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A CASE STUDY FOR APPLICATION OF DESIGN FOR AFFORDANCE METHODOLOGY USING AFFORDANCE FEATURE REPOSITORIES

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ABSTRACT

The characteristics of products and services that induce natural activities of people, namely affordances, play critical roles in making interactions successful and meaningful. Earlier a methodological framework for design for affordances has been devised where repositories of affordance features are used. Affordance features are retrieved from the repository so that the new affordance feature is to be designed through an analogical reasoning. In two classes of Product-Service Systems Design education, this design for affordance method has been introduced in a tutorial setting for designing a hand carrier cart. This paper describes how the method was introduced and shows new target affordance features in their design proposals with source affordance features retrieved from the repository. Target affordance features have been evaluated based on the distances from the sources. Implications obtained from this tutorial effort are discussed to enrich practical application of the design for affordance method.

Keywords: design for affordances, analogical reasoning, user-centred design, human-behaviour in design, design education

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1 INTRODUCTION

The characteristics of products and services that induce natural activities of people, namely affordances, play critical roles in making interactions successful and meaningful. That is, affordance is the message that induces human activity, and perception and judgment aspect of human activity is tightly related with affordance. While the importance of affordances have been emphasized a lot (Gibson, 1979), (Norman, 2002), not many systematic methodologies to design in such affordances have been developed. A systematic method, called Function-Task Interaction (FTI), to identify affordances using the interaction between functions and tasks has been proposed by Galvao and Sato (Galvao and Sato, 2006). Maier et al. introduced affordance-structure-matrix for evaluating what affordances are embedded in each component of a product. This matrix can illustrate correlations of affordances and also of components (Maier et al., 2007). The notion of affordance features, structural elements of artifacts that provide affordances, has been utilized in (Murakami et al., 2006), (Kim et al., 2008), (Kim et al., 2009), (Lim, 2011) and (Kim et al., 2011).

Recently, Kim et al. proposed a practical framework of design for affordances (Kim et al., 2012b). The proposed framework is composed of three major steps. First affordances are identified for the given design problem. This can be done in a few different ways including FTI method. The output of the first step is the list of affordances. The first step is marked by 1 Fig. 1 illustrating the framework. Then using the repositories of affordance features where multiple affordance features for a given affordance are compiled, affordance features for each affordance identified in step 1 are identified and compared as marked by 2 and 3 in Fig. 1. Then an affordance feature of a given affordance is to be selected considering design constraints and contexts of those in the repository so that the affordance feature with design constraints and contexts similar to the current design constraints and contexts is used in the subsequent process as noted by 4 in Fig. 1. The second step includes the selection of affordance features in the repository. Using the clues given by such affordance features, the new affordance feature is to be designed through an analogical reasoning. The last step in this framework is then the analogical reasoning step that converts the source affordance features in the repository into the target affordance features to support the affordance of the current design problem as noted in Fig. 1 as the transformation from 4 to 5.

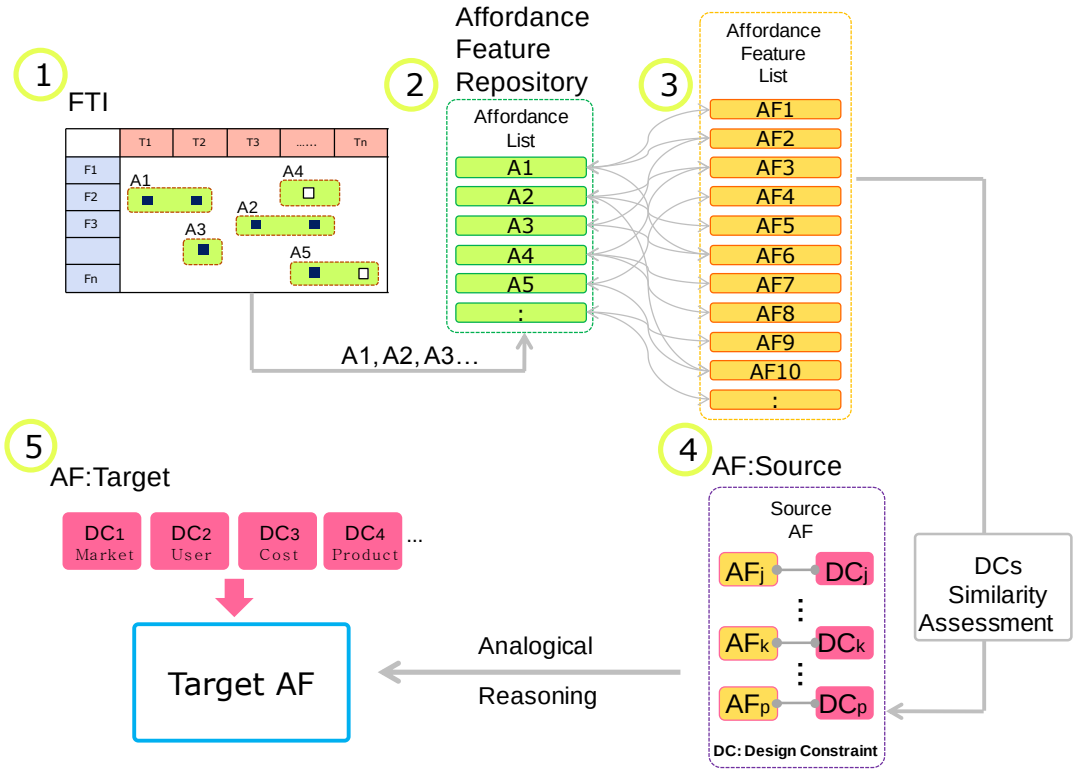

Figure 1. Design for affordance framework (Kim et al., 2012b)

The facilitation of the proposed design for affordance method is made by well-prepared affordance feature repository where affordance features and the corresponding design constraints and contexts are properly described. Before using the repository, the step of affordance identification should be done by the designers with thorough function and task analysis. The creative process of analogical reasoning from the source affordance features into the target affordance features would be done in many different ways reflecting the corresponding designer's design approaches. Some comparison of design processes in this framework has been reported in (Kim et al., 2012a) (Kim et al., 2012b) where design steps of several designers have been recorded and analysed through interviews with designers.
In the research described in this paper, applicability of the proposed design for affordance method has been studied so that ways to achieve practically meaningful usage of the design for affordance method could be identified. In two different occasions but with identical conditions, this design for affordance method has been introduced in a tutorial setting for designing a hand carrier cart. The participants include both practicing designers and students in interdisciplinary design courses. This paper describes how the method was introduced and shows new target affordance features in their design proposals with source affordance features retrieved from the repository. Target affordance features have been evaluated based on the distances from the sources. Implications obtained from this tutorial effort are discussed to enrich practical application of the design for affordance method.

2 CASE STUDY OF DESIGN FOR AFFORDANCE USING REPOSITORY: HAND CARRIER CART

To illustrate how the proposed design for affordance framework is to be used, a product design case study has been conducted. In the case study, the task was to re-design a hand carrier cart as shown in Fig. 2. Affordance identification using FTI has been done beforehand by researchers and presented to the designers and the affordance feature repository has been provided with guidance to use them to make their final design. Once each designer finished their design, a brief retrospective interview was done to capture designer's intent and reflections. Twenty eight students with different major fields such as mechanical engineering, system engineering, consumer science, design and architecture and six practicing designers participated. The design time duration of the experiment was limited to 60 minutes.

Figure 2. Hand carrier cart design

2.1 Functions and Tasks

Function

Researchers conducted a typical function decomposition for the hand carrier with 10 functions as shown in Fig. 3. F1 Import hand → F2 Stand on place → F3 Import object → F4 Contain object → F5 Support object→ F6 Move object → F7 Stabilize object → F8 Control movement of direction → F9 Export object → F10 Export hand.

Tasks

The user activities, or tasks, have been identified by researchers through a typical user activity observation. They are T1 Move hand carrier to use, T2 Load object on hand carrier, T3 Tilt hand carrier, T4 Drive hand carrier, T5 Stop hand carrier, T6 Stand hand carrier, T7 Unload object, T8 Move hand carrier to store and T9 Store hand carrier.

Identified Affordance

The interactions between these 10 functions and 9 activities have been determined and grouped to identify 9 affordances as shown in Fig. 3; Hand grasp-ability, Place-ability, Load-ability, Contain-ability, Support-ability, Move-ability, Stabilize-ability, Steering-ability, and Unload-ability.

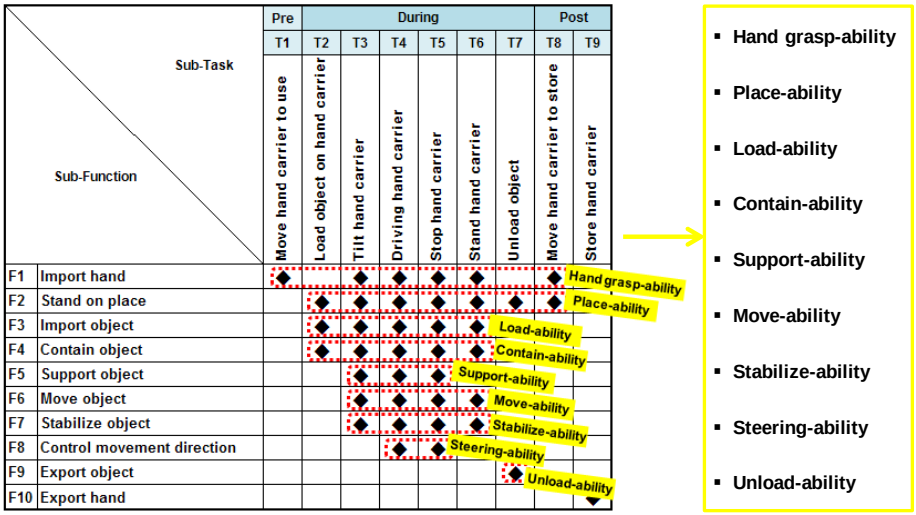

Figure 3. Affordances Identified by Function-Task Interaction of Hand carrier

2.2 Affordance Feature Repository

The affordance feature repository has been provided to the participants. For each affordance, five affordance features have been provided as stickers as shown in Fig. 4. For example, among the affordance feature stickers for Move-ability, three affordance features have wheels similar to original hand carrier design, while the other two have very different features and contexts while addressing the same affordance of Move-ability. The stickers of the affordance features selected by participants as source are to be attached around their final affordance feature sketch with comments about their design and selected affordance features in repository. 34 participants designed their new hand carrier by using the affordance feature repository.

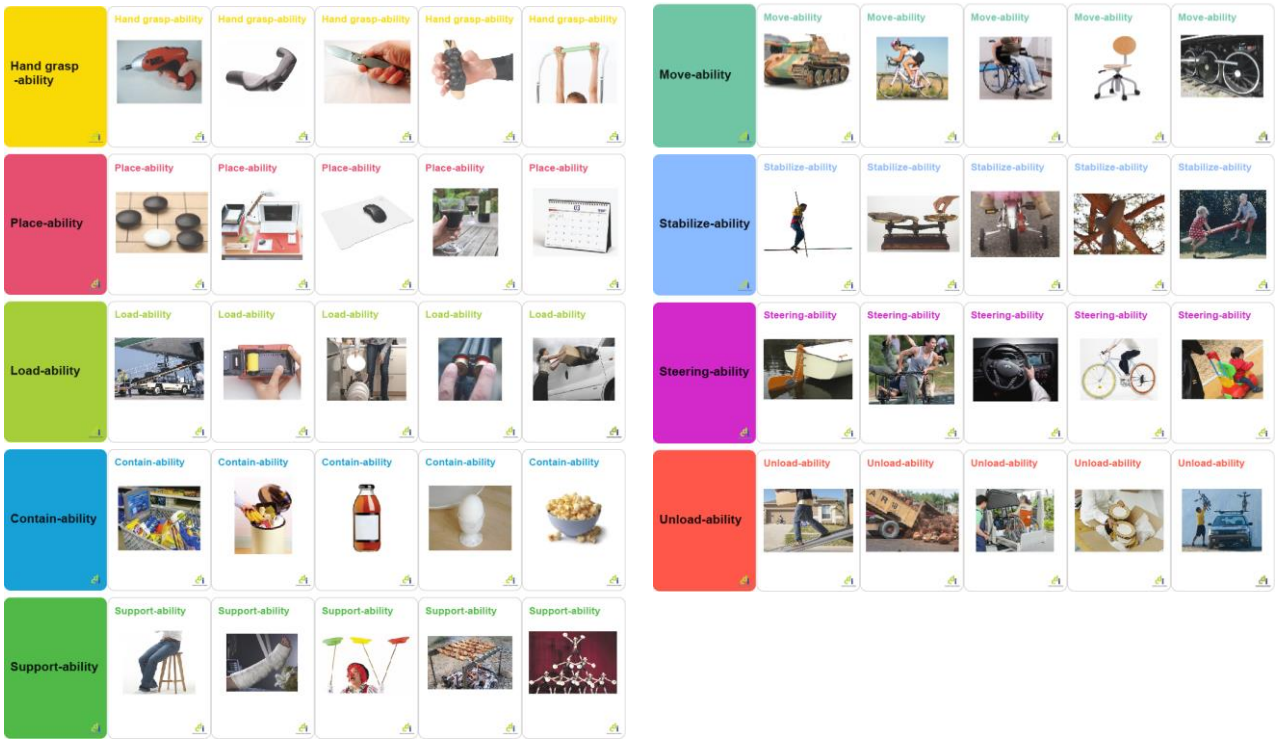

Figure 4. 9 Affordances and 45 Affordance features (in sticker type)

2.3 Evaluation of Level of Analogy for Design for Affordance using Repository

Design sketches done through analogical reasoning from source affordance features selected from the repository to target affordance features have been evaluated to understand the way the design for affordance method was used. Evaluation criteria are like the following. The case of direct analogy from the source to target was given 1 point. When shapes of source and target affordance features are different, 2 points were given. When function enhancements were made as well as shape change, 3 points were given. In the case of wrong interpretation of the source affordance features, -1 point was given. When affordance feature sketches came from other than the repository, 2 points were given.

The handle of the bicycle of the hand grasp-ability is taken as an example to illustrate the evaluation method. Among those 5 sketches in Fig. 5, the sketch of the target affordance feature with similar shape received 1 point. The design of handle with a different shape from the source handle received 2 points. The handle design of hand grasp-ability combined with the function to control direction of steering-ability was given 3 points. The sketch with wrong interpretation of affordance source colored in red got -1 point. Furthermore the case where source has been drawn outside affordance feature repository as colored in blue was given 2 points. Note that the scores of 1, 2 and 3 have been colored so that the darker the color indicates the higher score.

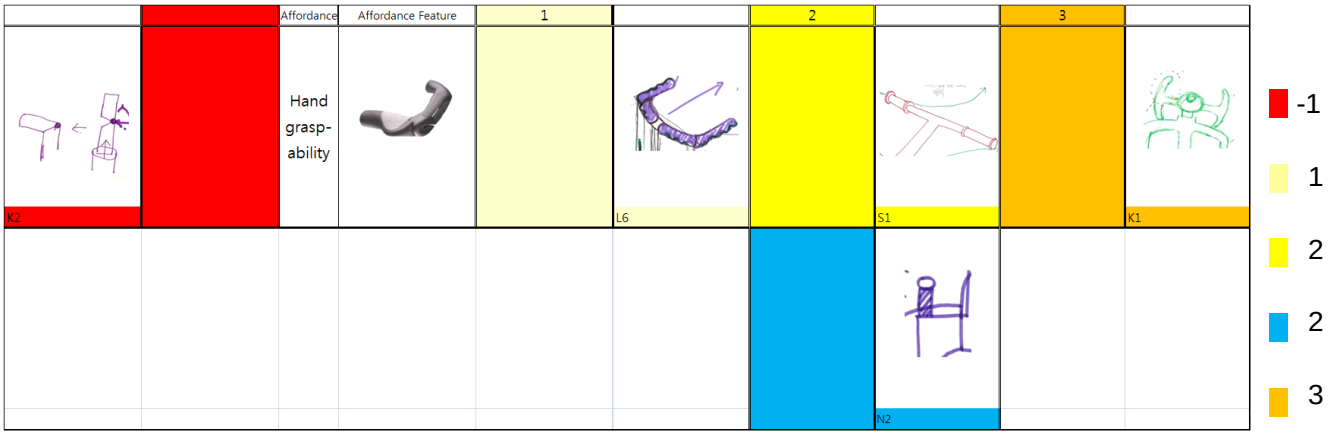

Figure 5. Evaluation of Level of Analogy for Design for Affordance (Hand Grasp-ability)

2.4 Result

All the affordance features resulted in their design proposals are shown in Fig. 6 next to the corresponding source affordance features from the repository. Source affordance features were positioned higher when they were used more. In case of all affordances (hand grasp-ability, place-ability, load-ability, support-ability, move-ability, stabilize-ability, steering-ability and unload-ability) except one, three affordance features for each affordance were used as the sources. However in contain-ability, one affordance feature, cart for the grocery market, was dominantly used as the source because its context is most similar with the hand carrier as compared with four other sources such as a trash box, bottle, egg stand and bowl with rather different contexts in terms of the objects being contained. Another observation made is that, for the case of contain-ability, many target affordance features were designed with remote associations and enhancement functions. More than 10 design proposals received 3 points for this affordance. This could be because the primary function of the carrier cart would be related with the contain-ability and the participants made more efforts in designing the corresponding affordance features. The score charts of all 34 final results are shown in Fig 7. The scores have been arranged so that visual patterns could be identified if exit. Also color coding was used to help visual inspection. While there was no easy visual observation can be made, close examination of individual design results provides positive assessment on the method.

Design for Affordance Final Sketches: Examples

Several examples of final sketches are shown with explanations of source affordance features and analogical reasoning so that the usefulness of the proposed design for affordance framework could be understood.

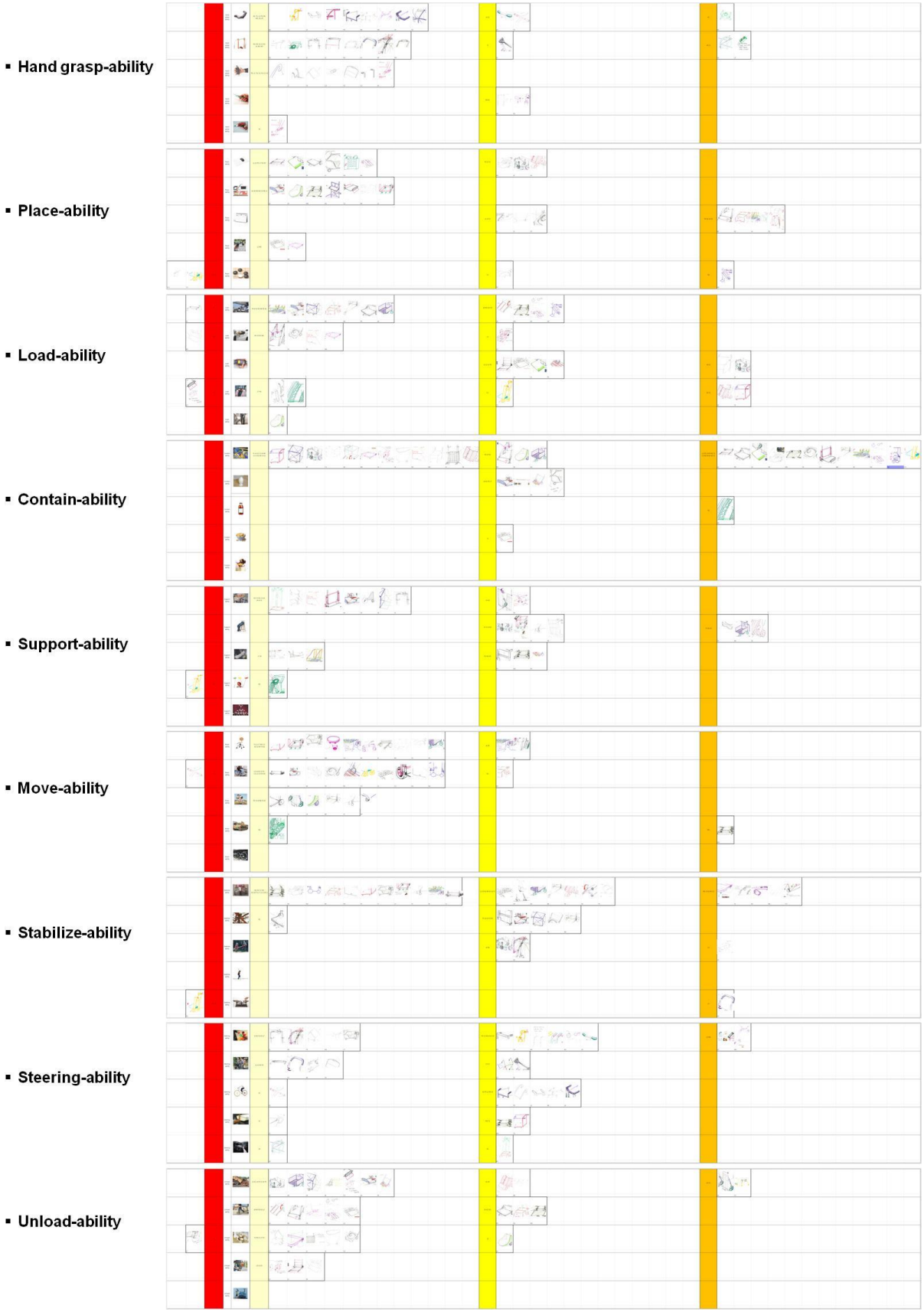

Figure 6. Distribution chart of score of final design sketch

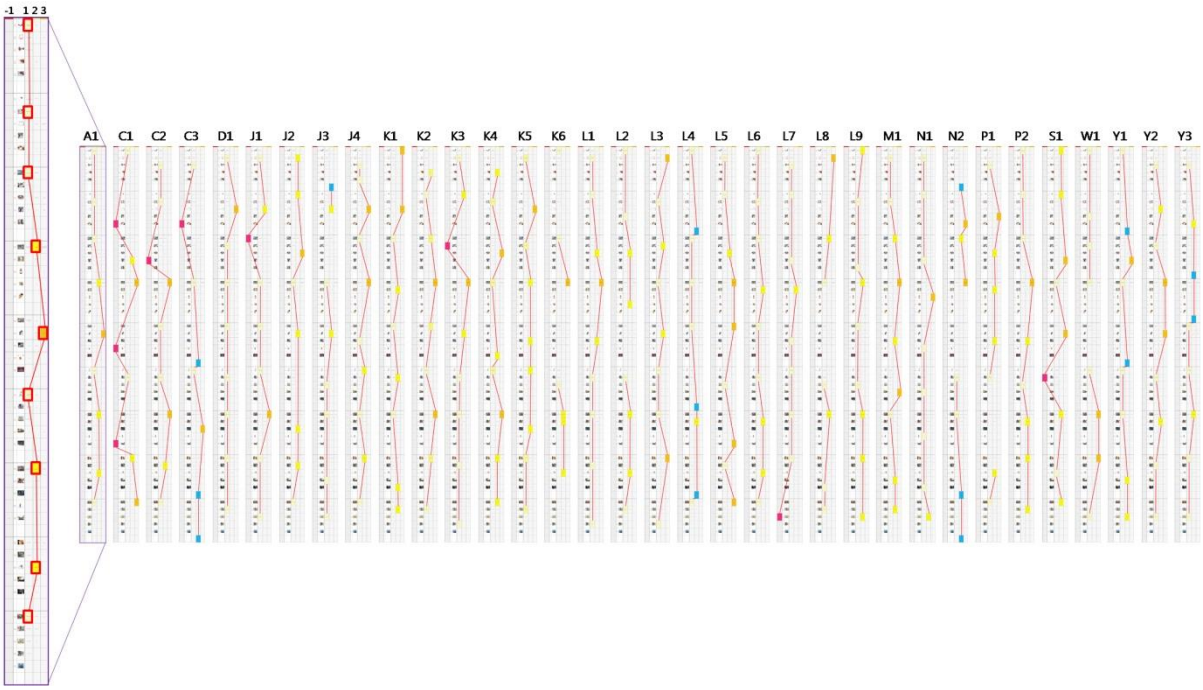

Figure 7. The distribution chart of the individual score result

Participant: L5

L5's sketch received the best score out of 34 sketches. Four affordance features of a new hand carrier such as for hand grasp-ability from the handle of the chin-up bar, place-ability from the bottom surface of the computer mouse, move-ability from the wheel of the bicycle and steering-ability from the handle of the hand cart were evaluated as direct analogy as shown in Fig 8 with light color of point 1. In case of the affordance feature of contain-ability, the bottom of new hand carrier was designed as flat shape which could contain without the limitation of size of objects as derived from the cart for the grocery market. Referencing the structure of the grill support in the repository of support-ability, the supporting part of hand carrier was developed to the foldable support net which could support diverse sizes of objects. L5 got an idea from the scale in the repository of stabilize-ability and the handle design which could make stable balance during moving was devised by extending the part of handle to access from the sides as well as from the middle-top. Unload-ability is enhanced with small handles wrapped around lower bars near the wheels so that tilting becomes easy. These 4 analogical reasoning cases with function enhancement received 3 points and make much improved carrier cart design.

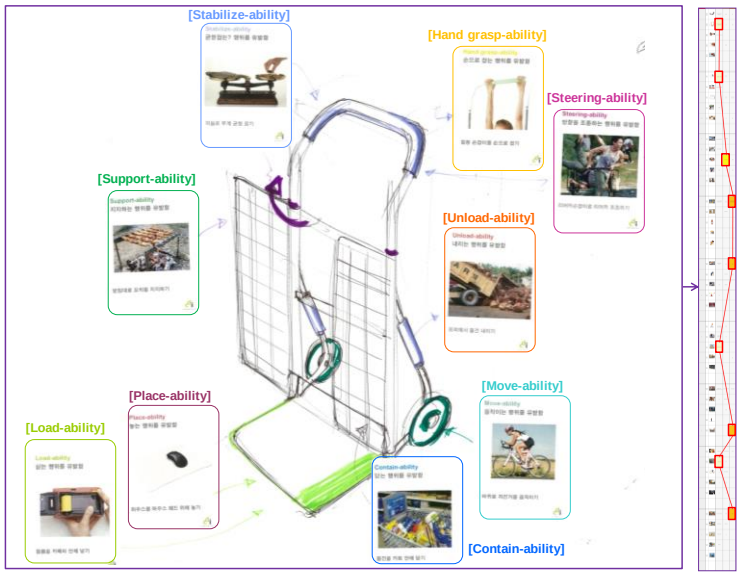

Figure 8. Final sketch and score result of L5

Participant: C2

In C2 sketch, five affordance features of new hand carrier such as for hand grasp-ability from the handle of the hammer, place-ability from the bottom surface of the laptop, support-ability from the structure of the grill, move-ability from the wheel of the wheel-chair and unload-ability from the inclined plane of the cargo truck were evaluated as direct analogy of point 1. In case of the affordance feature design of load-ability C2 chose the shot gun hole in load-ability and developed new idea, but this part was evaluated as wrong interpretation, because the final design shows neither morphological nor functional similarity to the source. The affordance feature sketch of contain-ability was similar to L5's sketch however C2 designed the extra equipment to hold objects from the hand carrier to improve the hand carrier's function. From the source of the extra wheels of the child bicycle in the repository of stabilize-ability, the stabilizer idea of new hand carrier design was created. When the object is loaded on the hand carrier and the hand carrier with the object is tilted and the extra wheels come out to help keeping the hand carrier's balance as shown in Fig 9. These two strong improvements came from the source affordance features in leading to remote analogy. Also the titled truck in unload-ability was used to design flapping piece to be used in unloading.

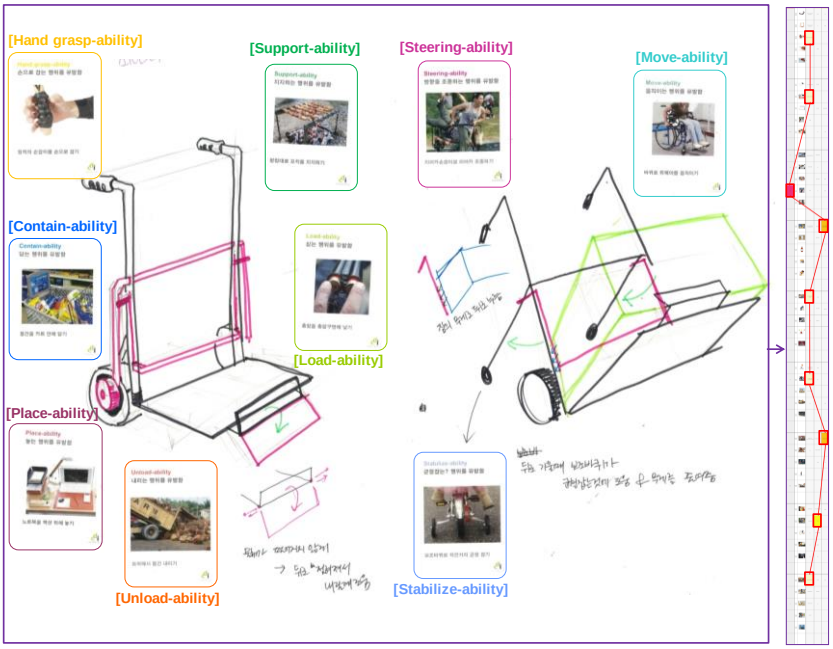

Figure 9. Final sketch and score result of C2

Participant: J4

Differently from other participants, J4 used 2 source affordance features of the repository. The handle of the electronic drill and that of the hammer in the repository were used for hand grasp-ability. Also the hanging support of hospital and the support of the grill were used for support-ability. In J4's sketch, three affordance features of new hand carrier such as for load-ability from the cargo trailer, stabilize-ability from the stabilizer of the bicycle for junior and unload-ability from the inclined plane of the cargo truck were evaluated as direct analogy. Using the construction of bottom of the desk calendar in place-ability repository, the bottom of the hand carrier was designed as foldable bottom structure. In the affordance feature design of move-ability not only the swivel wheels were developed, but also the structure of the wheel was presented with double wheels of hand carrier for moving stability. The assist device of the hand carrier was designed in the affordance feature in contain-ability to prevent loaded objects from falling outside and for unload-ability the assist device is easily removed due to the hinged door. In the affordance feature design of steering-ability used the bar shape which could be handled with one hand, however J4 modified the construction of the handles to two handle device for stable driving of heavy objects as shown in Fig 10. This design introduces many functional enhancements coming from creative transformation from repository affordance features. It is notable that effective color-markings for features, affordance by affordance, have been done during design.

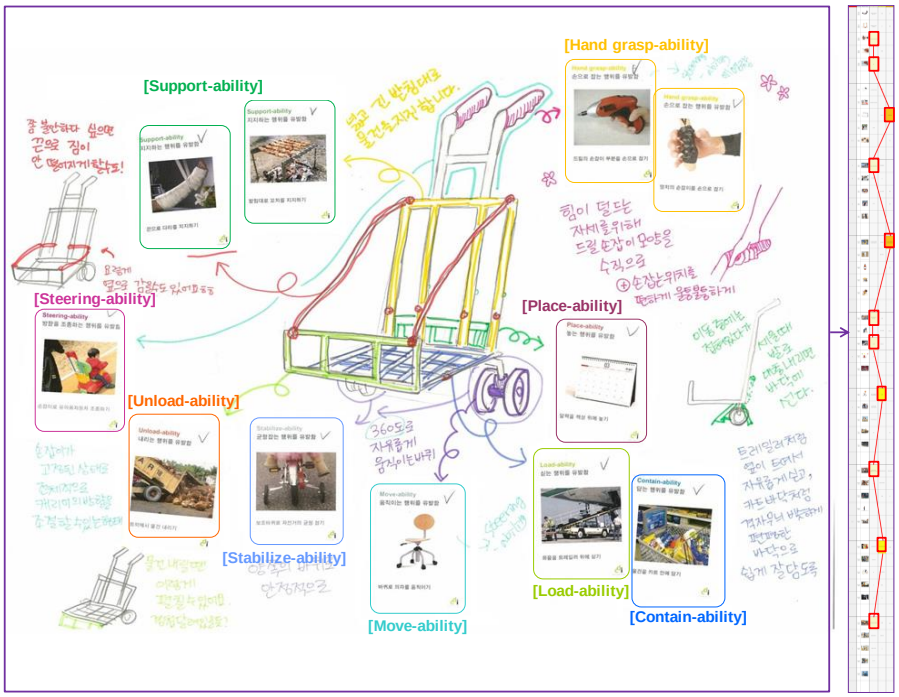

Figure 10. Final sketch and score result of J4

Participant: L8

L8 has relatively many direct analogy design as compared with the other participants. In L8 sketch, five affordance features such as for contain-ability from the shopping cart, move-ability from the wheel of the bicycle, stabilize-ability from the stabilizer of the child bicycle and unload-ability from the plane of the cargo truck were identified as direct analogy. Two affordance features of hand grasp-ability and steering-ability were considered together to combine two functions, therefore as a result the grasping bar was connected with the wheel to steer as shown in Fig 11. In case of affordance feature design of load-ability, the inclined plane of the cargo truck was developed to foldable inclined plane to load and unload object according to the context of the hand carrier.

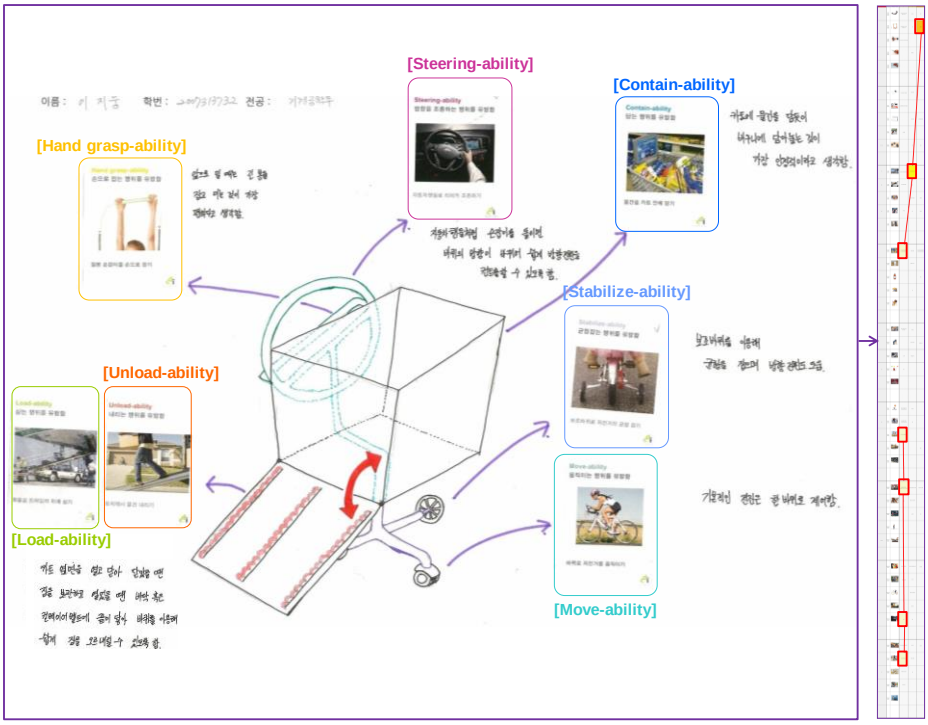

Figure 11. Final sketch and score result of L8

3 DISCUSSION AND CONCLUSION

In this paper, application of the design for affordance method using affordance feature repository has been described so that ways to achieve practically meaningful usage of the design for affordance method could be identified. The design for affordance method addresses affordances identified from function and task analysis one by one to devise corresponding product structures to give the affordance through analogical reasoning from corresponding affordance features in the repository.

This design for affordance method has been introduced in a tutorial setting for designing a hand carrier cart with 34 designers, including both practicing designers and students in interdisciplinary design courses. All the proposed designs of 34 participants have been evaluated based on the level of analogy for all affordances. As the participant group could be classified into a few set of different groups such as the set of students and practicing designers, the set of different majors, and the set of two tutorials, no significant difference has been observed. When cognitive characteristics of participants were used in searching for some sort of correlations with scores of their design proposals, no clear relation could be observed either. It would be desirable to conduct a more well-controlled experiment to find some relations with either designer characteristics or design contexts where affordances are very important.

An important observation is that those affordance features in the repository that are similar to the given design task in their contexts and constraints were used more than those with very different contexts and constraints. For example, when the object being contained is relatively large solid objects, contain-ability affordance feature of a bottle was not selected except one out of 34 participants. This confirms that similarity between contexts of source and target should be evaluated in choosing source affordance feature from the repository. Also it was confirmed that construction and provision of a good repository is very important in this design for affordance method. Note that our software version of the affordance feature repository uses the context-based activity modeling method (Kim & Lee 2011) so that specific contexts and constraints of the activities of the affordance features support are systematically and effectively represented and compared. Nevertheless, the fact that a lot of new good design proposals for hand carrier carts have been made even in the short 60 minute time design task is very meaningful. This was because good affordance feature designing was enabled by the proposed design for affordance method using the repository as primarily intended in this research.

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