

This is the abstract (pre-review) for a conference presentation. It has been altered slightly from the submitted version by: (1) removing authors' email addresses; (2) adding this note. The citation for the published work is:

W. J. WILSON, B. GALEMA, G. HAVERLUCK, "Adaptive Computer Based Training – Explorations, Experience, and Future Directions", *Proc. Conf. on Nuclear Training and Education: A Biennial International Forum (CONTE 2021)*, online (virtual), February 9–11, 2021, p. 15, American Nuclear Society (2021).

## **Adaptive Computer Based Training – Explorations, Experience, and Future Directions**

William J. Wilson, Blessile Galema, and Gord Haverluck

*Ontario Power Generation; 675 Sandy Beach Rd; Pickering, ON L1W 3X5; Canada*

### **INTRODUCTION**

What's the most effective and efficient form of instruction? From a learner's perspective, it's one-to-one tutoring because a tutor continuously adapts to the learner. [1]

Computer Based Training (CBT) also involves just one learner. It's often designed in a "one-size-fits-all" fashion, which can be effective for most trainees. [2] But is it efficient for all of them? Also, is a CBT that's suitable for a novice appropriate for a more advanced trainee? [3]

At Ontario Power Generation (OPG), we wanted to see if we could improve CBT efficiency using adaptive methods – without reducing effectiveness. We targeted two CBT courses for evaluation using simple bypass-oriented adaption methods.

We also developed some advanced adaption methods that should yield more benefits. They're targeted at fine-grained adjustment of content delivery.

### **DESCRIPTION OF THE ACTUAL WORK**

#### **Adaption Using Challenge Pre-Tests**

Every OPG Nuclear employee takes Nuclear General Employee Training (NGET) biennially. NGET includes an Initial CBT (for new employees) and a Continuing Training CBT. We evaluated the use of comprehensive challenge pre-tests in the Continuing Training CBT.

This CBT has 10 learning modules on a variety of topics (e.g., Human Performance, Safety Awareness). In April 2020, optional pre-tests were added to each module. In some cases, the pre-test followed a limited amount of training material.

The pre-tests all had passing marks of 90% and were more comprehensive and challenging than the exercises that could be bypassed.

#### **Adaption Using Training History**

Our Work Protection (Lockout/Tagout) process comprises several different personnel roles. One, termed

Holder of Record (HoR), is responsible for Worker safety inside an isolation boundary. A HoR also has workgroup coordination duties.

Another role exists to assist HoRs: the Work Group Coordinator (WGC). They can perform HoR duties having no direct impact on Worker safety.

A WGC has few prerequisite qualifications, but many WGCs also have HoR training. There are thus two distinct populations. One needs to learn the WGC and HoR responsibilities. The other only needs to learn WGC limitations.

We created a CBT in October 2019 to replace an existing WGC course. It checks training records for HoR credits within the past three years. If found, optional bypasses are enabled that allow trainees to skip ~40% of the CBT. All trainees complete the same final checkout.

#### **Recently Completed Work**

The preceding methods are coarse-grained. We also wanted fine-grained adaption, so we developed additional methods. One of these is the CBT Inline Question (CBTIQ). A CBTIQ:

- is inserted into CBT text content;
- appears as a blank to fill or complete, acting as a:
  - short-answer question;
  - short-answer question with a clue (cued recall); or
  - multiple-choice field;
- falls back – from short answer to cued recall to multiple choice – when answered incorrectly;
- optionally reveals content and/or calls a custom function when processing answer attempts;
- allows different content and/or a different function for each answer choice.

The CBTIQ facilitates many forms of adaption. It can show remedial content, select a learning path, or allow learner choice. It's perfectly suited to CBT implementation of Intrinsic Programming, originally modeled after the pupil-tutor relationship. [4]

We also designed an Adaptive Confidence Model (ACM) to complement the CBTIQ. It loosely simulates a

storage/retrieval-strength model of memory and learning. [5]

- A fast-changing confidence component  $C$  represents the trainee's current ability for correct recall. It increases or decreases quickly and decays to a baseline value  $B$  in 3 days if not otherwise updated. Its rate of change slows as it approaches the maximum value of 1.
- The baseline component  $B$  can only increase, but does so slowly. It represents the trainee's long-term mastery of a learning objective or micro-objective. Its rate of increase depends on its proximity to  $C$ .
- A trainee could raise  $C$  from 0.70 (the initial guess) to 0.95 in a day. That might result in  $B$  reaching 0.85. Achieving a  $B$  value of 0.95, however, could take years. (0.99 could take decades.)

The combination of CBTIQ and ACM is powerful. A CBTIQ can update the ACM and the ACM can change CBTIQ style. *The difficulty of a CBTIQ can thus be ramped up or down on the fly.*

Another potential use of the ACM is determining if a trainee should be provided a *worked example*, *completion problem*, or a full problem to solve. Choosing correctly can avoid overwhelming the trainee or triggering the expertise reversal effect. [3]

The ACM works with other exercises and activities. We recently added ACM hooks to our standard quiz engine. We plan to do the same for our other standard exercise types. Custom activities can also use the ACM.

## RESULTS

We saw positive results for the two CBTs using simple bypass-oriented adaption. Trainees benefitting from adaption reduced their training times by 30-40%. Overall savings were 20-25%.

Trainees experiencing adaptive delivery demonstrated higher performance. The NGET pre-tests were more comprehensive and challenging than the regular exercises. WGC trainees that bypassed material achieved higher scores (on average) on their checkouts.

Advanced adaption methods were developed and deployed in September 2020. We're adding them to CBTs now. Some practical results should be available by January 2021.

## CONCLUSIONS

Using adaptive methods in CBTs can yield significant increases in training efficiency and might increase effectiveness. Even very simple, coarse-grained methods can yield big gains.

## REFERENCES

1. B.S. BLOOM, "The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring", *Educational Researcher*, **Vol. 13**, No. 6, pg. 4 (1984).
2. W. THALHEIMER, "Does eLearning Work? What the Scientific Research Says!", <https://www.worklearning.com/wp-content/uploads/2017/10/Does-eLearning-Work-Full-Research-Report-FINAL2.pdf>, Work-Learning Research (2017).
3. J. SWELLER, J.J.G. VAN MERRIËNBOER, F. PAAS, "Cognitive Architecture and Instructional Design: 20 Years Later", *Educational Psychology Review*, **31**, pg. 261 (2019).
4. R.E. WALTHER & N. CROWDER, "A Guide to Preparing Intrinsically Programmed Instructional Materials", AMRL-TR-65-43, Wright-Patterson Air Force Base: Aerospace Medical Research Laboratories (1965).
5. R.A. BJORK & E.L. BJORK, "A New Theory of Disuse and an Old Theory of Stimulus Fluctuation", *From Learning Processes to Cognitive Processes: Essays in Honor of William K. Estes*, **Vol. 2**, pg. 35 (1992).