Ad hoc vs. Organised Orchestration: A Comparative Analysis of Technology-driven Orchestration Approaches

Lighton Phiri
Department of Computer Science
University of Cape Town
Cape Town, South Africa
lphiri@cs.uct.ac.za

Christoph Meinel
Hasso Plattner Institute
University of Potsdam
Potsdam, Germany
christoph.meinel@hpi.de

Hussein Suleman
Department of Computer Science
University of Cape Town
Cape Town, South Africa
hussein@cs.uct.ac.za

***Abstract*—The use of technology to orchestrate learning activities in formal learning spaces is becoming commonplace. However, orchestration is arguably conducted in an ad hoc manner. This paper presents a comparative analysis between ad hoc orchestration—using the PortableApps platform—and organised orchestration—using an implemented workbench user interface. The effectiveness and impact on teaching experience of the two orchestration approaches was evaluated using a within-subjects controlled study involving 55 participants. The results show that learning activities were orchestrated 21% faster with the workbench than using the ad hoc approach. The AttrakDiff 2 responses for the workbench approach scored higher means for all dimensions. The results suggest that participants were more effective when orchestrating activities using the workbench than when using the ad hoc orchestration technique. The results further show a more positive user experience when using the organised approach.**

***Keywords*—Computer-assisted instruction, orchestration, technology enhanced learning**

I. Introduction

The use of educational technology for teaching and learning in formal learning environments is increasingly becoming commonplace. One of the ways educators make use of educational technology to support teaching is by facilitating the real-time management of learning activities in formal learning environments, a process referred to as orchestration [1]. However, facilitating the orchestration of learning activities is hindered by challenges such as timing constraints and the complex nature of learning environments [2].

While there exists a variety of software tools and services for facilitating orchestration, these tools are often used in an ad hoc manner. In our previous work [3], we highlighted the ad hoc nature of contemporary technology-driven orchestration; and, additionally, proposed a streamlined approach to technology-driven orchestration through the use of an orchestration workbench. It was demonstrated that effective technology-driven orchestration of learning activities can be attained by explicitly organising learning activities [3].

The purpose of this study was to measure the effectiveness and user experience of two orchestration approaches—ad hoc and organised orchestration. The main contribution of this paper is the results from the comparative analysis of technology-driven orchestration.

II. Related work

Numerous works have defined and highlighted the challenges and complexities associated with the orchestration of learning activities [1], [4].

Several studies have also been conducted to evaluate orchestration approaches. Most of the studies demonstrate the feasibility of different orchestration approaches. For instance, the effectiveness of SceDer was demonstrated by testing it in school classrooms [5]. Using a mixed-methods approach, GLUE!-PS [6] was shown to support challenges in distributed learning environments, although with limitations [7]. GLUEPS-AR [8] was shown to support the implementation of pedagogical ideas, adaptation in runtime, and sharing orchestration load with students [9] in ubiquitous learning environments.

The vast majority of the studies were specifically conducted to evaluate the applicability of proposed orchestration approaches in authentic educational settings. This work is aimed at comparing our proposed orchestration approach [3] with contemporary ad hoc orchestration.

III. Workbench Prototype

A client-side Web-based orchestration workbench user interface was implemented, using HTML/CSS, Twitter Bootstrap and JavaScript, to assess the efficacy of organised orchestration. The workbench interface is loosely implemented based on the IMS Global Simple Sequencing specification conceptual model [10]. Specifically, the interface leverages linear directed sequencing.

In order to ensure seamless access to educational resources when orchestrating learning activities, workbench interface components were placed in appropriate region panels. Fundamentally, the goal is to facilitate seamless access to various orchestration functionality when switching between activities.

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While the workbench interface implementation was specific to the planned study, the fundamental idea is to enable centralised access to tools and services during a typical learning session. Furthermore, the implementation of the interface assumes the existence of a pre-session management backend service for facilitating scripting of learning activities.

IV. Method

A within-subjects design experiment was conducted, using random experimental blocks in order to counterbalance the learning effect. Participants orchestrated a learning scenario using two orchestration approaches—ad hoc or organised orchestration—yielding a total of two experimental conditions.

PortableApps, a fully open source and free platform that optionally works on portable storage devices [11], was used to simulate ad hoc orchestration, while the prototype workbench user interface was used to represent organised orchestration. PortableApps makes available a number of commonly used Windows application that are packaged and optimised for portability. The PortableApps platform was used as it implicitly enables access to applications in a similar manner as with commonly used operating systems. More importantly though, the platform ensured that all participants had access to a consistent ad hoc orchestration interface.

AttrakDiff 2 [12] was used in its entirety, without any modifications, as the core method of investigation as it assesses perceived user feelings about a system in the form of quantitative comparative data; specifically, the "Comparison A–B" [13] approach was utilised. AttrakDiff 2 measures attractiveness of interactive products using four dimensions: Pragmatic Quality (PQ), Hedonic Quality - Stimulation (HQ-S), Hedonic Quality - Identity and Attractiveness (ATT) of an interactive product. The instrument comprises of opposite adjectives—word-pairs—that are grouped to make up the four dimensions. The four dimensions were evaluated using the standard AttrakDiff 2 evaluation methodology—dimension means and word-pair means were computed for the two orchestration techniques. In addition, the results are also presented using standard AttrakDiff 2 graphs—portfolio-presentation and line graphs for dimension means and word-pair means.

A. Participants

Participants were recruited from among undergraduate student teachers, using poster advertisements, at a large university, after ethical clearance was granted. 61 individuals participated in the study, with 55 of them completing all assigned tasks.

Their level of study ranged from second year to fourth year, with varying specialisations and, on average, had been on teaching practice at least three times. In addition, 91% of participants had at least two years experience working with computers.

Each participant was compensated with ZAR 40.00 for their time.

B. Orchestration Tasks

Participants used the two techniques to orchestrate five learning activities detailed in a fifth grade science "What are fuels?" learning scenario from a standard teacher guide text book [14] using Desktop computers.

The scenario effectively involved using three educational resources: (1) the teacher guide PDF document; (2) the "Formation of fossil fuels" video; and (3) the "Fossil fuels" remote Web resource.

Participants performed three tasks while using the two orchestration approaches, by following a sequence of instructions provided.

C. Procedure

Participants were briefed about the experiment, asked to sign a consent form and fill out demographic information—level of study, teaching experience and computing experience, in order to assess the influence of control variables on the final results.

Participants were then randomly assigned to two groups—Group 1 and Group 2—to prevent potential order effects. The random assignment ensured that the two orchestration techniques were counterbalanced by alternating the order of exposure to the two techniques.

Participants were required to self report times when performing the tasks. They were then asked to fill out two AttrakDiff 2 questionnaires corresponding to the two orchestration techniques, after completing the tasks. Finally, participants were debriefed upon completion of all the experiment tasks.

D. Evaluation aspects

The time taken to complete the orchestration of learning activities, and the PQ and HQ-I dimensions were used to compare the effectiveness of the two approaches. This was done in order to ascertain where learning activities were orchestrated more successfully, easier or faster; the extent towards which orchestration goals were realised; and participants' level of comfort during the orchestration of learning activities.

In order to assess the user experience during the orchestration of the learning activities, the HQ-I, HQ-S and ATT dimensions were used to compare the two approaches.

Table I shows a summary of the experimental factors and associated experimental variables.

TABLE I
SUMMARY OF EXPERIMENT EVALUATION ASPECTS

Aspect	Factor	Variable	Scale	Description
Effectiveness	Speed	Time	Minutes	Time on tasks
	Success	PQ	[-3 – 3]	Dimension means
	Comfort	HQ-I	[-3 – 3]	Dimension means
User experience	UX	HQ-I	[-3 – 3]	Dimension means
		HQ-S	[-3 – 3]	Dimension means
		ATT	[-3 – 3]	Dimension means

V. RESULTS

A. Time on tasks

Figure 1 shows the average time it took for participants to complete the orchestration activities for each of the two approaches.

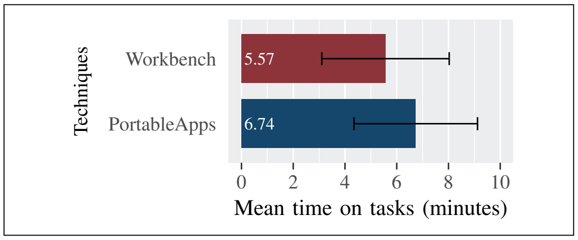

Fig. 1. Average time on tasks comparison

A paired samples t-test showed the workedbench resulted in significantly faster orchestration times ($p < 0.05$). Participants orchestrated learning activities 21% faster when using the workbench. Participants in Group 1 orchestrated the learning activities 27.4% faster using the workbench than with PortableApps, while those in Group 2 orchestrated the learning activities 14.7% faster when using the workbench. Interestingly, workbench orchestration was faster for participants in Group 1 than those in Group 2.

In terms of demographic patterns, participants in all study levels orchestrated activities faster using the workbench approach. For all teaching practice frequencies, participants orchestrated activities faster using the the workbench approach. Participants with '0–1 years', '2–3 years' and '5+ years' computing experience orchestrated learning activities faster using the workbench approach, however, those with '4–5 years' experience orchestrated them faster using PortableApps.

B. AttrakDiff 2 Means

The results were analysed and are presented using the standard AttrakDiff 2 methodology. Paired samples t-test were calculated across the four dimensions, showing significantly higher mean values for the workbench in all the four dimensions: (PQ: $p < 0.001$; HQ-I: $p < 0.001$; HQ-S: $p < 0.001$; ATT: $p < 0.001$).

Figure 2 shows the portfolio-presentation graph, with the character-regions occupied by the two orchestration techniques. In the portfolio-presentation, values for hedonic quality are represented in the vertical axis, while those in the horizontal axis represent values for the pragmatic quality. Bottom and left values represent low values, while top and right values represent high values. The aggregate values of the dimensions determine the position occupied by each approach. As shown in Figure 2, the workbench is located in the lower sector of the desired region. However, PortableApps is located in the neutral region, implying that it meets ordinary standards.

Figure 3 shows the results of the four dimension means. In all dimensions: pragmatic quality, hedonic qualities, and attractiveness, the workbench performs better than PortableApps.

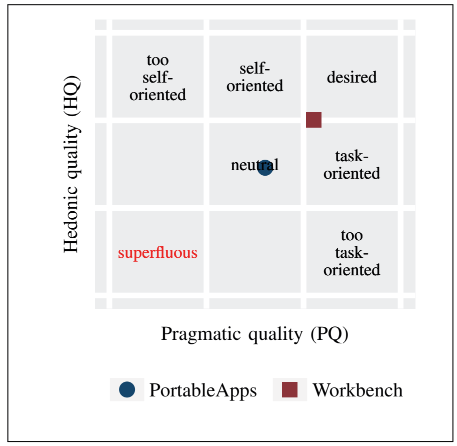

Fig. 2. Portfolio presentation graph comparison

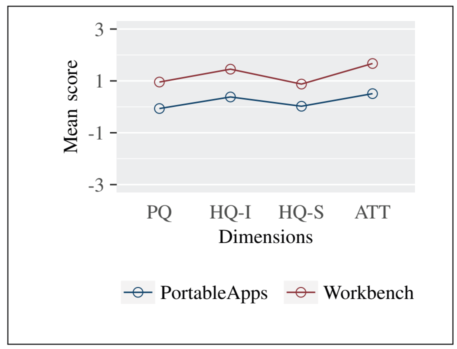

Fig. 3. Dimension means comparison

Further analysis of the dimension means was done using their associated word-pairs. The word-pair ratings for the PQ dimension show that the workbench was highly perceived as being more simple, clearly structured, straightforward, practical, and manageable. However, the workbench was perceived as being somewhat technical and unpredictable. These lower score responses can perhaps be attributed to the fact that participants were unfamiliar with the prototype interface. All word-pairs from the HQ-I dimension were rated with higher scores for the workbench. In the ATT dimension, the workbench had a higher score in all word-pairs.

A similar trend is observed when analysing the effect of the counterbalancing. For both Group 1 and Group 2, the workbench scores higher in all the four dimensions. The demographic results also have a similar trend with the overall results. Participants from all levels of study, with the exception of fourth year students, rated the workbench higher for all dimensions; the PortableApps had higher scores by fourth year students in the HQ-S dimension. In addition, participants rated the workbench higher irrespective of the number of times they had been on teaching practice or the computing experience they possessed.

VI. Discussion

A. Analysis 1: Effectiveness

As outlined in Section V-A, learning activities were on average orchestrated faster using the workbench. This is because the workbench interface facilitated easy access to functionalities required to perform the tasks.

Participants' perceived success at orchestrating activities is best supported by PQ word-pairs such as "Cumbersome – Straightforward" and "Complicated – Simple", which were rated highly in favour of the workbench.

B. Analysis 2: User experience

All word-pairs for the ATT dimension—a strong indicator of user experience—were highly rated for the workbench. The overwhelming positive responses in favour of the workbench are further corroborated by the following comments from some participants.

- "If I were to do this with my learners I would definitely do approach 1" (Participant 6, Group 1)
- "I liked it more than the second approach. This was really good and creative, easy to access your resources and activities" (Participant 2, Group 1)
- "The second activity was harder for me to do." (Participant 3, Group 1)

C. Analysis 3: Counterbalancing

As stated earlier, the counterbalancing had a similar effect on the results for the dimension means. However, the counterbalancing had an interesting effect on the task completion times: while participants orchestrated the learning activities faster in both groups, they were fastest in Group 1. The best possible explanation for the variation is the complexity and effort required during the transition between the two approaches.

The workbench was perceived to be both simple and requiring less effort during the orchestration of learning activities. Transitioning from the simple approach to the complex approach resulted in increased task times than when transition from a complex approach to a simpler one.

D. Analysis 4: Demographic differences

The influence of some control variables had a noticeable effect on the results. For instance, there was some correlation between demographics—year of study, teaching experience and computing experience—and task times: participants' task time patterns were similar for both approaches; for instance fourth year students orchestrated activities quicker using both approaches.

VII. Conclusion

In this work, we presented results from a comparative study of ad hoc and organised orchestration. A within-subject study was conducted, involving two orchestration interfaces.

The major findings are that an organised approach to orchestration enables participants to orchestrate learning activities faster than the ad hoc approach, and that their perceived success at orchestrating the activities was more pronounced when using the workbench. In addition, participants' experience was generally positive when using the workbench.

As part of future work, we are working towards making the pre-session management dynamic in order to facilitate the directed organisation and sequencing of activities before the actual orchestration of learning activities. In addition, since a number of learning activities and tasks performed by educators are common, we are exploring the possibility of building an infrastructure that will facilitate sharing of reusable orchestration sequence chains that are based on the proposed approach.

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