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A Data-Driven Design Pattern Production (3D2P) Methodology to Facilitate Effective Pedagogical Practice in Online Learning Systems

We want to uncover effective online math-problem designs, encapsulate them into design patterns, evaluate their effectiveness in varied contexts, and collaborate with researchers and practitioners to refine the patterns and facilitate their use.

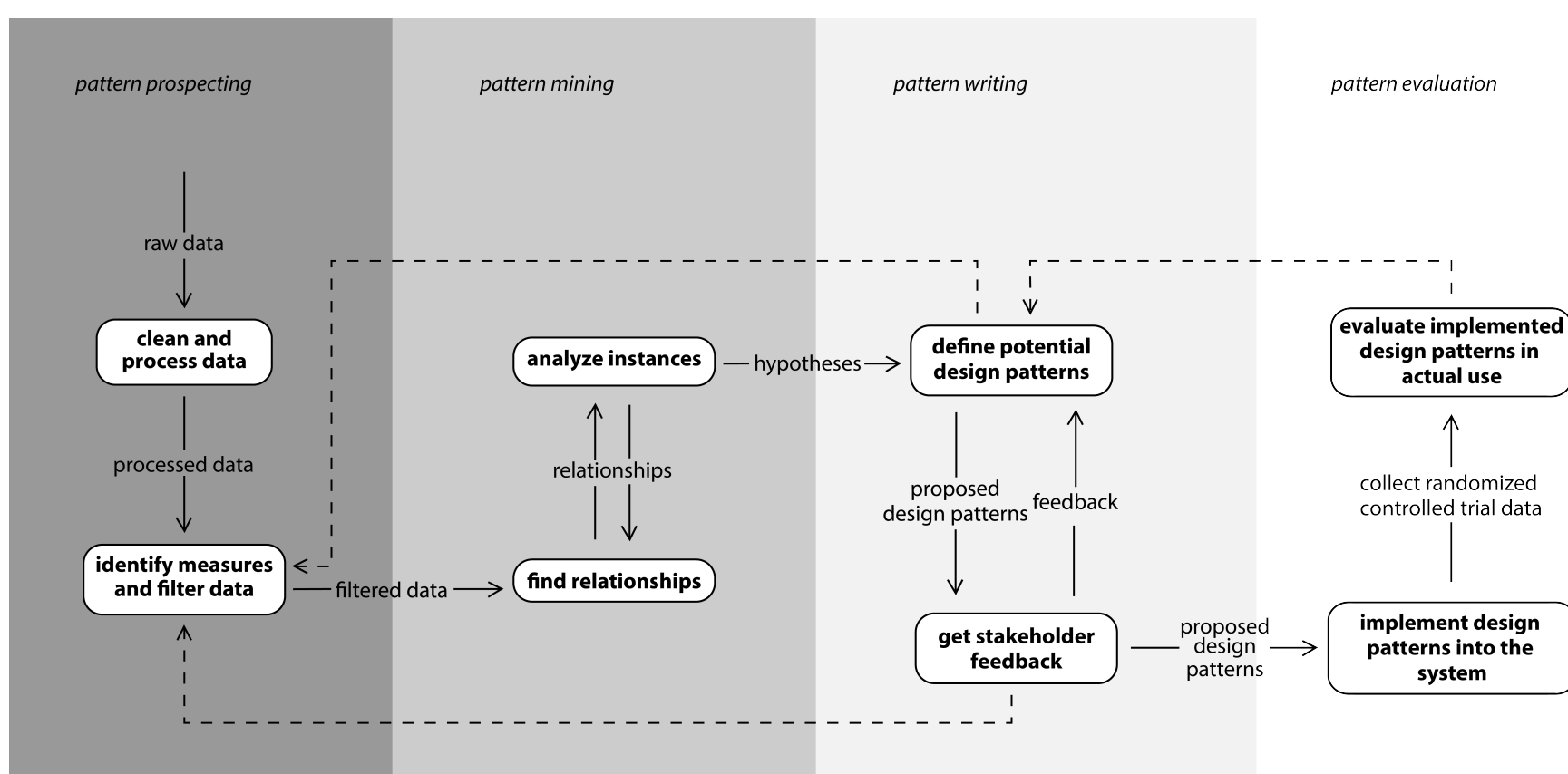
Research Questions

- what are the features of effective online math problems that influence student learning behavior (e.g., affect, engagement, performance)?
- what outcome measures can be used to assess student learning (e.g., post-test scores, mastery speed, affect)?
- how can current research and learning principles be used to help practitioners select and apply effective designs in their current context?

Proposed Solution

Data-driven Design Pattern Production (3D2P) Methodology

- Prospecting.** Find potentially interesting relationships in data.
- Mining.** Find recurring patterns and frame hypotheses to explain them.
- Writing.** Express hypotheses into design patterns.
- Evaluation.** Implement and evaluate design patterns in action.

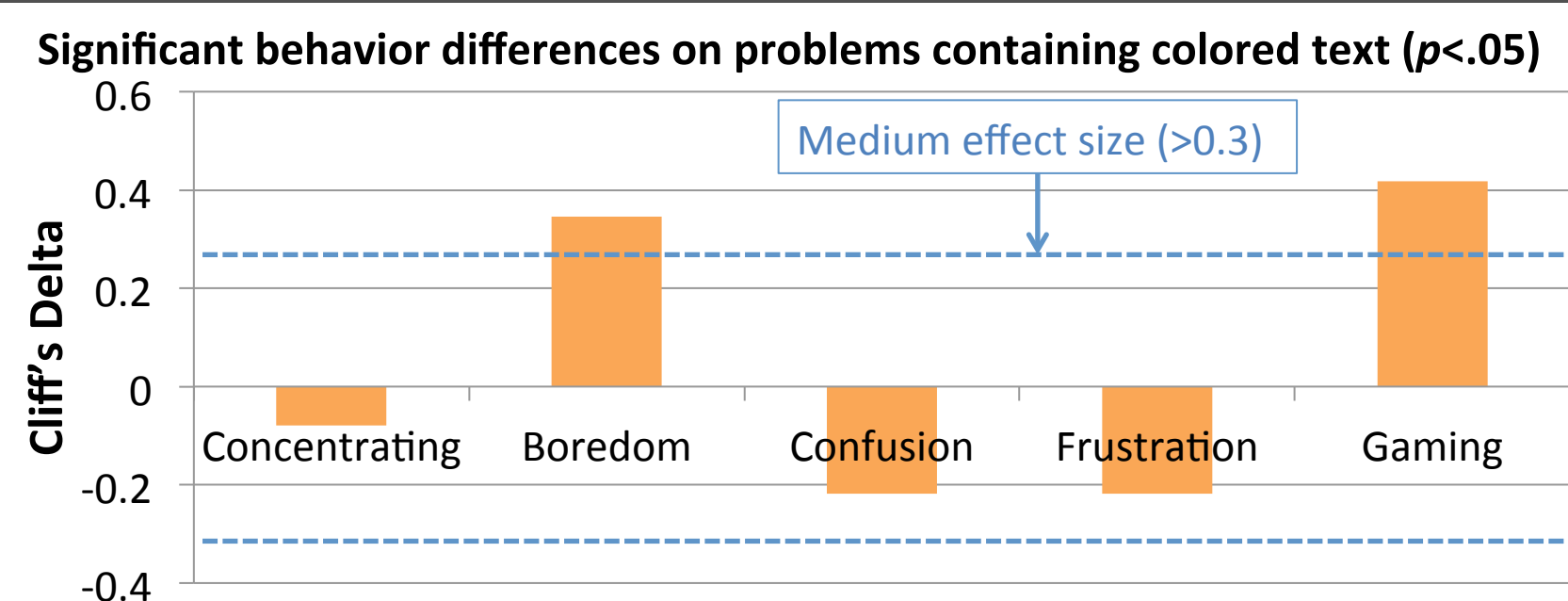


Lessons Learned

- design patterns, which are high-quality solutions for known problems in particular contexts, can be used to encapsulate knowledge that may make it easier for practitioners to select and apply solutions in their own context
- learning is complex and details are not considered in most principles and design patterns (e.g., prior knowledge, socio-economic background, urbanicity, learning environment)
- contextual details need to be incorporated into design patterns
- continued collaborative effort among stakeholders is essential

Case Study on ASSISTments' Online Math Problems

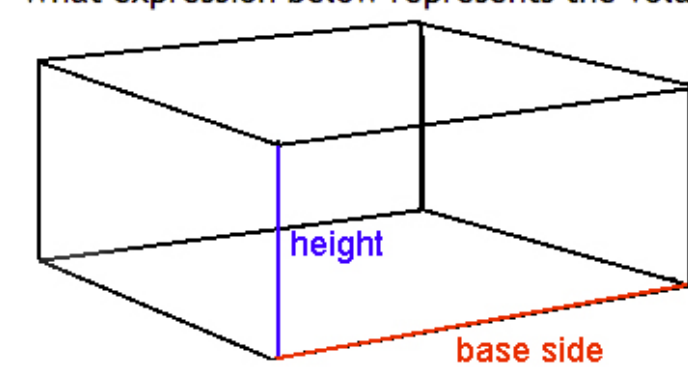
1. Pattern Prospecting



*Analyses based on data collected between 2012-2013 from the ASSISTments online learning system (<https://www.assistments.org>)

2. Pattern Mining

Now let's find the volume of a square prism with the dimension of the base y units on a side and $y/3$ units high. What expression below represents the volume of the square prism?



Q 1/4
Find x in the following system. $y = x + 3$ $3x - y = 5$
(You have 2 attempt(s) left.)

Q 19/24
Page 56 #3c
(You have 2 attempt(s) left.)

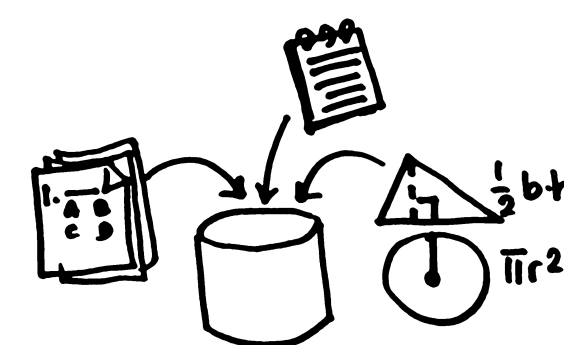
1%
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3. Pattern Writing

Several patterns were written based on findings from pattern mining. One such pattern is shown below:

All Content in One Place



Context. Students are solving problems in an online learning system

Problem. It is easier to create problems that link to existing content instead of manually encoding them, but it makes the learning task more difficult for learners.

Forces.

- Accessibility of content (e.g., textbook, website, files)
- Split-attention effect (Sweller et al., 1990; Cerpa et al., 1996; Mwangi & Sweller, 1998)
- Students' limited patience and attention (Arnold et al., 2005; Bloom 1974)

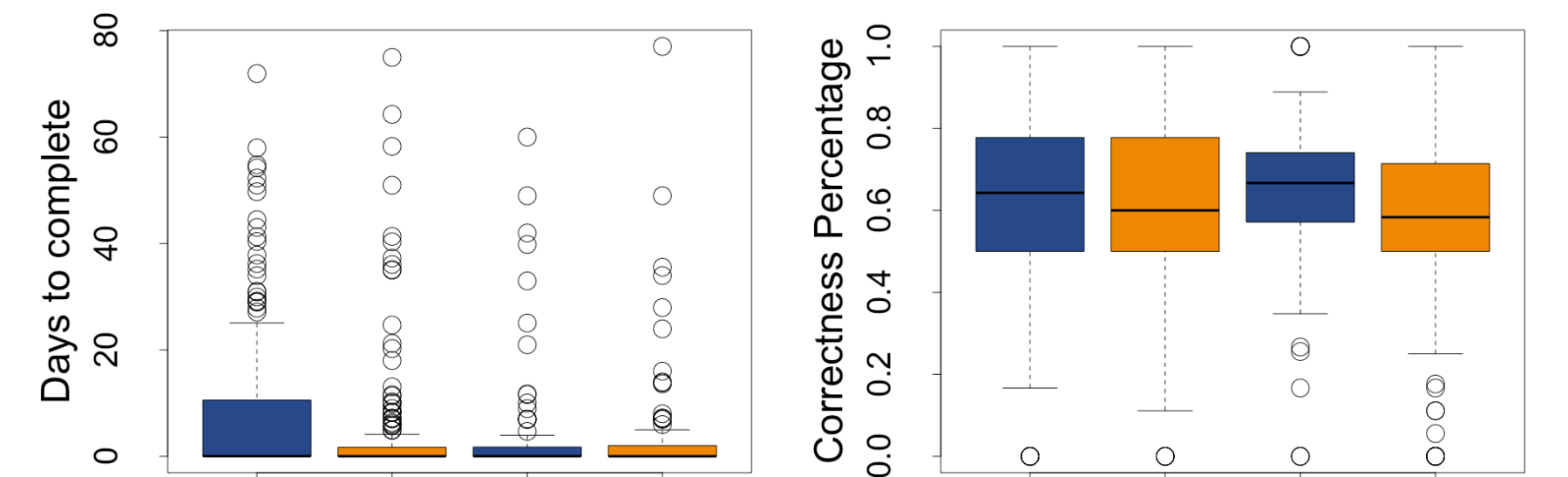
Solution. Therefore, encode or embed existing content into the online learning system.

(Inventado & Scupelli, 2015)

4. Pattern Evaluation

RCT (randomized controlled trials)	Description
Maximum answer attempts	Compare student performance when limited by a varied number of attempts
Embedded vs. external content	Compare student performance when all content is embedded to the problem or content is retrieved from external source (i.e., separate browser window)
Hint vs. no hints	Compare student performance when they are allowed access to hints or not in a problem set

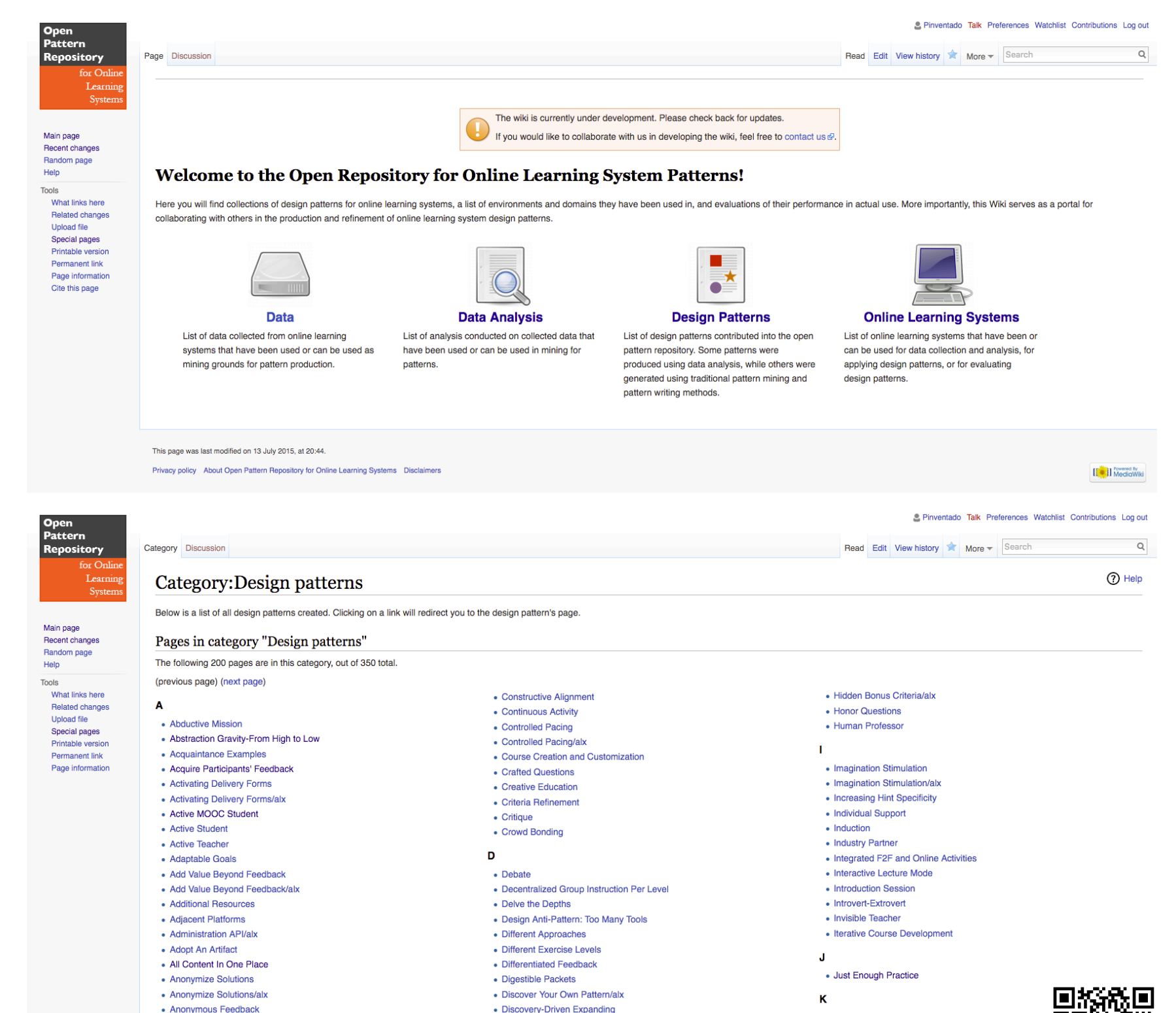
Outcome measure differences between conditions (hints vs. no hints) and learning settings (summer vs. regular school year; Inventado & Scupelli, 2016)



Acronyms: HS: hints (summer) NHS: no hints (summer) HR: hints (regular) NHR: no hints (regular)
Note: Chi-squared test showed higher dropout during the regular school year vs summer ($p < .001$).
Statistically significant effects according to Mann-Whitney U test: * ($p < .05$), ** ($p < .01$).

Open Pattern Repository for Online Learning Systems

Design patterns are published on an online repository to facilitate use and collaboration among stakeholders.



<http://www.learningenvironmentslab.org/openpatternrepository>



References
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