VitalSource

# Investigating Adaptive Activity Effectiveness Across Domains: Insights into Design Best Practices

**This is an overview of the adaptive activity design best practices research and findings by the VitalSource Research and Development team as published in July 2021 and presented at the 23rd International Conference on Human-Computer Interaction. You can read the entire paper here.**

## INTRODUCTION

The purpose of this paper is to investigate a set of non-STEM courses in which the adaptive activities did not have the net-positive increases in learning as had been found in previous research [1]. Courseware is a complex environment to design and create content for, and the adaptive activities are especially complex. This investigation is important to identify design best practices using empirical means so that improvements can be made to future adaptive design.

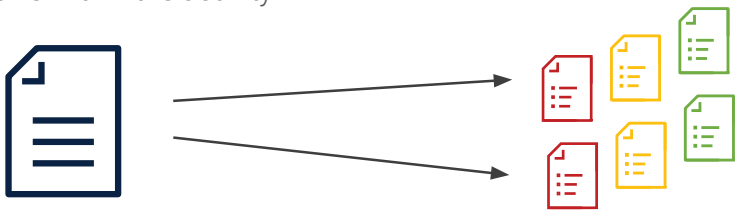
**The results of this research project identified key design best practices for the adaptive activities.**

- Have more than 8 adaptive questions per learning objective
- Have a ***minimum ratio*** of 50% scaffolded questions to high questions for **each** learning objective
- Ensure low and medium questions are written at a low and medium difficulty level

### DEFINING THE KEY TERMINOLOGY

The ***adaptive activities*** are formative activities delivered after a module of learning content to help students prepare for a module quiz. They are designed with sets of scaffolded questions against each learning objective from the preceding lessons. The platform uses the student's learning estimate to determine the level of question scaffolding the student should receive within the activity.

Performance on lessons determines scaffolding in adaptive practice.



A ***learning estimate*** is a predictive measure generated by Acrobatiq's Analytics Engine for each student on each learning objective. It is primarily based on how well a student performs on the formative practice for each learning objective. The learning estimate is categorised as ***low, medium, and high.***

***Formative practice*** are questions integrated into the lesson content that provide immediate feedback and repeated attempts without producing a grade.

***Summative assessments*** are the end-of-module quizzes that produce a score in the gradebook.

## RESEARCH QUESTIONS

1. ***How do the adaptive activities affect learning estimates for students?***
2. ***How do the adaptive activities affect student scores on summative assessments?***
3. ***What features of courseware design influence the effectiveness of the adaptive activities for increasing student learning estimates and outcomes?***

## THE DATA

**Table 1**

The data for each course analysed.

| Course | Students | Learning objectives | Total Data records |
|---|---|---|---|
| Project management | 72 | 47 | 2798 |
| Macroeconomics | 84 | 58 | 2797 |
| Finance | 76 | 50 | 3053 |

## RESEARCH QUESTIONS 1 & 2:

We repeated the same analysis of the adaptive activities done in previous research using a Probability and Statistics course. These research questions look at how the adaptive activities impacted learning estimates and summative assessment scores. In Probability and Statistics, the adaptive activities gave a net positive increase on learning estimates, and students who increased their learning estimate category scored higher on summative assessments [1]. In the current study, however, similar trends were found for all three courses.

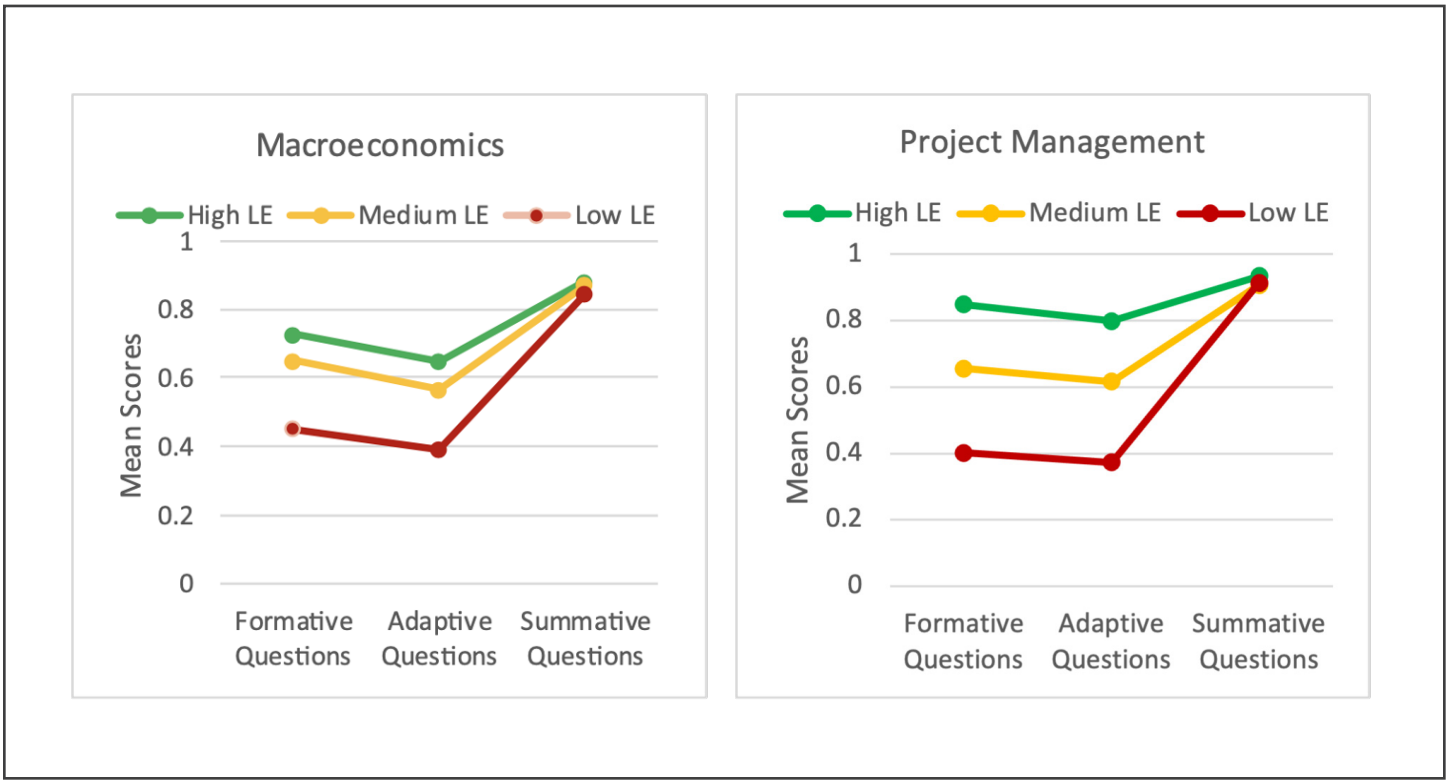
- There were net negative learning estimate changes for all courses, meaning there were more instances of students decreasing their learning estimate than increasing it after doing the adaptive activities.
- In Project Management and Finance, students who increased learning estimate categories after the adaptive activities also scored higher on summative assessments than their peers who did not increase their categories. In Macroeconomics, there was no discernable pattern.

These findings indicated we needed to investigate the course features in more depth to understand what was going on in these courses.

## RESEARCH QUESTION 3:

In order to investigate course features, we analysed several different components of the course.

**Alignment.** The difficulty alignment of the formative, adaptive, and summative questions could have an impact on the success of the adaptive activities. We found that the alignment for all courses showed lower mean scores on adaptive questions, while much higher mean scores on summative assessments, with all students scoring nearly the same no matter their learning estimate category. These results are surprising, as the summative questions were written to be the most difficult as a high-stakes assessment. This could indicate that there were circumstances in the classroom that may have led to high scores for all students, such as group-testing or practice in class.




**Amount of Scaffolded Practice.** Next we analysed the amount of scaffolded practice questions for the adaptive activities. We found that Probability and Statistics had an average of 14.05 adaptive questions available per learning objective, Project Management had an average of 6.69, Finance had an average of 5.17, and Macroeconomics had an average of 4.89 questions. This indicates the total number of adaptive questions per learning objective questions matters.

We further broke down the numbers of low, medium, and high difficulty questions per learning objective. When we looked at the 75th percentile (meaning 75% of learning objectives had fewer questions) the results showed a clear trend—the three non-STEM courses had very few scaffolded questions for most learning objectives. Students who needed scaffolding were not getting very much help.

**Table 9**
Adaptive practice available at the 75th percentile for each scaffold level.

| Course | Low questions | Medium questions | High questions |
|---|---|---|---|
| Project management | 1 | 1 | 7 |
| Macroeconomics | 1 | 1 | 4 |
| Finance | 1 | 1 | 3.75 |
| Probability and statistics | 5 | 5 | 9 |

This scaffolding ratio was further supported when looking at the learning objectives that had the largest learning estimate decreases after completion of the adaptive activities. Those objectives had zero to one questions at the low or medium level and up to 27 at the high level. The learning objectives that increased learning estimates the most had more scaffolding questions than high difficulty questions.

**Difficulty of Scaffolded Questions.** The final investigation showed that for two courses, the low, medium, and high questions were all performing at the same difficulty level. This means the low and medium questions were not truly providing any scaffolding benefits to students.

## CONCLUSION

While there were likely course implementation choices that obscured some lines of investigation around the summative assessments, the features of the adaptive activities themselves were largely related to their effect on student learning estimates. Adaptive activities with more questions per learning objective and high ratios of scaffolded questions (low and medium difficulty) to high difficulty questions were most successful in increasing learning estimates. The adaptive activities were developed based on research principles, but continued data analysis provides important insights into optimal design based on student use and therefore is a critical part of educational technology. The analysis of their performance in practice is necessary to identify problems and the best practices that can improve their effectiveness for students.

Van Campenhout R., Jerome B., Dittel J.S., Johnson B.G. (2021) Investigating Adaptive Activity Effectiveness Across Domains: Insights into Design Best Practices. In: Sottilare R.A., Schwarz J. (eds) Adaptive Instructional Systems. Design and Evaluation. HCII 2021. Lecture Notes in Computer Science, vol 12792, pp. 321–333. Springer, Cham. https://doi.org/10.1007/978-3-030-77857-6_22