EVIDENCE-CENTERED DESIGN AND FOUR PROCESS ARCHITECTURE FOR SIMULATION BASED ICT LITERACY ASSESSMENT

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ABSTRACT

The paper describes the innovative ICT literacy measure that that was created based on the Evidence Centered Design (ECD) principals together with automatic Bayesian Network scoring. System. The measure was developed within World Bank READ program in Russia which sought to develop contemporary problem-based and scenario-based approach to ICT literacy assessment for multinational secondary school environment. It was implemented on a sub-national scale in Russia during 2005-2013 and piloted for international use in United Kingdom, Armenia, and Tatarstan with strong support by the Government of Russia, Republic of Tatarstan, Armenia and the World Bank.

The ECD and the Four-process Delivery Architecture that that brought the computer-based ICT literacy assessment to life will be used as the framework for discussion: The activity selection process- selects a task or activity from the task library, or creates one in accordance with templates in light of what is known about the student or the situation and describes the interrelationships between processes for an adaptive test.

The presentation process is responsible for computerized presentations of tasks to the student, managing the interaction, and capturing work products such as Web delivery of ICT literacy assessment.

The summary scoring process is responsible for measurement models and concerns with the accumulation and synthesis of evidence across ICT tasks, in terms of student model variables described by ECD. Bayesian Network models used for this purpose. The response processing is responsible for automatically identifying the key features of the observable outcomes for one particular task. The ECD evidence rules that specified how this is to be accomplished will be discussed.

Introduction

The paper begins by describing the four-process delivery system architecture. We will provide a brief overview of the key elements of the ECD design of ICTL assessment upon which the four-process architecture system is based. Finally, an example of ICTL assessment will illustrate how the design and delivery of ICTL tasks is fulfilling the assessment purposes.

1. The Four Processes Delivery System Architecture For ICTL Assessment

ICTL assessment has four distinct processes such as selection, presentation, response, and summary.

- The Selection is the process responsible for test assembly (selecting and sequencing tasks) from the Task Bank .
- The Presentation is responsible for presenting the task to the test takers by using images, audio, etc. At this stage evidences about test taker responses are collected.
- The Processing is a step in the scoring. It provides evidence about test takers ICTL level.
- The Summary is one more step in the scoring process. It uses the collected evidences to update the our beliefs about the participant's ICTL level.

The interaction of these four processes constitutes an ICTL assessment cycle that is shown in Figure 1 below.

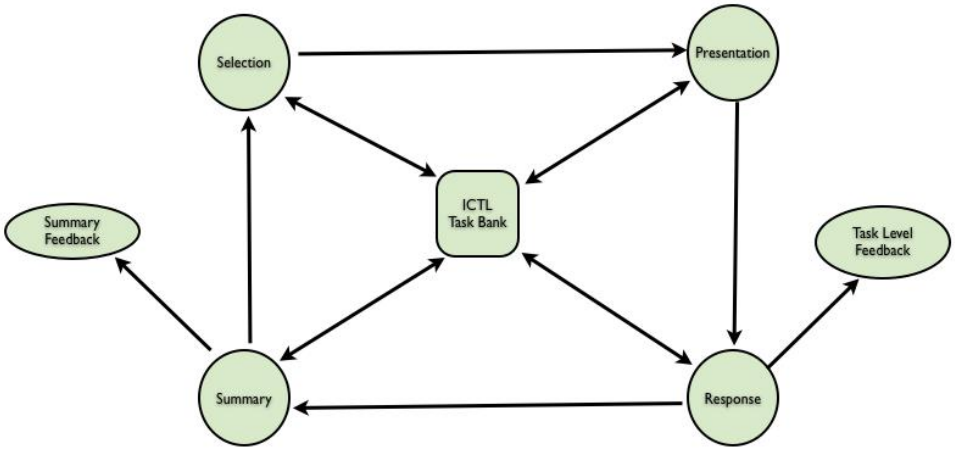

Figure 1. The four principle processes in the ICTL assessment cycle.

In Figure 1, the Selection Process selects an ICTL task (scenario based task) and directs the Presentation Process to display it on a computer screen. When a test taker has completed the task, the Presentation Process sends evidences of how the test taker interacted with the task to Response Processing. This process identifies essential evidences of observed behavior of a test taker during an interaction with the ICTL task and passes these evidences to the Summary Process. At this stage we are updating our beliefs about the test taker's ICTL proficiency level. Finally, the Selection Process makes a decision based on the current beliefs about ICTL proficiency level of a test taker and about what ICTL task should be selected next.

This four principle processes in the ICTL assessment cycle uses computers and run real-time concurrently in an asynchronous mode with an examinee taking a test. Once the Presentation Process is told to start a task, it generates a new Work Product whenever the test taker finishes a certain part of the task. Based on messages it may receive from any of the four processes, the Selection Process decides whether to let the current activities continue, to send a message requesting a new activity, or to make inquiries of the Scoring Record for updated estimates of test takers' ICTL proficiency level.

Such flexible sequencing of the four processes via messaging and separation of Response Processing from Summary Processing are making possible for ICTL assessment to generate Task-level Feedback and Summary Feedback.

Task-Level Feedback is an immediate response to a test taker interaction with a particular ICTL task. For example, in ICTL assessment the Response Processing performs diagnostic evaluation of a test taker. Then the Response Processing works together with related Selection Processing and indicates the correct answer after the response to a task or a part of the task was submitted, to suggest an alternative approach, or to explain how to solve the task and points common misconceptions. Task-level feedback in ICTL assessment is generated for real-time use during assessment administration.

For summative purposes, the Summary Processing in ICTL assessment reports beliefs about ICTL level of a test taker. This summative report is based on evidence from interaction of a test taker with multiple tasks (i.e., based on combined evidence from responses to any number of ICTL tasks.).

Now let's take a close look at the Task/Evidence Bank as it is a central part of the four principle processes in the ICTL assessment cycle, as shown in Fig 1.

2. Task/Evidence Bank

The Task/Evidence Bank is a database of ICTL tasks along with all the information necessary to select, present, and score the task. The bank contains information that required to:

- Characterize tasks. This information is used by Selection Process and it is coined by Russell G. Almond and Robert J. Mislevy as the Task Description Properties.
- Present tasks (e.g., font size, tools, etc.). This information is used by the Presentation Process and is coined by Russell G. Almond and Robert J. Mislevy as the Task Materials and Environment Variables.
- Extract and evaluate the salient characteristics by employing rubrics and solution data. This information is used by Response Processing and is coined by Russell G. Almond and Robert J. Mislevy as the Evidence Rule Data.
- Update a test taker's Scoring Record (scoring weights and conditional probabilities) by combining Weights of Evidence with observations from ICTL task responses. This information is coined by Russell G. Almond and Robert J. Mislevy as Weight of Evidence Parameters.

Figure 2 below shows Task/Evidence Bank for ICTL assessment.

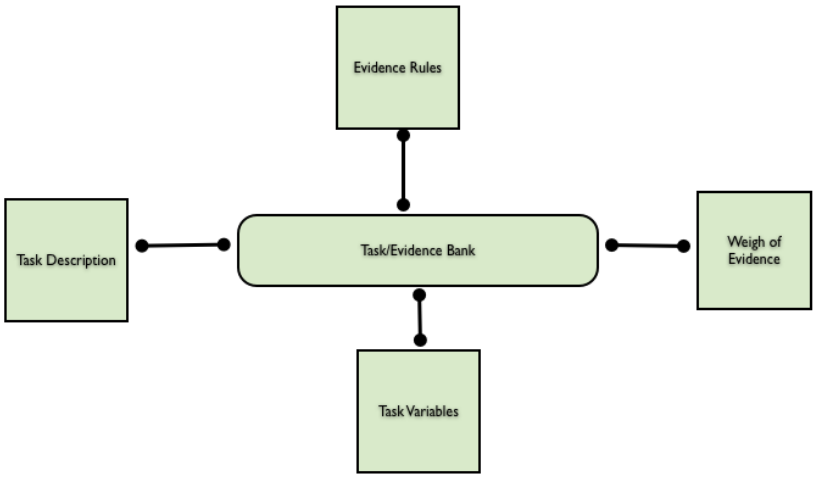

Figure 2. Task/Evidence

As shown in Figure 2, the Task/Evidence Bank stores the four kinds of information. Task Description is used by the Selection Process; Task Variable is used by the Presentation Process; Evidence Rule is used by Response Processing; Weight of Evidence is used by the Summary Process.

3. Evidence Centered Design (ECD) for the four principle processes in the ICTL assessment cycle.

The ECD framework provided a convenient structure for informing the specifications for each process of the ICTL assessment cycle and consists of six different models that specify a variety of information that is needed by the four processes to deliver the ICTL assessment (see Zelman, et al., 2011, p. 3). The responses in ICTL assessment are evaluated as summative and diagnostic. Working through the design process of ICTL assessment, we identified the claims, evidence, and tasks for the given assessment purpose and combine these requirements with the constraints (i.e., delivery to a large population of test-takers with a limited amount of time) specific for ICTL assessment.

The Student Model, mentioned above, represented what ICTL proficiencies we are measuring and what is Overall ICTL proficiency level. Task Model, mentioned above, is used to accumulate information across tasks and is capable of providing detailed task-level diagnostic feedback. Evidence to support inferences related to ICTL mastery is evaluated by the Evidence Model, mentioned above. In this Evidence Model, an algorithm matches a selected response containing the desired evidence against specifications for answer keys (Evidence Rule) to produce values " High", " Medium", and " Low." in order to reflect requirements for diagnosis. Information from multiple observables is used to update the student model variable.

At the same time the four principle processes in the ICTL assessment cycle goes through the four assessment processes as follows:

I. Start with the Selection Process by fulfilling the administrative requirements and selecting the next task from the Task/Evidence Bank.

II. The Selection Process has selected a task and sends an instruction to the Presentation Process. The Presentation Process uses the Task Model to determine which Presentation Material is expected for this task and what Work Products will be produced.

III. Response Processing consults the Evidence Rule to ascertain the "key," for this task by setting the Observables to appropriate values representing different diagnostic outcomes.

IV. The Summary Process takes the Observable and uses it to update the Scoring Record. At this stage ICTL assessment cycle determines how much beliefs about ICTL proficiencies of a test taker should be changed and which variables in the Scoring Record are affected by this change. This is accomplished by employing Bayesian Networks which implements successive updating of the probability distribution that reflects our current belief about ICTL proficiency of a test taker.

V. The Selection Process can now select the next task, or stop.

Figure3 below illustrates how components are used for ICTL assessment.

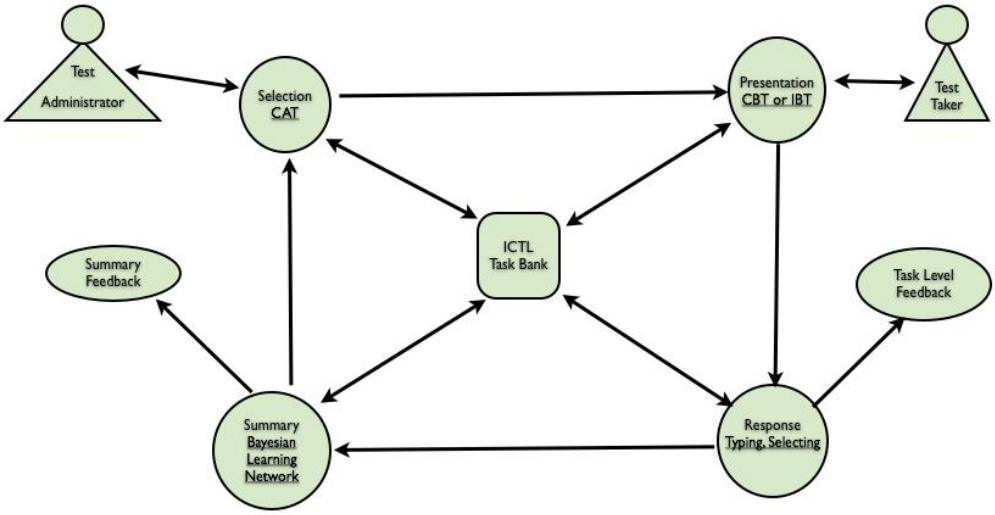

Figure 3. The assessment cycle specialized for ICTL assessment

The processes showed in Figure 3 enable ICTL assessment to provide diagnostic task-based and summative feedback via accumulation of evidence about multiple ICT proficiencies.

As was mentioned above, the ICTL assessment is fulfilling summative and formative purposes. The four principle processes in the ICTL assessment cycle allow to implement this multipurpose approach to ICTL assessment by linking different instances of the same collection of generic objects. We will describe the linking in grater details using ICTL assessment Evidence Model as shown in Figure 4.

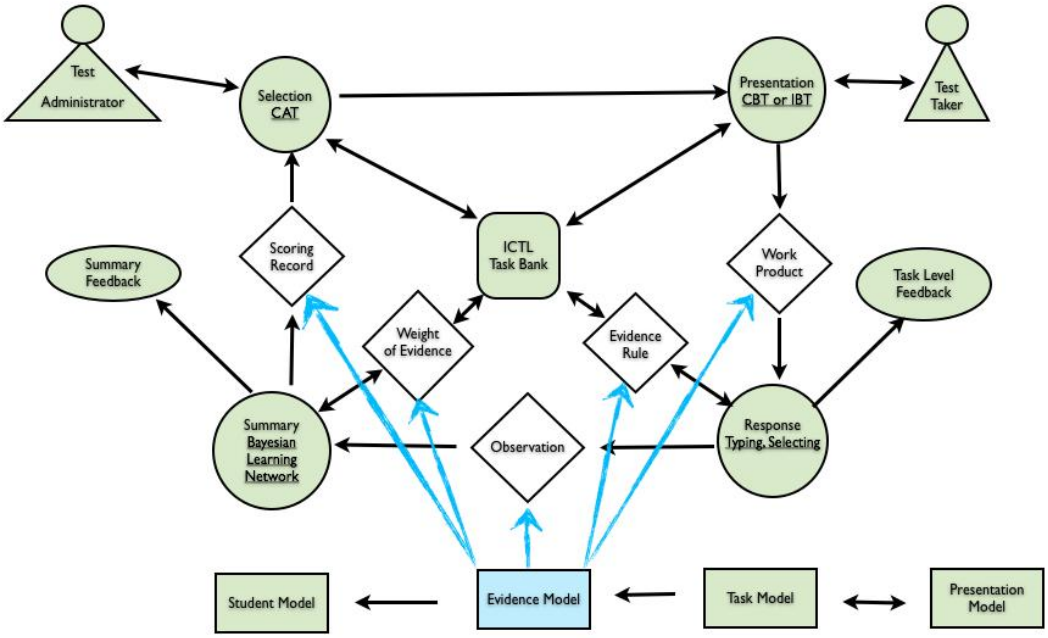

Figure 4. The ICTL Assessment Evidence Model

This Evidence Model describes both the observations and the data that are needed for those observations by updating the Scoring Records in light of the Weights of Evidence (i.e., observations). As Figure 4 shows, some of the observations and the data that Evidence Model contains are Observable Variables (Observations) , Evidence Rules, and Weights of Evidence.

When ICTL assessment is used as a summative instrument (i.e., is used for estimating overall ICTL proficiency level) the only Student Model Variable that is updated is an overall ICTL proficiency measure. The only Observable Variable that needs to be extracted is whether a response is scored as “High”, “ Medium”, or “Low”.

Conclusion

Designing ICTL scenario based assessment is a very difficult endeavor. Among many issues that test designers of ICTL assessment had to face are problems related to psychology, psychometric modeling, and fulfillment of multiple purposes. To resolve these issues and make the process of developing ICTL assessment efficient and feasible, we used the four principle architecture processes and ECD in the ICTL assessment cycle. This approach allowed us to develop valid and reliable ICTL assessment that fulfills multiple purposes by simply different linkages of instances from the same collection of generic objects.

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