HackEd: A Pedagogical Analysis of Online Vulnerability Discovery Exercises
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Research Questions
Do hacking exercises follow pedagogical best practices?
What challenges do exercise organizers face when applying these principles?

Exercise Criteria
- Educational – Intended to teach, not purely competitive
- Hands-on – active practice
- Online – publicly accessible
- Popular – Tranco/Alexa rank

Pedagogical Dimensions

Connecting to Prior Knowledge
- Personalization: Does the exercise provide challenges tailored to student age or experience?
- Utilization: Does the exercise leverage knowledge from prior challenges to solve later ones?

Organizing Declarative Knowledge
- Organization: Are challenges grouped by concept to create a hierarchy or highlight a related problem path?
- Context: In what context were challenges presented? Are there lectures, projects, an overarching story, or realistic challenges?

Practice and Feedback
- Actionability: Are there challenges where the student had to exploit insecure code or write secure code?
- Feedback: Do exercises provide direct feedback to guide the student? Are there hints or a forum to ask questions?

Metacognitive Learning
- Transfer Learning: Do challenges teach how, when, and why a mitigation or exploit technique should be used?
- Support: Are there additional materials linked to provide clarity beyond the exercises’ scope?

Results
- Difficulty/point indicators were common
- Not always optimal
- Almost all exercises have concept progression

Results
- Many exercises lacked clear structure
- Stories commonly used to provide context
- Few exercises included realistic challenges

Conducive Learning Environment
- Peer Learning: Does the exercise provide support for team formation or an online discussion forum?
- Inclusive: Do challenges contain extraneous load? Is supportive terminology used to reassure students?

Results
- Community through online forums
- Teams were rarely explicitly supported
- Extraneous load varies
- Most exercises use supportive terminology

Recommendations
1. Support metacognition through prompts to predict and reflect.
2. Use a graphical syllabus to provide structure.
3. Incentivize creating educational elements in community submissions.