

Key Findings From Simulation and Technology Research

Ronald Dietel, William L. Bewley, Gregory K.W.K. Chung,
Terry Vendlinski¹, and John J. Lee.

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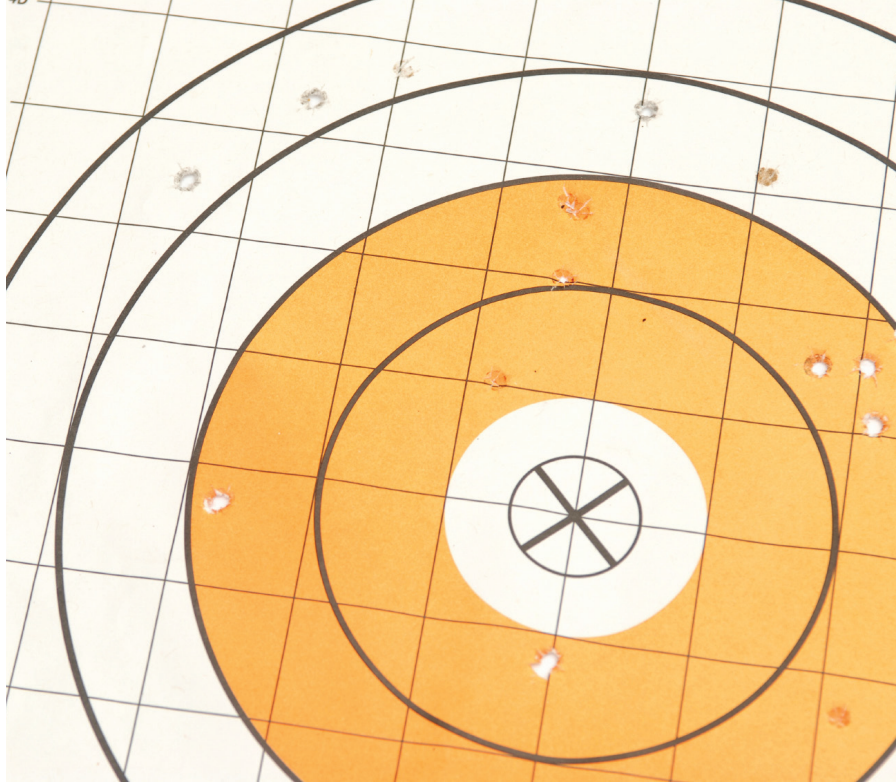
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Your objective: To hit a 19-inch target at 500 yards. That length is five football fields added together without the end zones. It's also a "standard" requirement for a U.S. Marine without a scope. A deflection of 1/16" inch (the thickness of a quarter) will produce a 2-foot miss, which is the same for a gentle 10 mile per hour breeze. Gravity alone causes a drop of more than 20 inches. Combine each error—we haven't mentioned breathing, recoil, or differences in bullets themselves—and a miss is nearly guaranteed.

Mission impossible? Not necessarily—especially if you have instruction, technology, and assessment that operate as a comprehensive learning system.

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Several years ago, the Office of Naval Research asked CRESST to help the Marine Corps improve their rifle marksmanship-training program, which has remained virtually the same since the early 1900's (Chung, et al, 2006). In fact, the Marine Corps training manuals of 1916 focused on nearly the same rifle skills—including posture, rifle handling, distance, and weather—as they do today (Harllee, 1916; U.S. Marine Corps, 2001). The CRESST research and development team from this project produced critical lessons that can be applied to today's increased use of computer games and simulations for learning. Those applications potentially include measuring K-12 student performance in reaching the Common Core State Standards, as well as applications for adult learning including medical and psychological applications.

¹A former CRESST senior researcher, Terry Vendlinski is now the Co-director of Assessment Research and Design in the Center for Technology in Learning, Stanford Research Institute.

Lessons From A Marksmanship Research Project

In the late 1980s and early 1990s, Eva Baker developed an assessment model that has been successfully applied to a broad scope of assessment and learning systems (1998). The model includes five cognitive demands shown in Figure 1, which represent a broad number of important skills. The five categories include content understanding, teamwork and collaboration, problem solving, communication, and metacognition (thinking about our thinking).

In our marksmanship project, for example, CRESST found that content understanding, sometimes called prior knowledge, showed a positive relation to marksmanship skills. Shooters with knowledge of breath control, sight adjustments and range effects consistently outperformed a control group of shooters who only practiced. Our results also confirmed several previous studies' findings (Boyce, 1987; Thompson et al, 1980; and Cline, Beals, & Seidman, 1960).

CRESST then used a sensor-based assessment system to measure the factors that differentiated between expert shooters and non-experts, including sensors that monitored breathing and trigger squeeze, plus muzzle movement. By assimilating and analyzing the sensor data, researchers could even reasonably predict where the bullet would hit the target. They also used the information to help improve the training of the marksmanship coaches.

Key Findings

- Deep content understanding has a positive effect on both student performance and teaching.
- Sensors can be used to increase student performance, assessment accuracy, and assessment efficiency.
- Simulations can be used to improve performance, rating accuracy, and coaching.
- Simulation-based assessments can produce reliable measures of high-level performance skills.
- Computer games can be used to increase student math performance; however, they may need to be adapted to current student proficiency.

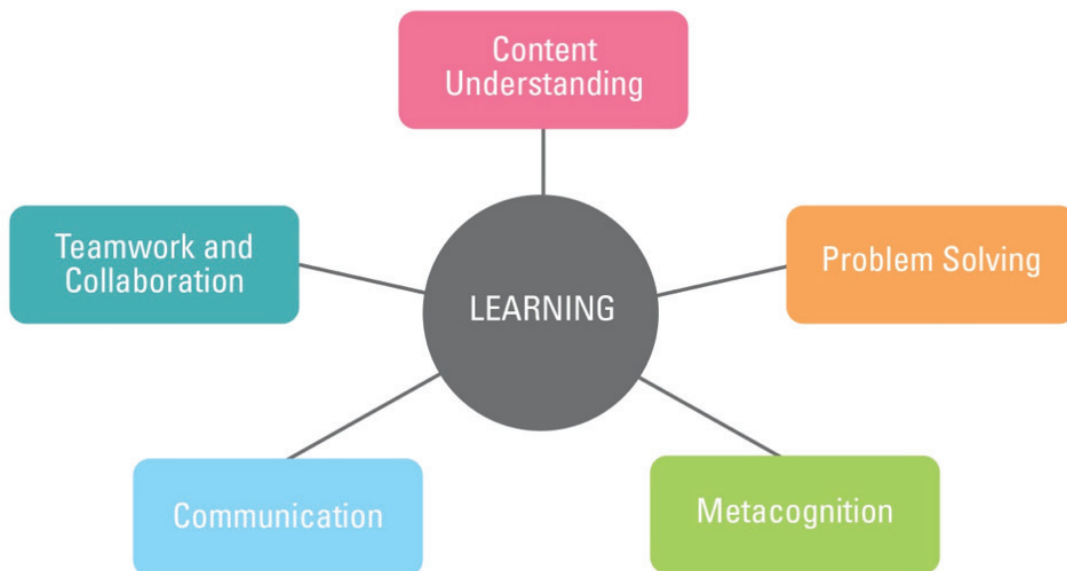


Figure 1. Model-based assessment example.

CRESST found that more knowledgeable coaches, i.e., those with deeper content understanding, generally provided guidance that improved shooter performance (more than coaches with less content knowledge). This is similar to many K-12 research studies, which have found that student achievement is strongly correlated to years of teaching experience.

CRESST researchers also found that sensors can help improve the interpretation of the shooter's performance. Traditionally, a shooter and coach review a target after a shooting session. The coach applies his or her expertise on what may have caused a specific pattern of shots. The sensor information, with data on breathing, trigger control, and rifle movement—provides additional data to help confirm or adjust the coach's interpretation of the target results. The coach and shooter use that information to make specific changes to improve performance.

Finally, CRESST researchers were able to develop a marksmanship simulation that can be done in virtually any location and without even firing actual rounds. The potential for greater efficiency and cost savings is substantial.

Lessons From Combat Information Center Simulation Research

CRESST measured the cognitive demands of communications and problem solving (also in the CRESST model) in another Navy research project, a computer-based assessment tool used to assess the performance of Navy Tactical Action Officers (TAOs) operating in a simulated Combat Information Center. The TAOs are responsible for tactical employment and defense of a Navy ship. During the simulation, they must respond to a number of threats, including enemy aircraft and submarines, quickly analyze multiple sources of data, and then use their knowledge of tactics and problem solving skills to defend the ship. During the simulation, communications with other ship personnel must be timely, accurate, and selective to only the most relevant details, while following prescribed procedures.

The CRESST TAO Assessment Tool, used by raters in the Navy's Multi-Mission Team Trainer, measures every decision that the TAO makes, as well as the elapsed time and sequence of events, and performance skills such as situation awareness and decision making. As with the rifle marksmanship project, the CRESST assessment tool provides raters and trainees with additional data to increase the dependability of the scores. Another advantage of the simulation is that it can measure a

broader range of skills and knowledge than a more traditional assessment or rating method.

Specifically, CRESST found that:

- *Analyses showed that the TAO Assessment Tool accurately measured TAO knowledge and skills including situational awareness, decision making, tactics plan implementation, communications, and timeliness.*
- *TAO Assessment Tool scores were highly correlated with certain background measures associated with experience. Scores were higher for students with greater prior experience, supporting the validity of the measures.*
- *Scores were generally consistent across raters. High inter-rater reliability indicated that raters were able to use the TAO Assessment Tool to consistently apply the rating criteria.*

In sum, the TAO Assessment Tool provides the Navy with additional accurate data to support their existing rating methods.

CRESST and the Office of Naval Research were also interested in whether or not performance data could be used to predict future performance. For example, if a TAO did *this* or did *that*, how likely were they to do *this* next? CRESST developed a Bayesian network to model the Combat Information Center system, and then used it to help predict performance in a tactics planning simulation related to anti-submarine warfare (see Figure 2). The network can be used to improve training, learning, and the assessment system itself. A longer term goal is to enhance the computer simulation so that it is like having a coach sitting right on your shoulder, guiding a student or trainee to improved knowledge, skills, and performance.

Lessons From K-12 Mathematics Video Games

In the K-12 area, CRESST has developed a series of computer games to help students improve their math proficiency. Researchers were interested in taking advantage of students' inherent interest in video games to determine if schools could tap that motivation to help teach important mathematics skills, such as the addition and subtraction of fractions. An initial pilot study, however, showed that teachers, who seldom play computer games, needed assistance in learning how to integrate computer games into their instruction (T. P. Vendlinski, personal communication, August 10, 2012; Vendlinski, et al., 2011). Consequently, CRESST researchers added a

three-component process of professional development as follows:

- *Part 1 - Guided assistance in helping teachers understand key conceptual ideas and frequent student misconceptions.*
- *Part 2 - Time for teachers to play the video games, become comfortable with the video game format, and provide a shared experience between teachers to enhance their video game fluency.*
- *Part 3 - Guided assistance in helping teachers link the video game to their own mathematics instruction.* This part of the professional development allows teachers to reflect on the first two components and to work with other teachers in determining the best way to use video games in the classroom.

The results from the study were very informative.

First, CRESST found that the *math games*, even if used for just 40 minutes of a single class period, *could lead to improved achievement*. The games focused on several foundational math concepts and most students showed at least some improvement from a pre-test to a post-test.

Second, *incorporating mathematics instruction or feedback into the game generally did not produce significant learning gains*; however, instruction on how to play the game generally produced significant learning gains. This interesting finding supports other research that cautions about taking away the motivational fun in a game by adding too much instructional information (Charsky and Ressler, 2011).

Third, *different treatments of videogame instruction and feedback produced different results for different students* (see Table 1). In general, middle school algebra and sixth grade students (i.e., students on grade level in math) benefited more than other students if they played the version of the game without instructional priming and feedback. However, high school students who were approximately two years below grade level in math, benefited most from a combination of video instruction designed to help them incorporate math concepts into game play and the text-based feedback.

These findings, although from a modest sample size of students, suggest that games designed for learning

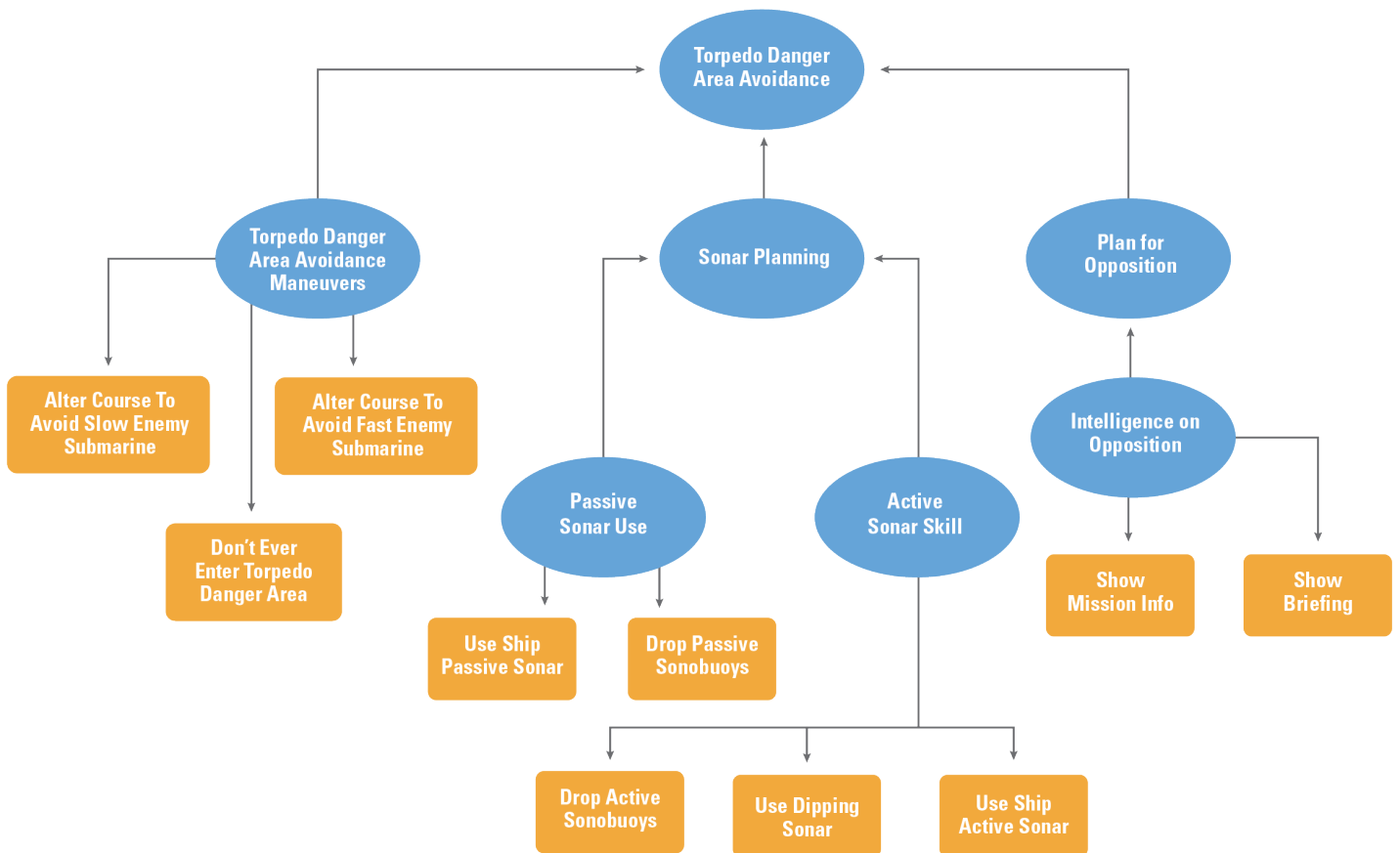


Figure 2. A Bayesian network for tactics planning.

Videogame Treatment	Pretest mean	Posttest mean	Significance level (p)
Middle school algebra students <i>Graphics-based game</i>	.85	.88	.009***
Sixth-grade students <i>Graphics-based game</i>	.55	.59	.011**
High school students <i>Pre-algebra level</i> <i>Video-based math instruction with</i> <i>graphics feedback</i>	.51	.58	.004***

* Statistical Significance Level: $p \leq .1$; ** Statistical Significance Level: $p \leq .05$; *** Statistical Significance Level: $p \leq .01$

Table 1. Student Gains from Pretest to Posttest Videogame Treatment by Class Type and Game.

may well need different versions for different types of students. Because students do not necessarily learn in the same way or at the same rate, differentiated games and feedback supports the concept of differentiated classroom instruction.

What Are Implications For The Future?

CRESST is applying the lessons from our technology research to other research efforts.

Researchers in our Center for Advanced Technology in Schools (CATS), for example, are applying our game learning systems to stimulate and assess young children's science learning, while analyzing principles of effective game development. We are also applying our rifle sensor techniques to assess medical procedural skills, developing simulators to help teach a variety of medical procedures such as prostate and vaginal exams.

CRESST researchers are creating comprehensive, next generation assessment systems. Grounded in ontologies of learning progressions, one CRESST system will support automated assessment development and administration, scoring and analysis, student monitoring and diagnosis, and access to instructional and professional development

resources. Another system, the CRESST Assessment Application (CAA), will automate assessment, which then can trigger instruction and learning to support military training simulations.

CRESST is also developing novel analytical methods to assess tools to help veterans and military personnel track their psychological well-being. Key goals include verifying and validating the tools' ability to detect subtle changes stemming from post-traumatic stress disorder and depression, as well as the improvement of psychological health through early detection.²

Mission possible.

² Our thanks to Roy Stripling for his input related to CRESST work currently in development.

References

- Baker, E. L. (1998). *Model-based performance assessment* (CSE Technical Report 465). Los Angeles, CA: University of California, National Center for Research on Evaluation, Standards, and Student Testing (CRESST).
- Boyce, B. A. (1987). Effect of two instructional strategies on acquisition of a shooting task. *Perceptual and Motor Skills*, 65, 1003-1010.
- Charsky, D., & Ressler, W. (2011). "Games are made for fun": Lessons on the effects of concept maps in the classroom use of computer games. *Computers & Education*, 56, 604-615.
- Chung, G. K. W. K., Delacruz, G. C., de Vries, L. F., Bewley, W. L., & Baker, E. L. (2006). New directions in rifle marksmanship research. *Military Psychology*, 18 (2), 161-179.
- Cline, V. B., Beals, A. R., & Seidman, D. (1960). Experimenting with accelerated training programs for men of various intelligence levels. *Educational and Psychological Measurement*, 20, 723-735.
- Harllee, W. C. (1916). *U.S. Marine Corps score book and rifleman's instructor*. Philadelphia: International Printing.
- Thompson, T. J., Smith, S., Morey, J. C., & Osborne, A. D. (1980). *Effectiveness of improved basic rifle marksmanship training programs* (Research Rep. No. 1255). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- U.S. Marine Corps. (2001). *Rifle marksmanship* (PCN 144 000091 00, MCRP 3-01A). Albany, GA: Author.
- Vendlinski, T. P., Chung, G. K. W. K., Binning, K. R., & Buschang, R. E. (2011). *Teaching rational number addition using video games: The effects of instructional variation* (CRESST Report No. 808). Los Angeles, CA: University of California, National Center for Research on Evaluation, Standards, and Student Testing (CRESST).