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Designing Adaptive Cybersecurity Hands-on Training

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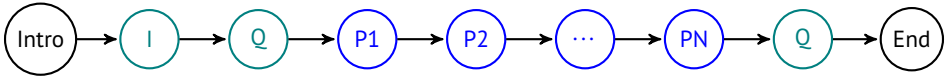
October 11, 2022 @ FIE’22 conference

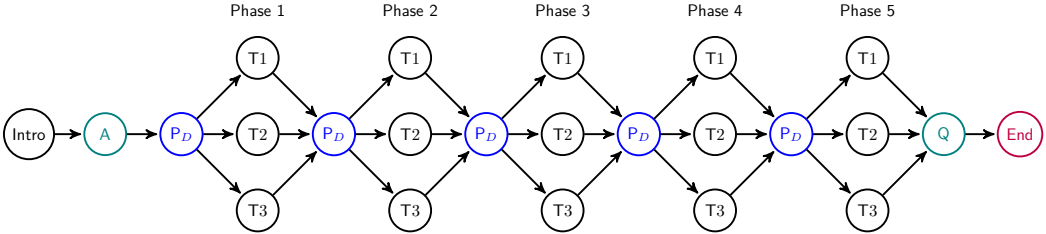
Common Cybersecurity Hands-on Classes

- Learners **interact with networks** of full-fledged operating systems and devices that **emulate real-world systems**.
- Learners' interaction is **driven by a learning environment** with or without a human instructor's assistance.
- Each student or team works with an **own instance** of the lab environment.



Generic structure of training with several phases (P), optional questionnaires (Q), and informative phases (I).

Adaptive Training Format



- A – a pre-training assessment,
- T_x – a task *x*,
- Q – a post-training questionnaire,
- P_D – a phase decision node.
- Published at FIE '21 (`https://ieeexplore.ieee.org/document/9637252`).
- Integrated into KYPO Cyber Range Platform.

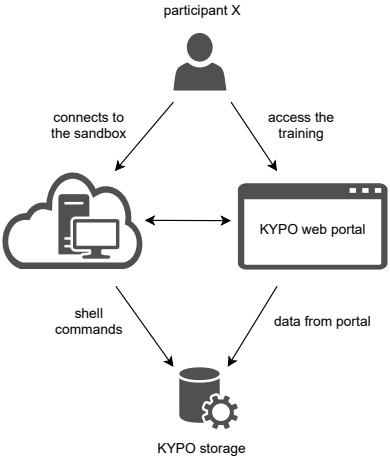
Adaptive Training – Metrics From Learning Environment

Data from portal

- Pre-training assessment
- Submitted answers
- Time to complete the task
- Solution displayed

Data from virtual hosts

- Shell commands typed



Adaptive Training – Tutor Model

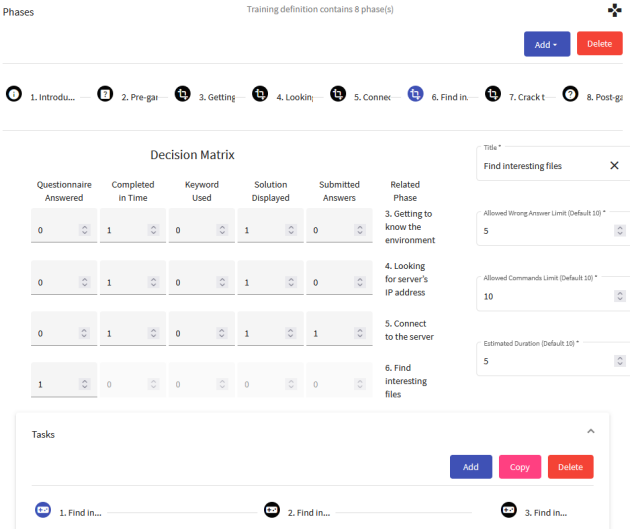
The model uses the metrics to evaluate the participants' performance and to assign a suitable task.

$$\boldsymbol{W}^{(x)} = \left(w_{ij}^{(x)}\right), i = 1, \ldots, m, \quad j = \alpha, \beta, \gamma, \delta, \varepsilon \tag{1}$$

$$f(x) = \frac{\sum_{i=1}^{x} \left[p_i w_{i\alpha}^{(x)} + s_i \left(k_i w_{i\beta}^{(x)} + a_i w_{i\gamma}^{(x)} + t_i w_{i\delta}^{(x)} + w_{i\varepsilon}^{(x)}\right)\right]}{\sum_{i=1}^{x} \left(w_{i\alpha}^{(x)} + w_{i\beta}^{(x)} + w_{i\gamma}^{(x)} + w_{i\delta}^{(x)} + w_{i\varepsilon}^{(x)}\right)} \tag{2}$$

$$T_y = \begin{cases} n_x, & \text{if } f(x) \text{ is equal to } 0 \\ \text{trunc}(n_x[1 - f(x)]) + 1, & \text{otherwise} \end{cases} \tag{3}$$

Setting Up the Model in the Learning Environment



Problem Statement

Complexity of the design of adaptive training for instructor

- Differences between variant tasks in a phase.
- Relations between phases and pre-training assessment.

Time-consuming testing of the designed training

- Adaptive training format requires setting many metrics and parameters.
- Learning environment does not aid the design process.

Goal of the Paper

Design a process and supporting tool to ease the design and analysis of adaptive training.

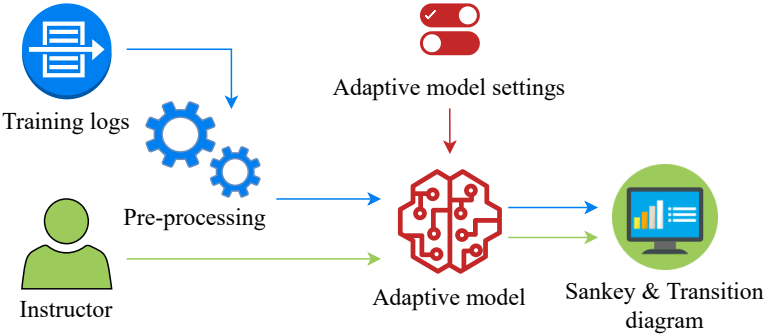
Expectations

- Time-saving and effectiveness of preparation of training for instructors
- Increased learning efficiency
- Increased learning experience
- Decreased training failure rate
- Participants finish the training in an allocated (expected) time

Proposed Design Process

- Learning Environment Preparation
- Setting Learning Objectives
- Base Tasks Design
- Variant Tasks Design
- Data Gathering and Evaluation
- Testing

Tool Assisting Instructor (Training Designer)



Tool: Pre-training Module

Input: **Performance matrix** set by an instructor

Questionnaire Answered	Completion Time	Commands Used	Solution Displayed	Submitted Answers
☑	10	2	☐	1
☑	30	25	☐	6
☑	20	14	☐	1
☑	10	4	☐	2

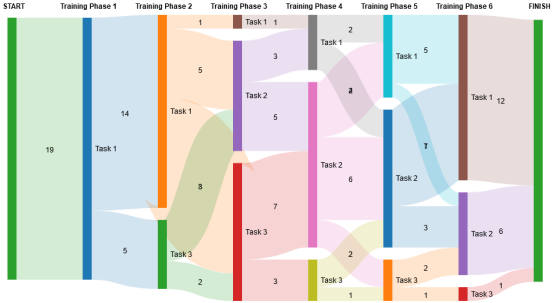
Output: **Transition graph of a single trainee** through training phases

Tool: Post-training Module

Input: **Configurable model** of the training instance

- Processes data collected from finished training sessions.
- Same interface as for setting the tutor model.

Output: Sankey diagram representing **pathways of all participants**



Conclusion

Original process of designing adaptive training

- No guidance for preparation
- High complexity of the preparation
- Time-consuming testing of settings of the tutor model

Proposed adaptive training design process

- Increased efficiency of adaptive training design
- Reduced time for instructors
- Increased participants' experience from the training

Ongoing work

- Testing the tool and design process with new trainings.

Publicly Available Contributions

KYPO Cyber Range Platform source code
https://gitlab.ics.muni.cz/muni-kypo-crp

KYPO Cyber Range Platform documentation
https://docs.crp.kypo.muni.cz

Full paper and slides
https://is.muni.cz/publication/2223817/

Stay in Touch

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MUNI KYPO Portal
https://kypo.muni.cz

KYPO Cyber Range Platform
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