Democratizing the Doer Effect—Using AI to Scale Learning by Doing

Rachel Van Campenhout, Ed.D.

Presentation for the UMBC Spring 2023 data science and learning analytics workshops

Feb 24, 2023

VitalSource®

Rachel Van Campenhout, Ed.D,
Research Scientist, Learning Engineering
Acrobatiq | VitalSource

research.vitalsource.com

Learning engineering is a process and practice that applies the learning sciences using human-centered engineering design methodologies and data-informed decision making to support learners and their development.

—IEEE IC Industry Consortium on Learning Engineering

VitalSource

Research: A continuum from learning theory to practical application

Learning Theory	Technical Methods	Efficacy of Learning Tools	Instructor Implementation
Replicating the doer effect findings to validate and generalize the learning by doing method.	Detailing methods for processes such as multilingual automatic question generation or the continuous improvement system.	Investigating the effectiveness of tools such as adaptivity or automatically generated questions using student data.	Discovering effective instructor implementation approaches that maximize student engagement and success.

research.vitalsource.com

VitalSource®

Topics for this Session

1. **Learning Science: The Doer Effect**
2. **Scaling the Doer Effect: Automatic Question Generation**
3. **Instructor Implementation: Teaching and Learning in Context**
4. **Current Research: CoachMe AI Questions**

VitalSource®

1

Learning Science: The Doer Effect

VitalSource®

The Doer Effect

Established and proven by Koedinger and colleagues at Carnegie Mellon University.

Koedinger, K., Kim, J., Jia, J., McLaughlin, E., & Bier, N. (2015, March). Learning is not a spectator sport: Doing is better than watching for learning from a MOOC. Proceedings of the Second ACM Conference on Learning@Scale (pp. 111–120). https://doi.org/10.1145/2724660.2724681

Koedinger, K. R., McLaughlin, E. A., Jia, J. Z., & Bier, N. L. (2016, April). Is the doer effect a causal relationship? How can we tell and why it's important. Proceedings of the Sixth International Conference on Learning Analytics & Knowledge (pp. 388–397). Edinburgh, United Kingdom. http://dx.doi.org/10.1145/2883851.2883957

Koedinger, K. R., Scheines, R., & Schaldenbrand, P. (2018). Is the doer effect robust across multiple data sets? Proceedings of the 11th International Conference on Educational Data Mining (pp. 369–375).

Doing **practice** has

6x

the effect size

than **reading** alone,

and is shown to be

causal to learning.

VitalSource®

The Doer Effect

There is a dire need for replication research in the learning sciences, as methods put forth for increasing student learning should be unequivocally grounded in reproducible, reliable research.

Van Campenhout, R. Johnson, B. G., & Olsen, J. A. (2021). The doer effect: Replicating findings that doing causes learning. Proceedings of eLmL 2021: The Thirteenth International Conference on Mobile, Hybrid, and On-line Learning, 1–6. https://www.thinkmind.org/index.php?view=article&articleid=elml_2021_1_10_58001

Van Campenhout, R. Johnson, B. G., & Olsen, J. A. (2022). The Doer Effect: Replication and Comparison of Correlational and Causal Analyses of Learning. International Journal On Advances in Systems and Measurements,, vol 15 no 1&2, http://www.iariajournals.org/systems_and_measurements/tocv15n12.html

Van Campenhout, R., Jerome, B., & Johnson, B. G. (2023). The Doer Effect at Scale: Investigating Correlation and Causation Across Seven Courses. In LAK23: 13th International Learning Analytics and Knowledge Conference (LAK 2023). https://doi.org/10.1145/3576050.3576103

Using 7 courses and 5 correlational and causal Doer Effect analyses, we ***replicated the same findings*** as Koedinger et al., 2015, 2016.

VitalSource®

2

Scaling the Doer Effect: Automatic Question Generation

VitalSource®

Automatic Question Generation

We compare automatically generated (AG) questions to human-authored (HA) questions in the same course using a mixed-effects logistic regression model.

In the same course, how do our AG questions compare to HA questions on:

- Engagement
- Difficulty
- Persistence
- Discrimination

VitalSource®

Automatic Question Generation

Van Campenhout, R., Brown, N., Jerome, B., Dittel, J. S., & Johnson, B. G. (2021). Toward Effective Courseware at Scale: Investigating Automatically Generated Questions as Formative Practice. Learning at Scale. pp. 295–298. https://doi.org/10.1145/3430895.3460162

Van Campenhout, R., Dittel, J. S., Jerome, B., & Johnson, B. G. (2021). Transforming textbooks into learning by doing environments: an evaluation of textbook-based automatic question generation. In: Third Workshop on Intelligent Textbooks at the 22nd International Conference on Artificial Intelligence in Education. CEUR Workshop Proceedings, ISSN 1613-0073, pp. 1–12. Retrieved from: http://ceur-ws.org/Vol-2895/paper06.pdf

Johnson, B. G., Dittel, J. S., Van Campenhout, R., & Jerome, B. (2022). Discrimination of automatically generated questions used as formative practice. Proceedings of the Ninth ACM Conference on Learning@Scale (pp. 325-329). https://doi.org/10.1145/3491140.3528323

Research has found no difference in how students use AI-generated versus human-authored questions.

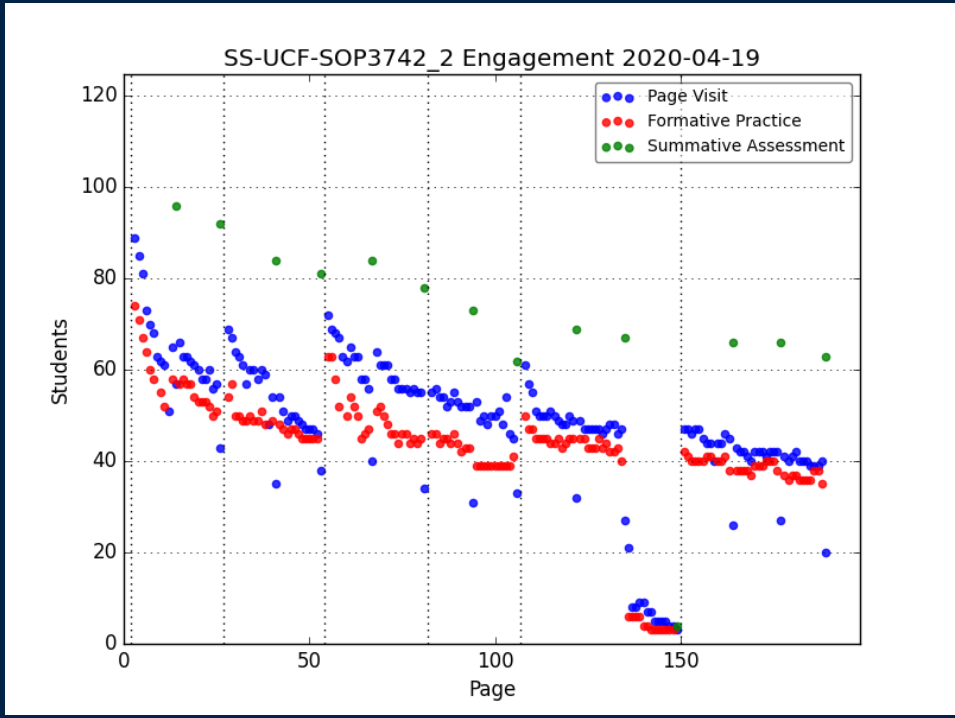
VitalSource®

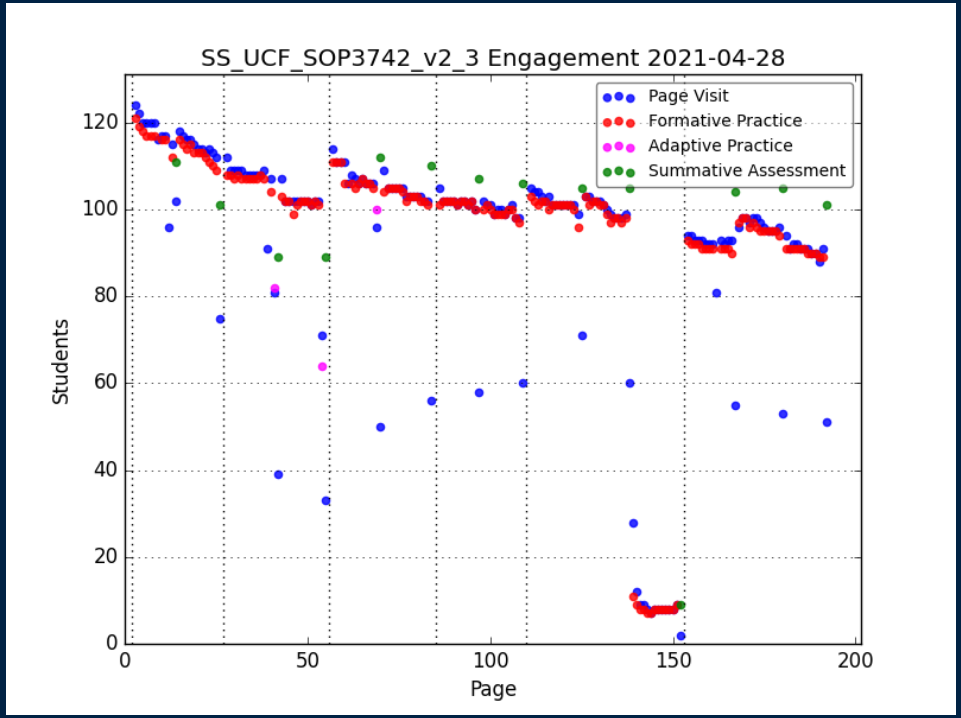
3

Instructor Implementation: Teaching and Learning in Context

VitalSource®

Instructor Implementation and Engagement





Left: Psychology of Sex and Gender courseware AG practice engagement with 2% grade for completion. Right, same course with 20% for completion.

VitalSource®

Student Exam Scores

Data from the three exams in Psychology of Sex and Gender, from 2019 to 2021.

Student exam scores for Psych from 2019 through 2021.

		Exam 1	Exam 2	Exam 3
Fall 2019	Mean Score	60%	63%	71%
	Score Range	39–101%	12–104%	19–104%
	n Students	97	78	71
Spring 2020	Mean Score	70%	68%	78%
	Score Range	23–98%	24–104%	39–104%
	n Students	98	86	71
Spring 2021	Mean Score	77%	78%	79%
	Score Range	43–102%	42–102%	42–99%
	n Students	106	105	104

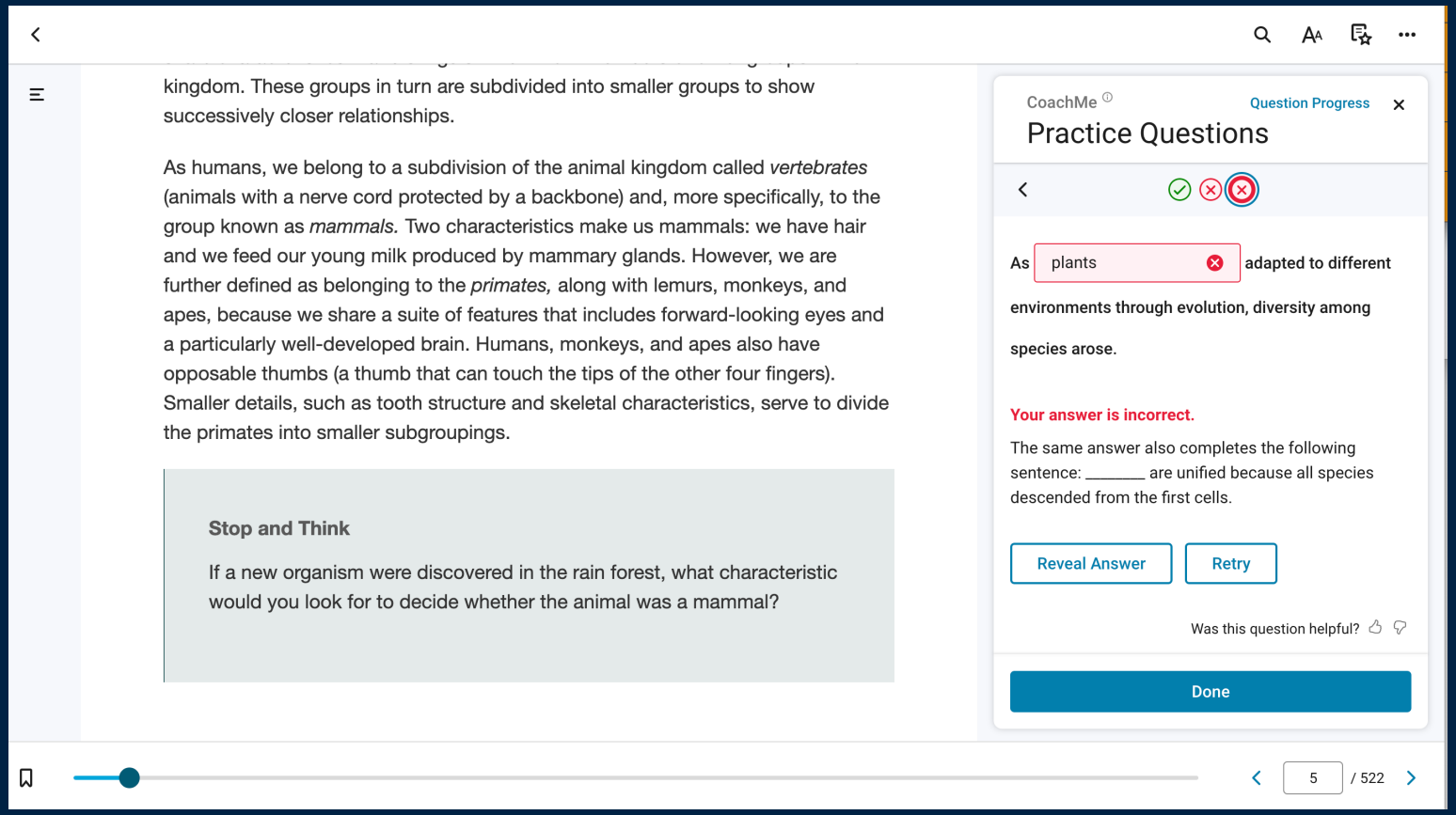
Hubertz, M. & Van Campenhout, R. (2022). Teaching and Iterative Improvement: The Impact of Instructor Implementation of Courseware on Student Outcomes. The IAFOR International Conference on Education – Hawaii 2022 Official Conference Proceedings, 201–210. https://doi.org/10.22492/issn.21891036.2022.19

4

Current Research: CoachMe AI Generated Questions

VitalSource®

CoachMe Practice Questions



VitalSource®

CoachMe Practice Questions

Figure 19.15

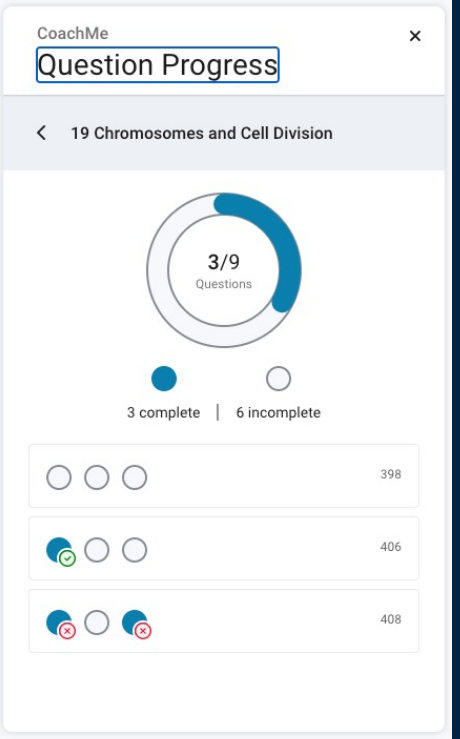
Nondisjunction is a mistake that occurs during cell division in which homologous chromosomes or sister chromatids fail to separate during anaphase. One of the resulting daughter cells will have three of one type of chromosome, and the other daughter cell will be missing that type of chromosome.

coin will come up heads, there is a fifty-fifty chance that a given daughter cell will receive the maternal chromosome from a particular pair. Each of the 23 pairs of chromosomes orients independently during metaphase I. The orientations of all 23 pairs will determine the assortments of maternal and paternal chromosomes in the daughter cells. Thus, each child (other than identical siblings) of the same parents has a unique genetic makeup.

Extra or Missing Chromosomes

Most of the time, meiosis is a precise process that results in the even distribution of chromosomes to gametes. But meiosis is not foolproof. A pair of chromosomes or sister chromatids may adhere so tightly to one another that they do not separate during anaphase. As a result, both go to the same daughter cell, and the other daughter cell receives none of this type of chromosome (**Figure 19.15**). The failure of homologous chromosomes to separate during meiosis I or of sister chromatids to separate during meiosis II is called **nondisjunction.**

What happens if nondisjunction creates a gamete with an extra or a missing chromosome and that gamete is then united with a normal gamete during fertilization? The resulting zygote will have an excess or deficit of chromosomes. For instance, if the abnormal gamete has an extra chromosome, the resulting zygote will have three



VitalSource®

Research Study: Bookshelf CoachMe

We are working with university partners to engage faculty in a research study using textbooks that contain the CoachMe practice questions. The goal of this study is to:

- Identify successful instructor implementation practices that maximize student engagement with the practice
- Identify student and instructor perceptions of the CoachMe practice questions for studying and learning
- Investigate the relationship between doing the CoachMe practice questions and student learning outcomes

VitalSource®

CoachMe: Fall 2022

Total Questions		18	10	27	10	67	48	43	14	19	256
Name	Days Used	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Book
Student 1	8	100	100	100	100	100	100	100	0	100	94.5
Student 2	7	100	100	100	100	100	100	100	0	100	94.5
Student 3	10	100	100	100	100	100	100	100	100	100	100
Student 4	5	100	100	100	100	80.6	85.4	83.7	85.7	100	88.7
Student 5	9	100	100	100	100	100	100	100	0	100	94.5
Student 6	9	0	0	0	0	0	89.6	83.7	0	84.2	37.1
Student 7	10	100	100	81.5	80	82.1	83.3	93	100	100	88.3
Student 8	11	94.4	100	100	100	100	100	100	0	63.2	91.4
Student 9	12	100	100	100	100	100	100	100	0	100	94.5
Student 10	12	100	100	100	100	80.6	81.2	83.7	0	100	83.2
Student 11	23	100	100	100	100	100	100	100	100	100	100

Most students completed 100% of practice in some chapters.

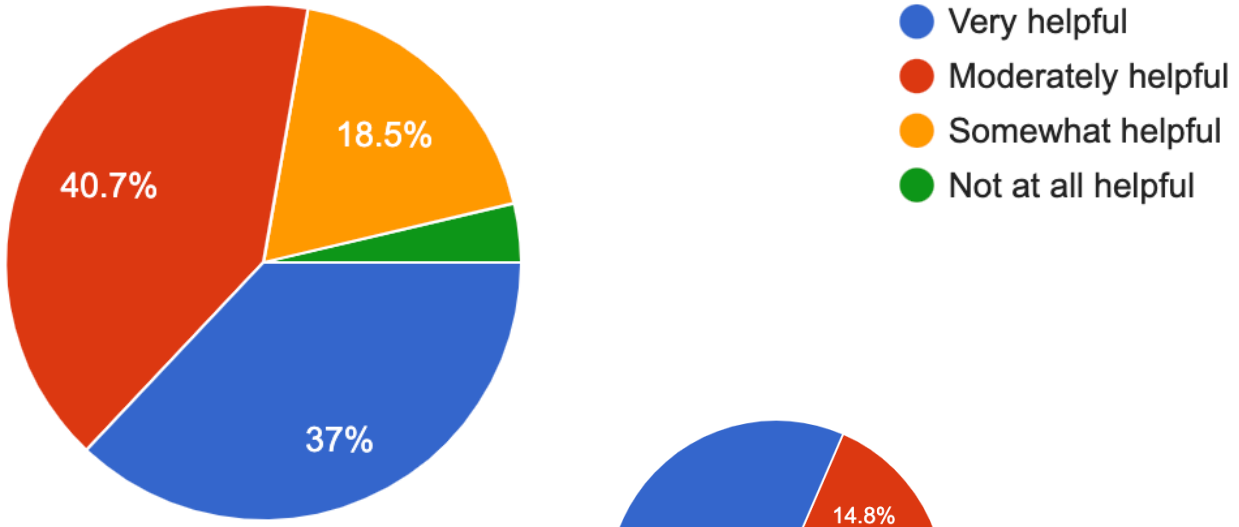
Many students completed 100% of the practice in the assigned chapters (Step 8 was not assigned).

A few students stopped at 80% of practice, particularly in chapters with a large number of practice questions.

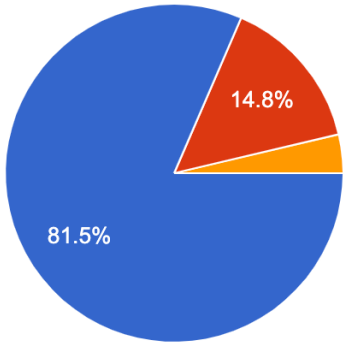
VitalSource®

How helpful did you find the practice questions for studying?

27 responses



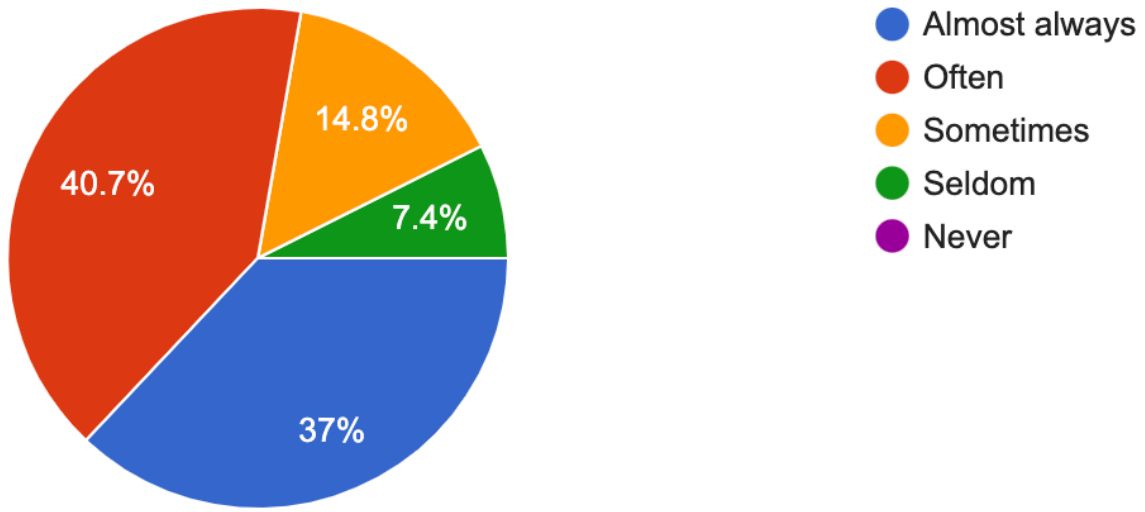
Similar responses to “in general” question.



VitalSource®

How often did seeing the percentage of practice you completed for a chapter in the progress panel motivate you to complete more/all of the available practice?

27 responses



VitalSource®

Student Perceptions Across Courses

Similar trends in student responses for courses with CM required:

- **Most students believe practice is helpful**
- **Most did 100% of practice when assigned**
- **Most used progress panel to monitor/complete**
- **Most would likely use CM again**

When CM was not assigned but sometimes used for extra credit:

- **Most students believe practice is helpful**
- **Larger range of usage for the progress panel**
- **Most students moderately or extremely likely to use them again...even though they only selectively used the questions for their existing course**

VitalSource®

Thank You!

For questions on the research, feel free to reach out to
rachel.vancampenhout@vitalsource.com

VitalSource®