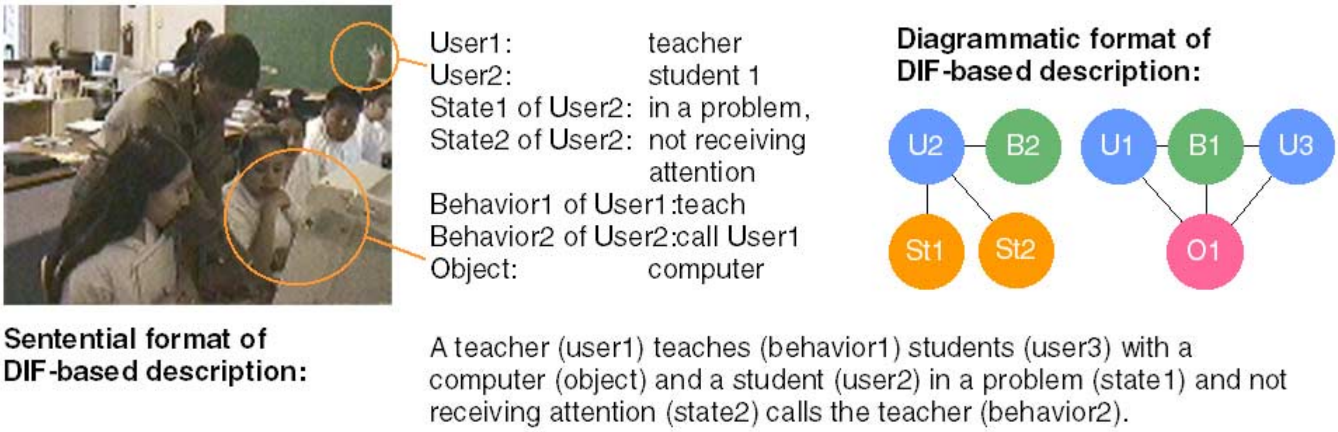

Figure 3 DIF-based description of a user study example

of Entities (Yoshikawa 1987). They can be observed by means.

- States: certain values of Attributes in Entities.
- Time: a period or a moment when an activity is performed, or it could be relational time information such as before, after, simultaneously, and etc.

DIF accommodates different documentation formats, representation methods, and viewpoints of various user study methods. The example in Figure 3 shows several different representation methods of the information with using the subset of DIF about a teacher's activity in a computer-lab classroom. Once the data is recorded in the basic DIF format, they can be translated into other formats of representation such as the sentence format shown in Figure 3. Depending on the nature of the project domain, an appropriate subset of DIF needs to be selected as a project framework in order to best represent the design information within the project.

3 Use of Design Information Framework

DIF provides various functions in design activities throughout the whole design process: creating and integrating aspect models for analysis and synthesis, generating prototypes, and retrieving accumulated design information.

As one of these applications of DIF, it is used as a basic organization to accommodate multiple views or aspect models. For example, a certain situation of a use of a product can be viewed by a state transition-based view or by a behavior-based view. Both of the two different views can be created by using DIF so that they can be combined into a new view. The combined view enriches the range of understanding of the situation of the use. Through this view, the possibilities to generate meaningful insights are increased.

The example in the Figure 4 about using a personal information device represents the location and behavior aspect models (Dix et al 1993 and Kirwan et al 1992). Different kinds of views can be combined with each other so that we can see different kinds of insights from the independent views. Each aspect model works as a filter screening and amplifying some type of information and rejecting others (Sato 1991), so the integration of several different aspects can reveal richer information by showing meaningful relationships among the aspects (Sato et al 2000).

As Figure 5 shows, if the behavior-based aspect model and the location-based aspect model are combined, we can easily see the relationships between the frequencies of user's movements from the sequential behavior flow and the spatial information of the specific behaviors on the device.

Through this result, it may show important insights about structuring interface elements. For example, it could reveal the pattern clearly, which shows that the distance between

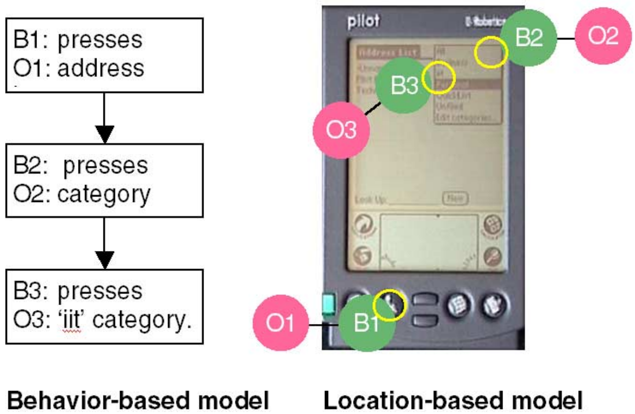

Figure 4 Two aspect models

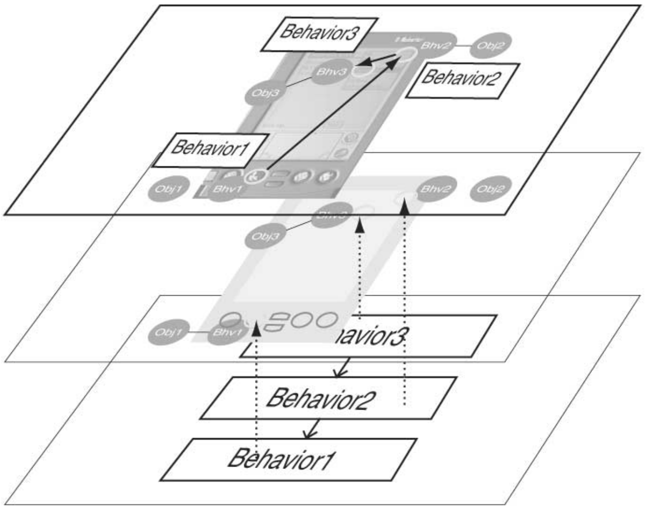

Figure 5 The location-behavior combined view

several specific interface elements are too far although users frequently access to those interface elements in performing sequentially connected tasks.

There are many ways of using DIF as a platform for describing new design concepts. One is to build scenarios to explain the new design concepts. The structure of scenarios is similar to the structure of the descriptions from user studies. Designers need to define who the potential users are, and how the users can interact with new products, and what the possible environment or context would be to construct a scenario of using a new product. Such information can be described based on DIF. Another possible way of supporting design through DIF is to develop aspect models of a new system including commonly used representation or modeling methods for human-computer interaction (HCI) design.

4 Computer-Supported Design Environment with DIF

Developing the computer-supported environment with DIF enables a development team to effectively utilize all the benefits of DIF. As Figure 1 shows, this environment supports four primary design phases: user study, concept development, prototyping, and evaluation.

When a development team collects the data on users and existing systems from user studies, the information can be organized and recorded based on DIF in this environment. It also supports viewing and manipulating observation resources such as video clips, snap shots, or sketches (Figure 6). These resources are linked to the DIF-based user data so that they can be referenced back through DIF at any stage of the development process.

With the data organized by DIF, this environment produces various aspect models according to the concerns of particular design activities. It also allows combining or overlaying the models together to introduce different views on the observed situations.

5 Conclusions and Future Studies

Design Information Framework has been developed for

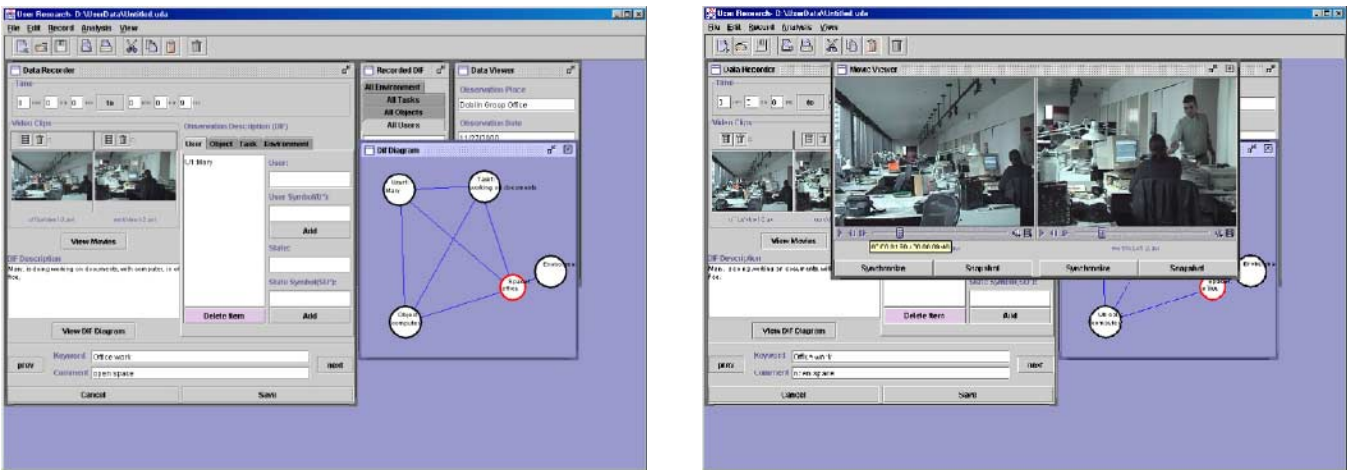

Figure 6 The screen snapshots from the Computer-Supported Environment with DIF

guiding a development team to document and organize information effectively in an interactive system design process and also for providing the sharable environment among multi-disciplinary teams. DIF provides a representation format of design information that supports the generation of different aspect models of a system, system use, and users as well as the mechanism for managing archived design information.

This research has focused on defining and structuring the DIF, and the future studies should be directed to the three courses: further developing methods and tools that fully utilize DIF, developing application cases of DIF in different subject domains, and generating prototypes by applying DIF. In order to understand how DIF can more effectively support work among multi-disciplinary team members, case studies need to focus on the interactions among the team members in an interactive system development, using DIF for their design activities. In developing DIF-based methods and tools, the development of scenario-based methods using DIF should be explored with case studies.

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