Operator Training with Simulator-Based Help in Quebec

Simulator-based Training of Forest Machine Operators
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Presentation Outline

- the forest industry in Canada and Quebec
- CTL operator training in Quebec
- operator variability, differences in human abilities
- simulator-based help for pre-screening and new operator preparation
- documenting added value
- "Personal Simulator" demonstrations
- conclusions

Canada's Forests

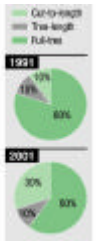
Quebec's Forests

- 765,000 km^2
- annual harvesting capacity of 55 M m^3
- 61 % softwood, 17% hardwood, 22% mixed forest
- 87% public lands, 11% private woodlots, 2% forestry company ownership
- forestry is Quebec's #1 industry (revenue, number of people employed, etc.)

Quebec's Forest Industry (2001)

- logging operations:
  - CAD$2.3B
  - 11,400 people
- sawmilling, pulp and paper:
  - CAD$10.4B
  - 83,000 people (1,419 sawmills, 64 pulp and paper mills) …in a population of ~ 6.5M people

Logging Industry Statistics (1) (2001, eastern Canada)

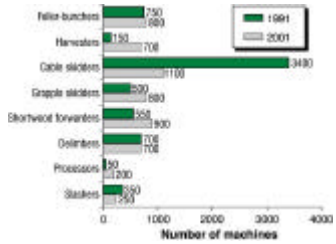


•The average timber volume is:

125 dm^3 – 4.4ft^3 - 20 bf
(based on 16' log)

We need 8 trees to get 1m^3 or 50 logs for 1 Mbf!

Logging Industry Statistics (2) (2001, eastern Canada)



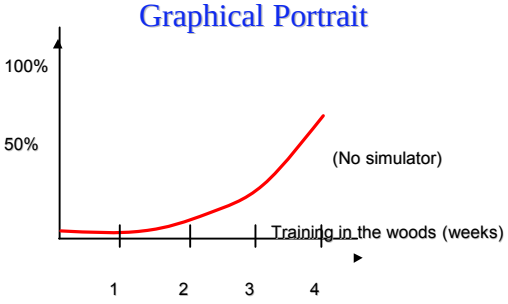
Operator Training in Quebec (since 1996)

- 5 forestry schools (vocational training institutes)
- 10 trainees per class, 2-4 classes per year
- 15 weeks at the school about theory, machine maintenance, etc.
- 11 weeks in the woods, including 4 weeks of harvester seat-time and 4 weeks of forwarder seat-time (day *and* night shifts!)
- target is 50% operator proficiency
- real costs > USD$20K per student!

CTL Equipment: Harvesters

CTL Equipment: Forwarders

Graphical Portrait



At Graduation

- in an average class of 10 students at the vocational training schools in Québec, when the training program ends:
  - "top" 3 find employment easily
  - "middle" 4-5 may find employment, especially when there are family ties
  - "bottom" 2-3 do not perform well enough in the woods to pass the course (and do not find work)

Everyone an Athlete? Everyone a Crane Operator?

- although "practice makes perfect" when learning skills, some people:
  - learn faster
  - attain higher levels of proficiency
- why is this so?
  - differences in "natural" abilities

Comparing Operators in the Woods (FERIC Study)

- 34 operators of mechanized logging equipment working in Western Canada
- 1:3 variations in operator productivity (less than 50 to over 150 trees per Productive Machine-Hour)
- analysis of the performance variation:
  - 1/3 due to to day-to-day differences within operators
  - 2/3 due to differences *between* operators

Comparing Operators in the Woods (FERIC Study)

Differences *between* operators due to differences in:

- motivation
- length of professional experience

but also:

- manual dexterity and hand-eye coordination
- visual depth perception, or "spatial reasoning"

Time for training simulation help, for pre-screening and operator preparation!

But What Kind of Simulator Do We Need?

(150M$, Boeing)

(15M$, CAE)

And in the Forest Industry?

ENSAM-Cluny
France, circa 1998
(1M$?)

What Kind of Simulator? (1)

Our "homework":

- inventory of mechanised logging equipment
- "human task analysis" in the woods, conducted by a university professor in *Industrial Engineering* and his graduate student
- review of existing research about simulator-based training, conducted by a university professor in *Education* and his graduate student

Insights from a Survey of Military Simulators

- simulators typically designed as machine "replicators", not training *aids*
- costly to purchase and maintain
- difficult to quantify the benefits of simulator training help, including training cost-effectiveness

--> training simulation should *complement*, not try to replace, time at the controls in order to provide as much training value as possible at the lowest possible price point!

What Kind of Simulator? (2)

Our constraints:

- too many manufacturers and machine specifics, so look for the "common ground"
- too much real world complexity (e.g. shapes of real trees), so simplify and provide help teaching the "basics"

What Kind of Simulator? (3)

Our conclusions:

- simulator help should concentrate on learning about the *doing of the work*, with just some elements of the *planning of the doing*:
  - harvester head functions
  - boom control
  - CTL principles
  - etc.

What Kind of Simulator? (4)

Look to *training professionals* to help guide the simulator's instructional design

- "Simulation Modules", for learning component skills in a structured way
- "Performance Indicators" to measure how well the simulated work is performed:
  - what the machine is doing
  - what is happening in the work environment

What Kind of Simulator? (5)

Our development philosophy:

- look to forestry school staff and *students* to field test early prototypes, in order more carefully *identify* and *improve* training value!

Our Beginnings (1994)

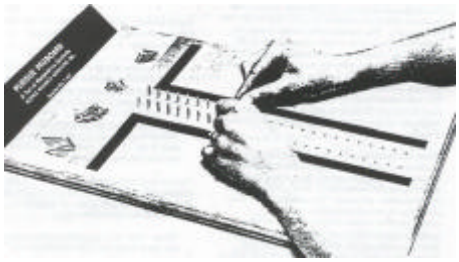
Our Field Tests at CFP Mont-Laurier (1997, 1998)

Psycho-Metric Tests vs. Simulator-based Evaluation (1)

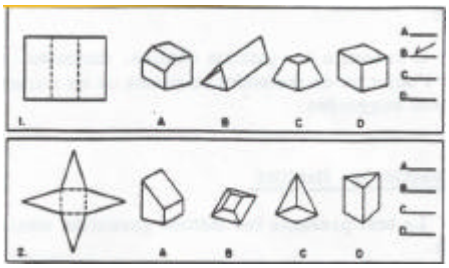
Comparing three predictors:

- psycho-metric test for manual dexterity and hand-eye coordination
- psycho-metric for spatial reasoning
- harvester simulator prototype

Testing Manual Dexterity and Hand-Eye Coordination



Testing "Spatial Reasoning"



Psycho-Metric Tests vs. Simulator-based Evaluation (2)

Pegboard test results:

- compared to the "industry" standardized score:
  - for students: average score slightly better, but wide variation for trainers, average score even better, with no (measurable) variation

Psycho-Metric Tests vs. Simulator-based Evaluation (3)

Paper Folding test results:

- compared to the "industry" standardized score:
  - for students: average score slightly better, but even wider variation ± 50-75%

  [no data for trainers]

Psycho-Metric Tests vs. Simulator-based Evaluation (4)

Comparing Pegboard and Paper Folding test results (11 students in total):

- 6 students superior scores for both
- 3 students poor scores for both

-> very good correlation between tests!

Psycho-Metric Tests vs. Simulator-based Evaluation (5)

Comparing consolidated psycho-metric test results and simulator results (11 students in total):

- 4 students superior scores for both
- 3 students poor scores for both

--> very good correlation once again

But for 4 students, superior or poor psycho-metric scores, but average simulator results!

Psycho-Metric Tests vs. Simulator-based Evaluation (6)

After evaluation in the woods, simulation judged to be the *best* predictor:

- poor simulation results *always* meant poor performance at the controls of real equipment
- although everyone's score continued to improve as the simulator-based work continued, "poor" students fell further and further behind "good" students as simulator-based training progressed
- poor simulator performance becomes evident after just 3-4 hours!

Why Simulation is Best

- psycho-metric tests can be used to evaluate *individual* human abilities, but only simulation can properly evaluate the *combination* of human abilities associated with doing the real work well
- simulation has much better "face validity", so it is better accepted by training candidates
- only simulation can help *prepare* training candidates for the real work by teaching real skills and building self-confidence

An Industrial Psychologist (1)

"Traditionally, an industrial psychologist attempting to measure the key competencies or aptitudes needed to operate the [forestry] machine would employ a battery of tests that would include general intelligence, three-dimensional perceptual ability, depth perception, hand-eye coordination, and mechanical aptitude.

An Industrial Psychologist

"It is clear that the Simlog harvester simulation software does a superior job of measuring these key competencies. The traditional paper-and-pencil tests would be an estimate of a candidate's ability to perform the key tasks of a Harvester operator, whereas the simulation is a *quantum step* towards measuring the aptitudes without the risk and expense of operating the actual machine."

Our First Products (1999)

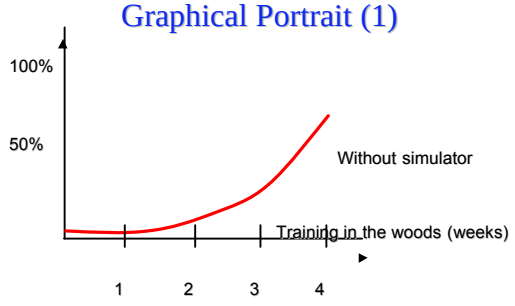
Simlog Data

- since 1999, Simlog's (harvester) simulation has been used to pre-screen and train hundreds of forestry people all across Canada
- most high scores consistently more than *2 times better* than most low scores (variability sometimes as much as 5!)

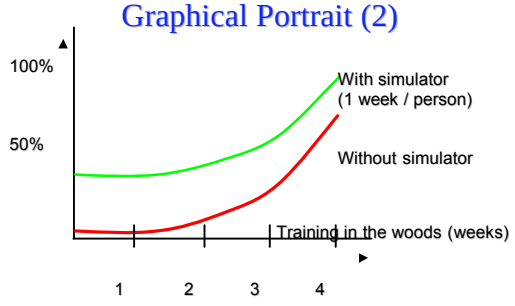
Simulator-Based Pre-Screening + Preparation

- forestry company in Eastern Canada; 42 people
- half-day of simulator-based pre-screening per person: 7 judged *not* suited for this kind of work
- 4 days of simulator-based training per person for the remaining 35, and then later in the woods:
  - 50% increase in wood harvested
  - 30% increase in "final" productivity
  - 30% decrease in costs associated with equipment maintenance

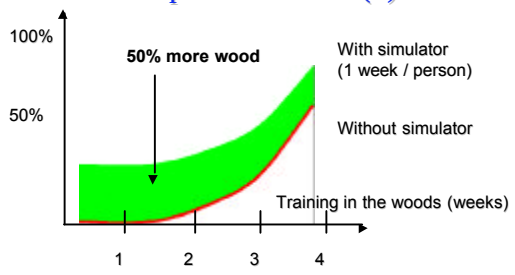
Graphical Portrait (1)



Graphical Portrait (2)



Graphical Portrait (3)



A Trainer's Comments (1)

"The Simlog Harvester Operator Training Simulator is an excellent tool for training new harvester operators […] By using the Simlog Simulator prior to seat-time in the real harvester, trainees gain confidence that helps them become efficient operators in a shorter period of time. The boom skills learned, and the knowledge gained about the flow of shortwood harvesting, become evident as soon as trainees begin work in the woods.

A Trainer's Comments (2)

"Simlog's approach to training is modular and very progressive, helping trainees acquire skills in a positive manner. The ability to measure and track the trainees' progress greatly helps the trainer but it is of even greater benefit to the trainees, who can see their performance and their skills improve as they progress through the training program."

Our Simulators Today (even more cost-effectiveness)

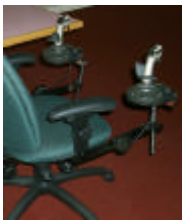
"Personal Simulators"

for the

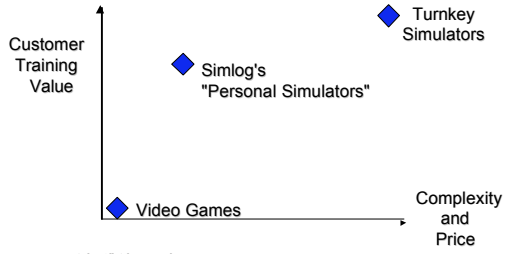
Personal Computers (PC)

PC joysticks modified for industrial control handles

A Customer's "Operator Chair"

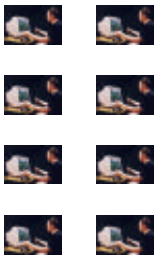


A Graphical Portrait



Personal Simulator Demonstrations

A Vision of the Future
(CFP Dolbeau 2005)



- simulator-based training as an *integral* part of the regular CTL program
- 8 *independent* training stations
  - 4 are portable (laptop PCs)
  - 4 are stationary (desktop PCs)
  - all stations equipped with PC joysticks modified for industrial control handles

Conclusions (1)

- forestry is Quebec's number 1 industry (revenue, number of people employed, etc.)
- since 1996: new CTL operator training at five forestry schools across the province
- since 1999: Simlog simulator-based help with pre-screening and operator training (and new "Personal Simulators" since 2001)

Conclusions (2)

- 3 key natural abilities are important for mechanized logging
- wide range in these natural abilities: factor of 2-3!
- (Simlog) simulation is better than psycho-metric testing for evaluating these natural abilities
  - better predictive validity
  - better face validity
  - and also provides real *training* help!

Conclusions (3)

- today's forestry machine simulators:
  - provide real operator training value
  - offer different kinds of hardware-software complexity and price combinations
- your training *needs* will help you make the most appropriate choice