Structured Troubleshooting: A new perspective on training and maintenance
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Research Vision

To create validated training environments tailored to learner(s) and staff, optimizing the use of technology
Overview

• Background “Structured Approach to Troubleshooting”
  Paper and Pulp industry
  Royal Netherlands Navy

• Innovation

• Empirical results

• Further steps..
Expert operators

Diagram:

1. Symptom
2. Judgment: Serious problem? (Yes/No)
3. Possible faults
4. Testing: Is this the fault? (Yes/No)
5. Determination of repairs
6. Consequences of repairs
7. Ordering of repairs
8. Application of repair (local or global)
9. Evaluation: Problem solved (Yes/No)
10. Exit

Symbols:
- : Serious problem
- : Not very serious problem
OK.. Conveyer belt of pulper 1 broke down.. Conveyer belt of pulper 1.. If that one breaks down.. Yeah.. See how long that takes to repair.. Not postponing the decision for very long, to ensure we don’t have to halt the installation
Novice operators

- symptom
  - possible faults
  - testing: is this the fault
    - yes
      - determination of repairs
      - application of repair (local or global)
      - EXIT
    - no
  - EXIT
Protocol excerpt (2)

OK.. You notice the following alarm conveyer belt of pulper 1 broke down.. I would.. I would stop the pulper to start with and then I would halt the whole cycle afterwards and then try to repair the conveyer belt..

(...) 

But you have to halt the whole installation, because otherwise they don’t have any stock anymore..
Previous studies

- Technicians Weapon Engineering who just passed a maintenance course:
  - Solve approximately 40% of presented problems
  - Have insufficient testing skills
  - Lack a systematic approach to troubleshooting
  - Have no high-level functional overview of systems
  - No relationship between theoretical knowledge and troubleshooting performance
Conclusions

• Training courses do not result in sufficient troubleshooting skills

• Theoretical knowledge does not suffice for troubleshooting

• Experience on the job does not guarantee good troubleshooting performance!

• Troubleshooting becomes unstructured if a technician lacks an ability to divide systems into functional parts
Training

• Too long

• “Hands on” sometimes “theory in front of system”
  • Theory-oriented vs practice-oriented

• Insufficient possibilities for students to obtain hands-on experience
Structured approach to troubleshooting

- **General strategy:**
  - Problem description
  - Hypothesis generation
  - Hypothesis testing
  - Repair and evaluation

- **Functional decomposition**

- **General plan, applicable across systems**
  - (Not monkey-see monkey-do)

- **Fault Isolation Form**
Evaluation

Does Structured Troubleshooting lead to a significant performance improvement?
Results

• **Percentage of problems solved**
  
  Regular (6 weeks) 40%
  Structured (7 weeks) 86%

• **Quality of system knowledge (1-5)**
  
  Regular (6 weeks) 2.87
  Structured (7 weeks) 4.59

• **Quality of reasoning (1-5)**
  
  Regular (6 weeks) 2.60
  Structured (7 weeks) 4.64
Question

Does Structured Troubleshooting lead to a significant performance improvement?

Answer:

YES!
Remaining issues

• Results due to more training time?

• Results and method not applicable across systems?
Results

• **Percentage of problems solved**
  - Regular (6 weeks) 40%
  - Structured (7 weeks) 86%
  - Redesign (4 weeks) 95%

• **Quality of system knowledge (1-5)**
  - Regular (6 weeks) 2.87
  - Structured (7 weeks) 4.59
  - Redesign (4 weeks) 4.77

• **Quality of reasoning (1-5)**
  - Regular (6 weeks) 2.60
  - Structured (7 weeks) 4.64
  - Redesign (4 weeks) 4.84
Implications

- Redesign of a number of courses
- Acceptance of course design method as standard within Naval Weapon Engineering School
- Development of “Guide to Course Design for Maintenance Courses”
- Implementation of a Universal Trainer Troubleshooting
- Client-centered courses on Troubleshooting
Further steps

- Redesign of troubleshooting management training
- Redesign of manuals
- Integration of electronic manuals in the workplace with e-learning
- Innovation of maintenance philosophies