Conference Poster

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Dynamical Feedback and Affordances-Constraints in Technology-Mediated Learning and Assessment: An in-Class Experimental Study

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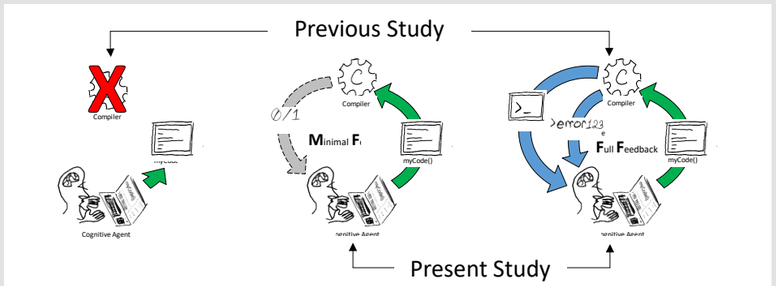
1 Introduction

How do we assess learning in complex technology-mediated practices? How does the coordination of technological affordances and constraints mediate immediate performance and individual learning? In the technology-mediated practice of programming, the compiler functions as a source of both affordances and constraints to the human cognitive agent. The compiler affords the compilation of executable programs and dynamically informative compiler feedback, while the compiler also constrains acceptable code to a specific syntax. In this in-class experimental study, I investigate the contribution of compiler affordances and constraints to performance and learning in programming.

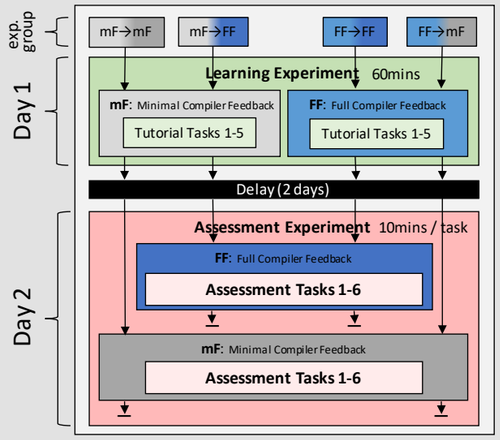
2 Research Question



A previous study on the validity of resource-rich versus resource-poor assessment by Halbherr, Lehner, & Kapur (2019) compared learning and assessment in programming with **zero compiler feedback** (i.e. with a completely deactivated compiler) versus with **full compiler feedback** (i.e. with a fully functional compiler). The study (unsurprisingly) found **full feedback learning** to be **superior** to zero feedback learning both when assessed with tasks with full or with zero compiler feedback. Intriguingly however, the performance difference between the full and zero feedback learning groups was larger in the zero feedback assessment than in the full feedback assessment. In other words, the **zero feedback assessment** was **more sensitive** to the superiority of full feedback learning than the full feedback assessment. The study furthermore found **higher** scores on **conceptual performance in zero feedback assessment tasks** than in identical full feedback assessment tasks. The previous study proposed the **lack of a need to comply with compiler constraints** as the likely cause of this conceptual performance facilitation in zero feedback tasks.

The present study compares the **full compiler feedback** condition versus a **minimal compiler feedback** condition. Instead of a completely deactivated compiler, students in the minimal feedback conditions can send their code to a compiler, but only receive feedback on whether or not their code compiles – i.e. one bit of information and thus literally minimal feedback. In the minimal feedback conditions, students also cannot access or execute their compiled programs. In comparison to the zero feedback condition of the previous study, the minimal feedback condition introduces a need to comply with the compiler's constraints – syntactically correct code – while maximally denying exploiting its affordances – dynamically informative feedback. Furthermore, the study compares both manually and automatically scored student performances.

3 Method



The study implements a double treatment experimental design (Halbherr & Kapur, 2019). On Day1, students engaged in a learning experiment. Two days later, on Day2, students engaged in an assessment experiment. Both in the learning and in the assessment experiment, students were independently assigned either to the minimal feedback experimental condition, or to the full feedback experimental condition.

4 Hypotheses

The present study investigates the following follow-up hypotheses of the previous study.

Constraints Constrain Performance (H1): The need to comply with compiler constraints such as syntactically correct code mediates lower assessment scores in conceptual performance. ***Affordances Afford Learning (H2)***: The opportunity to exploit compiler affordances such as dynamically informative feedback mediates improved learning outcomes. If these hypotheses are true, then the minimal feedback condition that introduces a need to comply with constraints but still denies the according affordances should let the compiler-deactivated performance facilitation disappear while maintaining a comparatively larger learning facilitation for the compiler-activated learning condition.

Programming competency consists of two subcompetencies: ***Conceptual Competency***, defined as 'deep', transferrable learning that is independent from 'superficial' details associated with a specific technological tool (e.g. some specific syntax), and ***Coordination Competency***, i.e. students' skills in complying with the compiler's constraints and in exploiting its affordances. Furthermore, ***Conceptual Learning constitutes a form of Resource-Internalization (H4)***, mediated through the coordination of resource affordances-constraints in the learning activity.

5 Results

ANOVA and ANCOVA results

Manual Scores	*F*	*p*	Partial η^2
Corr. Model[a]	15.244	.000	**.188**
Intercept	559.152	.000	**.739**
LC	20.356	.000	**.094**
AC	21.459	.000	**.098**
Interaction LC*AC	.850	.358	.008

a. R Squared = .188 (adjusted R Squared = .176)

Manual Scores	*F*	*p*	Partial η^2
Corr. Model[a]	3.365	.012	.102
Intercept	6.199	.014	.050
Exercises	8.255	.005	**.065**
LC	4.731	.032	.038
AC	.844	.360	.007
Interaction LC*AC	.034	.855	.000

a. R Squared = .102 (adjusted R Squared = .071)

Auto Scores	*F*	*p*	Partial η^2
Corr. Model[b]	9.046	.000	**.233**
Intercept	3.691	.057	.030
Exercises	22.615	.000	**.160**
LC	1.815	.180	.015
AC	12.792	.001	**.097**
Interaction LC*AC	.935	.336	.008

b. R Squared = .233 (adjusted R Squared = .207)

6 Discussion

The results support all three hypotheses. The Minimal Feedback assessment condition of the present study, Study2, in contrast to the Zero Feedback assessment condition of the previous study, Study1, does not facilitate higher manual assessment scores than the Full Feedback assessment condition. This confirms the first hypothesis: **Constraints Constrain Performance**.

Conversely, the Minimal Feedback learning condition, same as the Study1 Zero Feedback learning condition, leads to inferior performances in the manually scored assessments than the Full Feedback learning condition. This confirms the second hypothesis: **Affordances Afford Learning**.

Intriguingly however, the effect size of the comparatively superior learning facilitation of the Full Feedback condition is drastically reduced in comparison to Study1. In other words, the Minimal Feedback condition and the Full Feedback condition lead to much more similar results in learning facilitation than the Zero Feedback condition. This may indicate that the dynamical embedding of feedback is the stronger mediator of conceptual learning than the (amount of) information this dynamical feedback carries. Put another way, the compiler 'constraints' appear to be driving conceptual learning more so than the compiler 'affordances'. In keeping with our original hypotheses, this leads to the tentative conclusion: ***Constraints Afford Learning***. Put yet another way, the distinction between affordances and constraints – at least regarding conceptual learning – appears to lose much of its original meaning.

Following on, we can now summarize: Dynamical compiler feedback appears an important driver of conceptual learning, yet at the same time does not contribute to immediate conceptual performance. This finding is commensurate with the third hypothesis: **Conceptual Learning is Resource-Internalization** mediated by the coordination of resource affordances-constraints.

On the other hand, when looking at the auto-scored results, there is a substantial performance facilitation effect for the Full Feedback compiler-activated assessment condition in comparison to the Minimal Feedback assessment condition. This indicates that the amount of information the dynamical compiler feedback carries is an important facilitator of successful compliance with constraints in immediate task performances. Hence, we may conclude: ***Affordances Afford Resource Coordination***.

7 References

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