The Effect of Digital Versus Traditional Orchestration on Collaboration in Small Groups

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Abstract. We are developing an intelligent orchestration system named FACT (Formative Assessment using Computational Technology). Orchestration refers the teacher's management of a face-to-face classroom workflow that mixes small group, individual and whole class activities. FACT is composed of an unintelligent Media system and an intelligent Analysis system. Although the Analysis system, which is still being refined, is designed to increase collaboration, prior work suggests that the Media system could possibly harm collaboration. Thus, we conducted an evaluation of the FACT Media system in classrooms, comparing it against traditional classrooms. We coded videos of small groups in order to measure their collaboration. The FACT Media system did no harm: the distribution of collaboration codes in FACT classrooms is statistically similar to the distribution in traditional classrooms. This null result is welcome news and sets the stage for testing the benefits of the Analysis system.

Keywords: Orchestration · Collaboration · Digital media

1 Introduction

The FACT Media system [1–5] is a general purpose orchestration system similar to Group Scribbles [6]. It is unintelligent in that it does not know about the task the students are doing, so it cannot give feedback and advice. Such feedback and advice will eventually be given by the overall FACT system, which combines the FACT Analysis system and the FACT Media system.

For the FACT Media system, the biggest risk is probably its impact on collaboration. When students work face-to-face in small groups on digital media, then either (a) all the members of the group work on a shared display, or (b) each member of the group works on their own display of a shared document. Let us consider first case (a).

When a whole group is trying to edit the same display, it is easy for one person to dominate the interaction, thus harming collaboration [7]. This can occur even when everyone in the group has their own mouse [7–9] or when the display is a large horizontally mounted multi-touch screen [10, 11].

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Now for case (b). When each person has their own view on a shared document, students often try to refer to an object by pointing at their own screen, which fails because the other group members cannot see what the finger is pointing at [7]. This can harm grounding (i.e., group members arriving at a common understanding of noun phrases and other referential phrases). Grounding is an essential component of collaboration [12].

2 Evaluation

This study compared the amount of collaboration in classrooms that were using either traditional paper-and-pencil media or the FACT Media system. The classes enacted one of 8 Classroom Challenges, which are formative assessment lessons developed by the Mathematics Assessment Project (MAP, see http://map.mathshell.org). The traditional classes used the original paper-based versions of the Classroom Challenges. Pairs worked on a large paper poster. Their problem solving usually involved taking turns arranging paper cards on the poster or writing explanations on cards or on the poster. When they were finished, they glued the cards down.

In the FACT classes, pairs of students worked on the same Classroom Challenges but used electronic versions of posters and cards. They wrote, typed or drew on the cards or the posters, and they arranged cards on the poster. In both FACT and traditional classes, the teacher walked around the classroom visiting groups.

The participating classrooms were in schools near Nottingham, England or the South San Francisco bay area. Teachers were recruited by the MAP researchers in England and by the Silicon Valley Mathematics Initiative in the San Francisco bay area. All teachers were experts at enacting the Classroom Challenges.

The students were in 6th grade math classes, but some schools mixed grade levels in the same classroom. We asked teachers to choose Classroom Challenges that were at the right level of difficulty for their particular classes.

Every lesson was recorded by three cameras. One shoulder-mounted camera followed and recorded the teacher. Two other cameras, which were mounted on tall tripods, focused downward on the students' desk. Each recorded a single group (pair). Students' conversation was recorded by a boundary microphone on the table.

For each class, the 3 video streams were synched in Elan (https://tla.mpi.nl/tools/tla-tools/elan/), a video annotation system, and then divided into 30-second segments. We first used the teacher videos to locate segments of small group activity. Only lessons with at least 30 segments of small group activity were included. Then, using the videos of pairs, we assigned to each segment a code indicating the pair's behavior during that segment.

Our coding scheme was based on Michelene Chi's ICAP framework [13] which is perhaps the only coding scheme for collaboration that has associated its categories with learning gains. Our codes are shown in Table 1, along with their corresponding ICAP categories. The table rows are ordered from most desirable to least.

Most videos were coded by two coders. Interrater agreements (Kappa) averaged 0.74. Disagreements were resolved in a meeting of the two coders and one of this paper's authors.

Table 1. Average percentage of number of segments per code

	Description (ICAP categories in parentheses)	FACT	Paper
1	*Co-construction.* Both students shared their thinking. Their contributions built upon each other. (Interactive)	2.8%	4.0%
2	*Cooperation*. The students worked simultaneously and independently on different parts of the poster. (Constructive + Constructive)	10.6%	7.1%
3	*Unclear*. One or both the students explained their thinking, but the audio was not clear enough to determine whether it was one or two. (Constructive + Passive, or Interactive)	0.4%	0.9%
4	*One explaining*. One student explained his or her thinking (talking constructively) but the other student was either silent or merely agreeing. (Constructive + Passive)	4.0%	4.2%
5	*None explaining*. Students made edits, but neither explained their thinking. If they talked at all, their speech merely repeated their edits. For example, one student might say "Let's put card B here," and the other student agrees. (Constructive + Passive)	53.8%	67.7%
6	One student was off-task; the other worked without much talk. (Constructive + Disengaged)	4.5%	0.9%
7	The teacher was visiting the pair. (Passive + Passive)	3.3%	6.6%
8	The teacher was making a brief comment to the whole class, and these students were listening. (Passive + Passive)	1.1%	5.0%
9	The students were stuck and waiting for help from the teacher. (Disengaged + Disengaged)	0.6%	0%
10	The students were done with the task and waiting for the teacher to give them something else to do. (Disengaged + Disengaged)	11.8%	2.8%
11	Both students were off-task. (Disengaged + Disengaged)	7.1%	0.8%

2.1 Results

We coded 15 traditional pairs and 59 FACT pairs. For each pair, we counted the number of segments per code. Because the total number of segments was different for different pairs, we converted the counts into percentages. Table 1 presents the averages.

To understand these results, it helps to first consider the first 5 codes, which represent students doing problem solving together. Figure 1 shows the distribution of just these 5 codes. They are not reliably different (Chi-square, $p = 0.3$, $N = 59$, traditional distribution treated as expected probabilities). Thus it appears that FACT did not make a difference in how students worked together.

There were differences in the distribution of codes 6 through 11, where students were not working together. FACT seems to have reduced the amount of teacher intervention (codes 7 and 8), increased off-task behavior (codes 6 and 11), and increased the time students spend waiting for the teacher (codes 9 and 10).

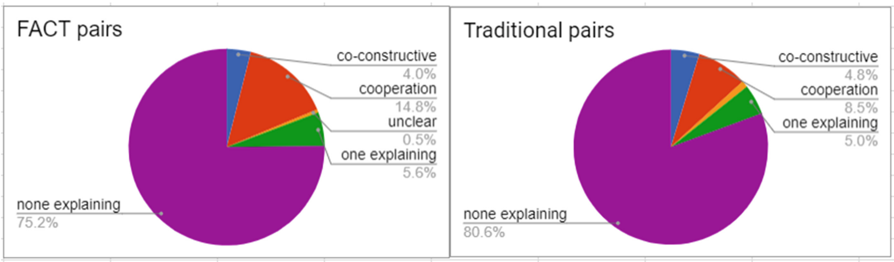

Fig. 1. Distribution of working-together codes (codes 1 through 5)

2.2 Discussion

Because this was a field study, we had no control over many important factors, including the participants, activities, time of year and time of day. Also, we compared the treatments with a single level of analysis (pairs) rather than the customary multi-level analyses (e.g., pairs nested in classroom nested in teacher nested in school). Thus, our results should be viewed with as preliminary.

Despite its limitations, the study suggests that the FACT Media system does not harm collaboration compared to the traditional, paper-based enactments of the Classroom Challenges. The proportion of the 5 working-together codes is the same for both FACT pairs and traditional pairs.

The amount of good collaboration (code 1, co-construction) in both venues is surprisingly small, under 5%. Gweon et al. [14], Hausmann et al. [15] and Viswanathan et al. [1] coded 14%, 20% and 25% of their segments as co-construction, respectively. However, all three studies involved undergraduates working in labs, whereas our data came from middle school students working in classrooms. Although the amount of co-construction was low, this finding sets the stage for the next phase of the FACT research agenda, which is to use AI technology to increase the amount of Interaction.

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