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Adaptive Orientation Methods in Computer Adaptive Testing

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Abstract: In computer adaptive testing, if the examinee answers correctly a question, then the next question is harder. Otherwise, if the examinee answers wrongly, then the next question is easier. It would be useful for the examinees to know their current status. Furthermore, the amount and timing of this orientation information revealed to the examinees may differ depending on their learning characteristics. Either the examinee or the adaptation engine may select the orientation information that is appropriate for the particular examinee. This paper investigates the various areas of orientation information that would be available to the examinees. In addition, it presents methods for adapting the orientation information to each examinee.

I. Introduction

The examinees are tested on a subject Topic which is composed from Subtopics. Each Subtopic is composed from Items. After the examinee answers an Item, another Item (harder, easier or of same difficulty) within the same Subtopic is presented. When a certain number of Items within a Subtopic are answered (or when a certain level of examinee performance in a Subtopic is achieved, or when a certain Time in a Subtopic is passed) the testing proceeds to another Subtopic.

In Computer Adaptive Testing (CAT), if the examinee answers correctly, then the next Item is harder. If the examinee answers wrongly, then the next Item is easier (Sri Krishna 2001, Stauffer and Kenyon 2001, Di Challis 2003). CAT provides increased efficiency saving up to 50% in test taking time. Furthermore, CAT enhances the examinees' interest and motivation. In addition, CAT improves the score accuracy for high and low ability examinees, since it presents Items at any proficiency level (and not only around the average). Item Response Theory (IRT) provides the mathematical framework for selecting the next Item based on the Item Difficulty Level (Linden and Hambleton 1996, Wainer 2000).

It would be useful for the examinees to know their current status in order to be challenged, stimulated, motivated, or to design their testing strategies. This paper investigates the amount and type of orientation information available to the examinee in CAT. Furthermore, it provides methods for adapting the orientation information to the examinee. To our knowledge, there are not previous studies to investigate this adaptive orientation problem. The closest previous studies to this problem investigate the adaptive navigation problem (Weber and Brusilovsky 2001, Kinshuk and Lin 2003, Yudelson, Brusilovsky and Sosnovsky 2004, Heraud 2004).

II. Areas of orientation information

In this section, we investigate the various areas of orientation information that would be available to the examinee. In CAT, the adaptive engine should adapt the Content, the Time & Duration, the Difficulty Level, the Presentation Style, Media & Format, the Orientation, the Communication and Collaboration, the Feedback and the Control of the testing to the examinee's state. Thus, the above parameters become time-varying. Therefore, the orientation information is also time-varying. The examinee's state is described by the examinee's infrastructure, background, preferences, cognitive, emotional and conational characteristics, and performance (score, achievements, etc.).

Analyzing the information that would be shown to the examinee in order to be effectively oriented, there are some issues to be investigated. The first issue is the amount of orientation information which would be: 1) Simple &

Spare, 2) Plentiful & Abundant. The second issue is the timing of the orientation information which would be: 1) Instantaneous, 2) Delayed. The third issue is the locality of the orientation information which would be: 1) Local (e.g. the Current and/or/not the Previous and/or/not the Next Item), 2) Metropolitan (e.g. the Current and/or/not the Previous and/or/not the Next Subtopic), 3) Global (e.g. the whole Topic). For example, a *global* examinee would prefer Global orientation on the Subtopics, Items, Scoring etc., while a *sequential* examinee would prefer Local step-by-step orientation. An *expert* may prefer Simple & Spare orientation, while a *novice* may need Plentiful & Abundant orientation.

Next, we describe various areas of orientation information (Diagram 1). *Orientation on the Content* consists of information about the already tested Subtopics and/or Items, the current Subtopic and/or Item, and the remaining Subtopics and/or Items to be tested. *Orientation on the Time* consists of information about the Time passed and remaining on the Topic, Subtopic or Item. *Orientation on the Difficulty Level* consists of information about the passed, current and/or next Item Difficulty Levels. *Orientation on the Score* consists of information about the previous, current, and/or expected Scores for the examinee. *Orientation on the Comparison* of the examinee to other examinees consists of information on the average examinee, the mean examinee, the low 20% examinees, the top 20% examinees, and/or an expert. This information may be only on the Score or on the full state of the other examinees. *Orientation on the Presentation Style, Media and Format* reveals information about the past, current, and/or next expected Presentation Style, Media and Format. *Orientation on the Communication and Collaboration* consists of information about Sent (messages, talks, video, etc.) and/or Received (messages, talks, video, etc.) activities to/by the examinee. *Orientation on the Feedback* consists of information about the past and current presented Feedback. *Orientation on the Control* consists of information about the percentage, the priorities and the areas on which the examinee or the system has control previously and/or currently. *Orientation on the Examinee Characteristics* consists of information about what was previously and/or what is currently the estimated Examinee Characteristics, Styles, etc. *Orientation on the Educational Outcomes* consists of information about the previously and/or currently Educational Outcomes of the test.

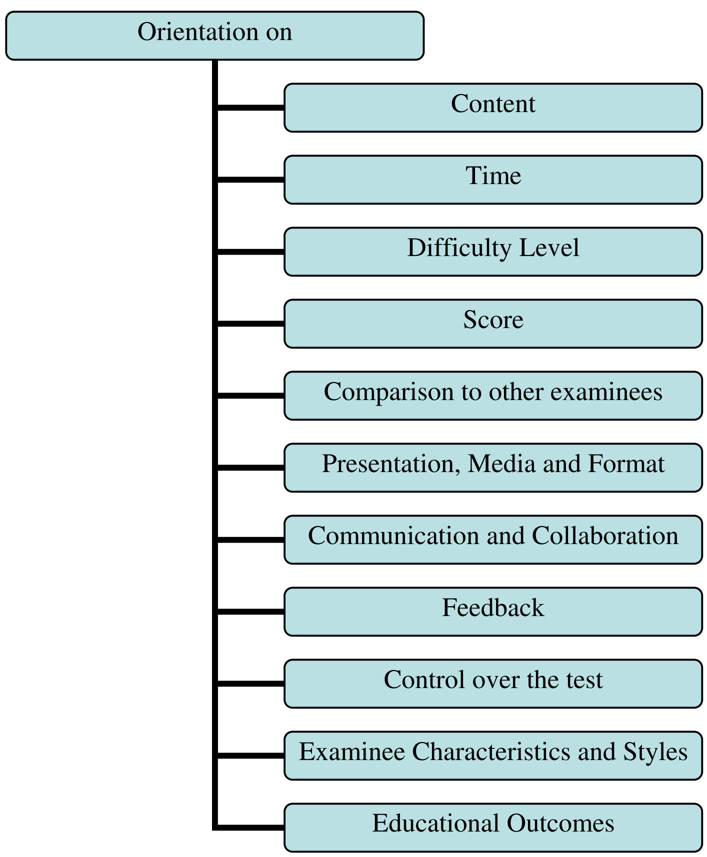

Diagram 1: Orientation information areas.

The Orientation information may be shown to the examinee on directed or undirected Graphs, Plots, Timer, etc. It is of major importance that the orientation information does not distract the examinee, rather it supports her. So, the appropriate orientation information should be shown to the examinee according to the examinee's state. Thus, the adaptation engine should monitor the examinee and adjust the orientation information shown to her.

III. Adaptation methods for presenting the Orientation information

Depending on the examinee's state, the adaptation engine would control the following parameters: i) Amount of orientation information, ii) Timing of presenting orientation information, iii) Locality of orientation information, and iv) Area of orientation information to be shown to the examinee. Next, we describe adaptation methods that may be used to control these parameters (Diagram 2). For example, starting with no orientation information the Adding & Generating method may present some orientation information. The Removing method may remove some of this. The Deactivating, Disabling & Hiding method may temporarily hide part of the supplied orientation information. The Activating method may activate some of the hidden orientation information. The Annotation may supplement the orientation information with further annotations explicitly describing the examinee's current status. The Highlighting method may underline some of the presented orientation information. The Ordering & Sorting would order the orientation information. For example, the Items would be sorted with respect to: 1) Score, or 2) Difficulty Level, or 3) Media & Format, or 4) Learning Characteristics, or 5) Educational Outcomes.

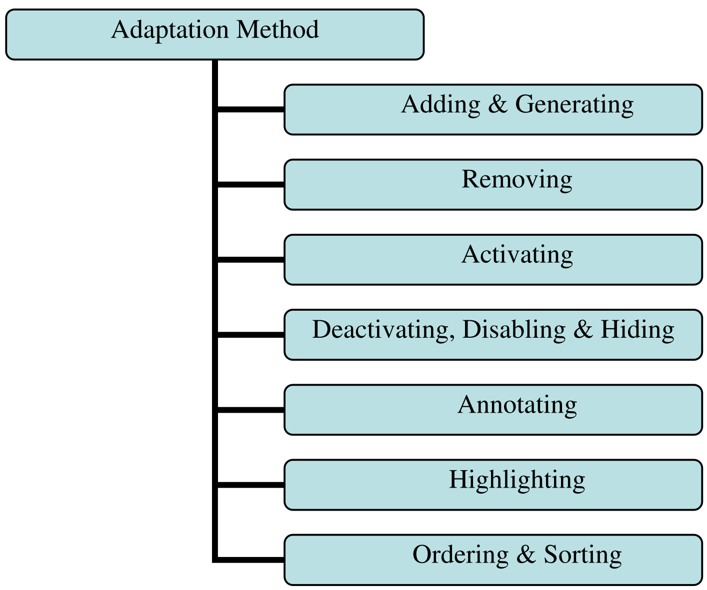

Diagram 2: Adaptation methods.

Furthermore, these adaptation methods may be applied whenever a special condition is met. Such *conditions* may be the following:

- Achieved Score above or below a threshold.
- Number of Items presented to the examinee above or below a threshold.
- Number of Correct Answers above or below a threshold.
- Number of Wrong Answers above or below a threshold.
- Rate of Correct Answers above or below a threshold.
- Rate of Wrong Answers above or below a threshold.
- Max achieved Difficulty Level above a threshold.
- Min achieved Difficulty Level below a threshold.
- Examinee Preferences match a specific model.
- Learning Characteristics match a specific model.
- Educational Outcomes match a specific model.

IV. Orientation Example

Thus, the adaptation engine applies the above adaptation methods to the orientation information, in order to effectively support the examinee. For example, applying the Showing, Highlighting and/or Annotating methods results to the following cases:

- Show ALL, and Highlight/ Annotate CURRENT.
- Show ALL, and Highlight/ Annotate FOLLOWED PATH.
- Show FOLLOWED PATH, and Highlight CURRENT.
- Show NEIGHBORS, and Highlight/ Annotate CURRENT.
- Highlight/ Annotate CURRENT.

Next, we elaborate further this example for various orientation information areas. We consider orientation with respect to information on the Subtopics, Items, Difficulty Levels, Time, and Scoring.

A. Subtopics orientation

Show the organization of all Subtopics, and Highlight and/or Annotate

- o the followed Subtopics path, or
- o the current Subtopic, or
- o the Subtopics for which a condition is met.

Show the followed Subtopics path, and Highlight and/or Annotate

- o the current Subtopic, or
- o the Subtopics for which a condition is met.

Show the followed Subtopics path and the remaining Subtopics, and Highlight and/or Annotate

- o the current Subtopic, or
- o the Subtopics for which a condition is met.

Show the parent and child Subtopics, and Highlight and/or Annotate the current Subtopic,

- Show and/or Annotate only the current Subtopic.

B. Items orientation

Show the organization of Items within the current Subtopic, and Highlight and/or Annotate

- o the followed Item path, or
- o the current Item, or
- o the Items for which a condition is met.

Show the followed Item path within the current Subtopic, and Highlight and/or Annotate

- o the current Item, or
- o the Items for which a condition is met.

Show the followed Item path and the remaining Items within the current Subtopic, and Highlight and/or Annotate

- o the current Item, or
- o the Items for which a condition is met.

Show the parent and child Items, and Highlight and/or Annotate the current Item.
Show and/or Annotate only the current Item.
Show the followed Subtopics path and the number of Items presented within each Subtopic, and Highlight and/or Annotate

- o the number of Items presented within the current Subtopic, or
- o the number of Items presented for which a condition is met.

Show the followed Subtopics path with the number of Items presented within each Subtopic and the remaining Subtopics with the estimated number of Items to be presented within each Subtopic, and Highlight and/or Annotate

- o the number of Items presented and the estimated number of Items to be presented within the current Subtopic, or
- o the number of Items presented and the estimated number of Items to be presented for which a condition is met.

Show/Plot the number of Items presented for each Subtopic covered, and Highlight and/or Annotate

- o the number of Items presented within the current Subtopic, or
- o the number of Items presented for which a condition is met.

Show/Plot and/or Annotate the number of Items presented and the estimated number of Items to be presented within the current Subtopic.
Show/Plot and/or Annotate the number of Items presented within the current Subtopic.
Show/Plot and/or Annotate the number of Items presented for which a condition is met within the current Subtopic.
Show and/or Annotate Alternative Versions of the current Item.
Show and/or Annotate Similar Items to the current Item.
Show and/or Annotate Related Items to the current Item.
Show and/or Annotate Items with one step lower Difficulty Level than the current Item.
Show and/or Annotate Items with one step higher Difficulty Level than the current Item.

C. Difficulty Level (DL) orientation
Show/ Plot the followed Difficulty Level path for each Subtopic covered, and Highlight and/or Annotate

- the Difficulty Level path for the current Subtopic, or
- the average Difficulty Level for the current Subtopic.

Show/Plot the followed Difficulty Level path within the current Subtopic, and Highlight and/or Annotate the Difficulty Level for the current Item.
Show and/or Annotate the Difficulty Level for the current Item.
Show the minimum, maximum and average achieved Difficulty Level for each Subtopic, and Highlight and/or Annotate these for the current Subtopic.

D. Time orientation
Show/Plot the followed Item Time path for each Subtopic covered, and Highlight and/or Annotate

- the Item Time path for the current Subtopic, or
- the average Item Time for the current Subtopic, or
- the current Item Time.

Show/Plot the followed Item Time path within the current Subtopic, and Highlight and/or Annotate

- the current Item Time,
- the average Item Time.

Show/Plot the followed Subtopic Time for each Subtopic covered, and Highlight and/or Annotate the Time passed and the Time remaining for the current Subtopic and/or the total E-Assessment.
Show and/or Annotate the current Item Time.
Show and/or Annotate the current Subtopic Time.
Show and/or Annotate the minimum, maximum, average Item Time.
Show and/or Annotate the minimum, maximum, average Subtopic Time.
Show/Plot the followed average Item Time for each Subtopic covered, Highlight and/or Annotate the average Item Time for the current Subtopic.
Show the average Subtopic Time, Highlight and/or Annotate the current Subtopic Time.

E. Scoring orientation
Show/Plot the followed Item Score path for each Subtopic covered, and Highlight and/or Annotate

- the followed Item Score path within the current Subtopic, or
- the average Item Score within the current Subtopic, or
- the current Item Score, or
- the Total Score.

Show/Plot the average Item Score path for each Subtopic covered, and Highlight and/or Annotate

- the average Item Score within the current Subtopic, or
- the current Item Score, or
- the Total Score.

Show/Plot the followed Subtopic Score path, and Highlight and/or Annotate

- the current Subtopic Score, or
- the average Subtopic Score.

Show/Plot the followed Subtopic Score path, and Highlight and/or Annotate the Total Score.
Show the average Subtopic Score, and Highlight and/or Annotate

- the current Subtopic Score, or
- the Total Score.

Show the followed Item Score path within the current Subtopic, and Highlight and/or Annotate

- the current Item Score, or
- the average Item Score within the current Subtopic, or
- the Total Score.

Show the current Item Score within the current Subtopic, and Highlight and/or Annotate

- the current Item Score, or
- the Total Score.

Show and/or Annotate the current Item Score and the Total Score.
Show and/or Annotate the current Subtopic Score and the total Score.
Show and/or Annotate the minimum, maximum, average Item Score and Total Score.
Show and/or Annotate the minimum, maximum, average Subtopic Score and Total Score.
Show and/or Annotate the opportunities for next Item options to choose.

V. Conclusions

In CAT (Computer Adaptive Testing), it would be beneficial for the examinee to know her current status. For example, if the examinee knows her current score or the next subtopic to be tested, then she would design and apply her testing strategies appropriately. This paper presents the various areas of orientation information that would be available to the examinee. The CAT system may show to the examinee orientation information on any of the following areas: Content, Time, Difficulty Level, Score, Comparison to others, Presentation, Media & Format, Communication & Collaboration, Feedback, Control, Examinee Characteristics, and Educational Outcomes. However, some users may need a lot of orientation, while others may need minimum orientation. So, another issue is how to control the presentation of this orientation information. The paper presents methods to adapt the orientation information to the examinee. The CAT system may adapt the orientation information using the following methods: Activating, Adding & Generating, Deactivating, Disabling & Hiding, Removing, Annotating, Highlighting, Ordering & Sorting. A comprehensive example is given to show the various areas of orientation information that would be available to the examinee.

References

Di Challis (2003). ‘Committing to quality learning through adaptive online assessment’. In *Proceedings Second ATN Evaluations and Assessment Conference*, 2003.

Heraud, J.-M. (2004). ‘A Web-based adaptive educational system where adaptive navigation is guided by experience reuse’. J.C. Lester eta al. (Eds.): *ITS 2004*, LNCS 3220, pp. 824-826, Springer-Verlag Berlin Heidelberg.

Kinshuk and Lin, T. (2003). ‘User exploration based adaptation in adaptive learning systems’. *International Journal of Information Systems in Education*, 1 (1), pp. 22-31, 2003.

Linden, W. and Hambleton, R. (Eds.), (1996). *Handbook of modern item response theory.* Springer-Verlag 1996.

Sri Krishna, T.M. (2001). ’Web-based adaptive testing’. *Learning Technology newsletter*, Vol. 3, Issue 3, pp. 44-47, July 2001.

Stauffer, S. and Kenyon, D. (2001). ‘A computer-assisted, computer-adaptive oral proficiency assessment instrument prototype’. In *Proceedings of the 23rd Annual Language Testing Research Colloquium*, p. 62, 2001.

Wainer, H et al. (2000). *Computer Adaptive Testing*. Second Edition. London: Lawrence Erlbaum Associates, Inc.

Weber, G. and Brusilovsky, P. (2001). ‘ELM-ART versatile system for web-based instruction’. I*nternational Journal of Artificial Intelligence in Education*, Vol. 12, pp. 351-384, 2001.

Yudelson, M., Brusilovsky, P. and Sosnovsky, S. (2004). ‘Accessing interactive examples with adaptive navigation support’. *Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT 2004).*