An Advancement-record System Using Knowledge Adaptable to Children’s Developmental Stages

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Abstract Recently, advancement-record systems for early childhood education have been commercially marketed in Japan. The academic advancement of children is recorded by using knowledge constructed from many advancement-inspection items. Such a record is required by law, and it’s effective for third-party appraisal by the Japanese government. The knowledge conventionally used in such a system, however, has two major limitations. One is the subjective score selection. The advancement score is recorded in ambiguous expressions, such as “possible,” “almost possible,” and “impossible.” The other limitation is that the items are fixed for each school year. If the highest score is selected at the starting point of one school year, the nursery teacher cannot read any developmental process from a constant item value for one year, even if the item is evaluated every month. To resolve these problems, this paper proposes an advancement-record system that uses a new type of knowledge. This knowledge has two key features: 1) Objective score selection based on Vygotsky’s psychological theory of “The Zone of Proximal Development,” and 2) Re-designed knowledge using items that can be chosen freely, according to the advancement stage of each child. The proposed system thus provides more detailed daily observation of child development as well as statistical analysis of advancement scores.

Keywords. ICT Application System, Advancement Record, Early Childhood Education, Nursery Schools, Nurture, Nursery Teachers, Kindergarten Schools

1. Introduction

Recently, advancement-record systems for early childhood education domains, such as nursery schools or kindergarten schools, have been commercially marketed in Japan [1][2][3]. Such record-making and compilation is required by law, and the recorded documents can be effective for third-party appraisal by the Ministry of Health, Labor and Welfare of the Japanese government.

This type of system uses knowledge for advancement inspection. The knowledge is constructed from many advancement-inspection items, each of which depends on the age of the child1. This knowledge has five major categories: Health, Human relations,
Environment, Language, and Expression, and each major category is divided into “sub-categories.” Finally, each sub-category has several advancement-inspection items. Conventional record systems, however, have two major limitations. One is the subjective score selection, because the advancement score is recorded in ambiguous expressions such as “possible,” “almost possible” and “impossible.” The other limitation is that the advancement-inspection items are fixed for one school year. If the highest score is selected at the starting point of one school year, nursery teachers cannot read any development process from a constant item value for one year, even if the item is evaluated every month.

To resolve these problems, this paper proposes an advancement-record system using a new type of knowledge. The proposed knowledge has two important features. One is its objective score selection based on Vygotsky’s psychological theory “ZPD: The Zone of Proximal Development.” The other is its re-designed knowledge with items that can be chosen freely, according to the advancement stage of each child. The proposed knowledge provides 1) more detailed observation of child development, 2) graphical output for easy observation, and 3) statistical analysis of the advancement scores.

In the following, Section 2 describes the details of conventional advancement knowledge and its problems. A new advancement-record system is proposed in Section 3. Section 4 gives the details of the graphical user interface. Finally, Section 5 concludes the paper.

2. Conventional Advancement Knowledge

Figure 1 shows a sample of conventional advancement knowledge used in evaluating a child’s developmental stage. The knowledge is large and written in Japanese. The knowledge consist of 334 items. Only a part of the knowledge is shown in Fig. 1. The knowledge has five major categories: Health, Human relations, Environment, Language and Expression, each of which is divided into sub-categories. The sub-category is constructed from many advancement-inspection items.

In Fig. 1, the major category is “Health,” which has the two sub-categories “Meal” and “Nap.” The sub-category Meal has 10 advancement-inspection items. Each advancement-inspection item has a score, assigned by nursery teachers. The score value is selected from cross, triangle, and circle, which correspond to “impossible,” “almost possible” and “possible,” respectively.

This type of conventional knowledge has the following major disadvantages.

1. Subjective score selection by nurturing persons: The advancement score is recorded in ambiguous expressions. Thus, two item values cannot be compared if different nursery teachers record them. Furthermore, it is not possible to compare item values if the nursery teacher records them at different times, even if the same nurturing person records the item values.

2. Items locked into age: The items are fixed for each school year. If the highest score is selected at the starting point of a school year, the nursery teacher cannot read any developmental process from the constant item value for that year, even if the item is evaluated every month.

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2 These major categories are selected in “Nursery School Nurture Guide” (in Japanese) [6].
3. No standardization: The sub-categories and items within the recorded advancement knowledge vary among nursery schools in Japan. Thus, if a child moves from one nursery school to another, the old record may have little or no meaning at the new nursery school.

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Sub Category</th>
<th>Evaluation Item</th>
<th>Recording Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>May-05 Oct-05 Feb-06</td>
</tr>
<tr>
<td>Meal</td>
<td></td>
<td></td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eat after greeting</td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eat vegetable, eat fruit and the food of others</td>
<td>O 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Try to eat alone, using spoon or fork</td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Try to eat at the easing of nurturing person</td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eats and swallows very well</td>
<td>X X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eats without dropping while using a cup</td>
<td>X X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does not play with the meal</td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Try to eat with chopsticks</td>
<td>O O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wipes hands and face before and after lunch</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eat after removing packaging paper</td>
<td>O 0</td>
</tr>
<tr>
<td>Health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steps alone</td>
<td>X X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steps during scheduled nap time</td>
<td>Delta Delta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wake up very well</td>
<td>O O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Doesn’t disturb the other children after waking up</td>
<td>X X</td>
</tr>
</tbody>
</table>

Figure 1. Example of Conventional Advancement Knowledge (part of the Knowledge)

A conventional record is written two or three times in one school year. The evaluation results are recorded in May, Oct. and Feb. as shown in Fig. 1. Thus the score can be input a few months after the child’s actual advancement achievements. Furthermore, the nurturing persons are unable to refer to changes in scores for their daily guidance. Consequently, the conventional record becomes no more useful than as a mere “report for the government.”

To resolve the above problems, the authors adopted three approaches: 1) Re-selected Items from authorized diagnostics methods that are widely used in Japan, 2) Items Not Locked into Age, 3) Objective Score based on Vygotsky’s ZPD: The Zone of Proximal Development. The newly designed knowledge was implemented in a new advancement-record system, which is described in the following section.

3. New Advancement Record System

3.1 System Overview

The authors have developed a new advancement-record system. Figure 2 shows the system overview. The advancement information is shared among parents, a nursery teacher, a chief nursery teacher, a medical doctor, and a public-sector parenting support center under an access-control scheme. The advancement-inspection record should be a tool for daily nurturing. In order to achieve this goal, nursery teachers should evaluate the items every month in the proposed system. This interval is shorter than that of conventional systems.

Figure 3 shows a block diagram of the system, implemented by Xoops [9] and MySQL [10]. The system provides advancement-inspection interface screens for the nursery teachers. The nursery teachers can input and read the evaluation scores for each
child. The item score is merely a “number,” and the knowledge contains many inspection items. It is not easy to read the advancement stage of each child from raw data, and to solve this problem, the system offers two output features. One is a graphical-output sub-system and the other is a statistical-analysis sub-system, which employs the R system [11].

3.2 Advancement-inspection Knowledge

The advancement knowledge was completely re-designed for the proposed system. Here, it should be noted that there is no existing standard for advancement-inspection knowledge. One of our targets in knowledge design is to provide a candidate for the standard advancement-inspection knowledge. The knowledge used in the proposed system has three major features as described below.

*Inspection Items Selected and Modified from Major Inspection Documents*

Since there is no standard for advancement-inspection knowledge, the authors designed the knowledge by using three documents commonly used in Japan: 1) Nursery School Nurture Guide (in Japanese), published by The Ministry of Health, Labor and Welfare of the Japanese Government [6], 2) Infant Spiritual Advancement Diagnostics: from...
three years old to seven years old (in Japanese), published by Makoto Tsumori and Keiko Isobe [4], and 3) Infant Advancement Inspection Method by Onjyouji (in Japanese), published by Munenori Onjyouji [5].

The Nursery School Nurture Guide is conceptual, so it is difficult to generate concrete items from this document. Therefore, many items were selected from the commonly used advancement-inspection tests in “Infant Spiritual Advancement Diagnostics” by Makoto Tsumori. This document has very concrete descriptions and thus is effective for item generation. However, it contains no items for children younger than 3 years old. Therefore, the third document, Infant Advancement Inspection Method by Onjyouji, was incorporated. Finally, 334 items in 32 sub-categories were selected as shown in Table 1.

Table 1 Numbers of Items in Five Major Categories

<table>
<thead>
<tr>
<th>Major Categories</th>
<th>Healthy</th>
<th>Human</th>
<th>Environment</th>
<th>Language</th>
<th>Expression</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>From birth to less than six months</td>
<td>14</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>From six months to less than twelve months</td>
<td>11</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>From twelve months to less than eighteen months</td>
<td>18</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>From eighteen months to less than twenty-four months</td>
<td>13</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Two years old</td>
<td>14</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td>Three years old</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>Four years old</td>
<td>16</td>
<td>10</td>
<td>18</td>
<td>11</td>
<td>9</td>
<td>58</td>
</tr>
<tr>
<td>Five years old</td>
<td>13</td>
<td>10</td>
<td>18</td>
<td>11</td>
<td>9</td>
<td>61</td>
</tr>
<tr>
<td>TOTAL</td>
<td>112</td>
<td>67</td>
<td>58</td>
<td>57</td>
<td>40</td>
<td>334</td>
</tr>
</tbody>
</table>

Items Chosen Freely, according to Advancement Stage of the Child

The inspection item scores are inputted every month in the proposed system. Let’s assume that each item is fixed for one school year. This scheme is widely employed in conventional knowledge-recording systems. If the highest score is selected at the starting point of one school year, the nursery teacher cannot read any developmental process from the constant item value for one year. For instance, if the score is 4 in April³, the record is 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4 for one school year.

Figure 4 shows the relation between some items for one-year-olds and those for two-year-olds. The entire body of knowledge is very large. The number of one-year-old items is 40, and that of two-year-old is 34. Figure 4 shows a small part of this knowledge. The major categories are selected by the Japanese government, and the knowledge used for each age has identical categories.

The names of sub-categories, however, are not identical. In Figure 4, sub-category “Meal” of major category “Health” for one-year-olds is not included in the major category “Health” for two-year-olds. Thus, the sub-categories can never be described in a one-to-one mapping over plural years. The number of items for one sub-category varies with the child’s age. In some cases, no identical sub-category name can be found in the knowledge sets for higher-age/lower-age comparison.

In the first stage of the authors’ study, they tried to find a one-to-one mapping for all item names. However, this target is far away from the real world. Thus, as shown in

³ In Japan, the school year starts on 1 April.
Figure 4, the authors finally made each sub-category correspond to others in different age-years as much as possible. Consequently, a seamless one-to-one mapping between item names is not guaranteed in the proposed knowledge.

**Objective Score Selection based on Vygotsky’s Psychological Theory**

For the sake of objective observation, the appraisal value must not contain any ambiguity. Vygotsky [8] maintained that a child follows the nurturing adult’s example and gradually develops the ability to do certain tasks without help or guidance. He called the difference between what a child can do with help and what he or she can do without guidance the “zone of proximal development” (ZPD). From this point of view, the authors defined the following five evaluation scores for the inspection items used in the objective observation.

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Sub-Category</th>
<th>Item Contents</th>
<th>Major Category</th>
<th>Sub-Category</th>
<th>Item Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meal</td>
<td>Tries to eat with spoon by himself/herself.</td>
<td>Clothes</td>
<td>Wishes to put on and remove clothing by himself/herself.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meal</td>
<td>Enjoys the time of the meal.</td>
<td>Clothes</td>
<td>Lays out the clothes by himself/herself if the clothes are simple.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes</td>
<td>Tries to wear or lay out clothes with interest.</td>
<td>Clothes</td>
<td>Puts on the clothes by himself/herself with the support of the nurturing person.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense of Relief</td>
<td>Relies on the nurturing person, he/she has a sense of relief.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Score 0: Completely impossible  
Score 1: Possible with active support of nurturing persons  
Score 2: Possible with indications by nurturing persons  
Score 3: Possible if child is with friends who act simultaneously  
Score 4: Possible through personally achieved advances

The above standard for score selection is general and does not depend on issues related to the particular item. Figure 5 shows the proposed system’s interface screen for inputting the advancement-inspection item scores. Each of the above criteria is described in the left-center of the user interface. Each item is shown in the center of the interface screen, and the item score is selected by using a “radio button.”

The removal of ambiguity in the items’ evaluation provides several advantages. First, this scheme removes the influence of the evaluator’s judgment style. Even if one class has two nursery teachers, the scores can be decided mutually between them. Second, the objective score absorbs the difference due to the fact that observation results may be inconsistent over time. Even if the observation judgment of a nursery teacher changes over time, the score difference is kept minimal. This means that the evaluated scores can be applied to statistical analysis or displayed by graphical output for easy observation.
4. Graphical User Interface

The proposed system has four major interface screens: 1) user interface for evaluation, 2) graphical output of the evaluation scores, 3) statistical analysis results, and 4) user management. The user management interface has features such as user account create/modify/delete options and user property controls, and it’s accessed by the system administrator. The details of the administrator’s interface are omitted in this paper.

![Figure 5. User Interface for Evaluation](image)

User Interface for Evaluation

The user interface for evaluation shown in Fig. 5 has score input function for each inspection item. The items’ score values are inputted through “radio buttons.” There are many sub-categories and items, so the inspection-item area can be scrolled up and down. The evaluation screen also has two “Note Areas” for the nurturing person’s comments.

One of the most important interface features is the “button for increasing/decreasing age.” In Fig. 5, the right-facing arrow indicates “increase the age for the item,” and the left-facing arrow indicates “decrease the age for the item.” The arrow does not appear if there is no identical sub-category name in the target knowledge. If the corresponding sub-category has plural items, an item selection sub-window appears in the screen for the nursery teacher to select the appropriate items.

Figures 6(A) and 6(B) show graphical outputs of the average values for each sub-category of one child. The child is selected from the list of names in the class. Figure 6(A) shows score value distribution for each sub-category. Figure 6(B) shows the change in score value distribution over time. The value of the sub-category is the average of all items in the sub-category.

Figure 7 show a radar chart graph of all sub-category values for one child. The average score of all children in the class is shown by the solid red line in the graph. The nurturing person can read the tendency of advancement in each sub-category and
compare the values with the class as a whole. These charts enables users to grasp the
balance of growth of the child development by this graph.

Figures 6 and 7 avoid the risks of showing values determined by subjective criteria.
First, if the scores were selected at different times, the values could not be compared
with each other in Fig. 6. Moreover, if one class has two nursery teachers, their
averaged values would be reflected in Fig. 7. These graphical outputs are thus very
convenient for daily observation, providing fruitful results from objective score
selection based on Vygotsky’s psychological theory.

![Figure 6. Ratio for Each Score](image6)

**A) Score Value Percentage for Each Major Category**

![Figure 7. Values of Sub-categories and Averaged Value in the Class](image7)

**B) Time Dependency of Five Score Values**

Figure 6. Ratio for Each Score

Figure 7. Values of Sub-categories and Averaged Value in the Class
Correspondence Analysis of the Score Values

The nurturing person can read only the statistical results by himself/herself in Figs. 6 and 7. These graphs are written from raw inspection-score data. To read more detailed information, statistical analysis can be applied. In the proposed system, “Correspondence Analysis” is employed for the objective observation.

Correspondence analysis enables us to analyze two-way tables that display some measurement of correspondence between the rows and columns. This method was originally developed in France by Jean-Paul Benzércri in the early 1960's and 1970's. Similar techniques have been developed independently in several countries. For instance, Chikio Hayashi of the Institute of Statistical Mathematics of Japan proposed a similar method in 1952 [7].

Figure 8 shows an example of correspondence analysis of item scores. The analysis tool is the “R” system, a free version of the S-plus statistical analysis package. The result shows two dimensions, first component and second component. The triangle mark shows the name of the sub-category. The black circle mark shows each child. Twenty-three children are plotted in Fig. 8. If a black circle mark (child) is located near a triangle mark, the child has a high score for the corresponding sub-category. If one black circle mark (child) is located away from the other children, the behavior is considered “unique,” and the nursery teacher should pay special attention to the child.

5. Conclusion

This paper has proposed newly designed advancement-inspection knowledge for the early childhood education domain, specifically nursery schools in Japan. The proposed knowledge has three important features: 1) Advancement-inspection items selected and
modified from commonly used inspection documents in Japan, 2) Items chosen freely, according to advancement stage of the child, and 3) Objective selection of advancement scores based on Vygotsky’s psychological theory. The totally re-designed knowledge and objective score-selection scheme enables the system to analyze scores statistically and to display graphical outputs as an effective feedback tool for daily nurture. The new knowledge is suitable for wide use and may become a candidate for a new standard of advancement-inspection knowledge.

Furthermore, a new advancement-inspection system was demonstrated in this paper. This system employs the above knowledge. The advancement information is shared among parents, a nursery teacher, a chief nursery teacher, a medical doctor, and a public-sector parenting support center. The objective score enables the nurturing persons to compare the inspection item scores among different classes and different observations over time. The system is implemented by using Xoops and MySQL. An evaluation trial will be started in a real nursery school in Osaka, Japan from April 2006.

References