Exploring Cross-cultural Differences in Student Game Designs for WearableLearning

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Abstract: In this paper, we describe a study exploring cross-cultural differences in the game designs of middle school students from the USA and Argentina. Students created game design artifacts as part of the *WearableLearning* curriculum, which were coded to identify game aspects such as social and physical interactions, technology incorporation, and game characteristics and representations. We describe initial findings on how students' culture is potentially expressed in their game designs and discuss future directions for designing interactive learning environments that engage students in game design activities.

Keywords: learning technologies, game design, constructionism, culture

Introduction

The digital revolution has reshaped education and efforts to improve student learning outcomes. For example, individualized learning technologies have been found to improve learning outcomes and enhance student motivation (Hamada & Hassan, 2016). There is also a growing research focus on the intersections of culture, learning, and technology. Learning takes place in cultural contexts and learners' cultural backgrounds shape their learning habits (Ladson-Billings, 1995). Research on how culture influences learning suggests that instruction and learning environments should be consistent with learners' cultural experiences (Benson et al. 2017). Mohammed and Mohan (2011) argued that deficiencies in cultural awareness in digital learning platforms and instructional design cannot be ignored, given the rapid rise of digital learning. Some interactive learning environments (ILEs) have been expanded to account for the socio-cultural aspects of learners, such as the use of avatars that provide a sense of familiar cultural presence for learners (e.g., Arroyo et al., 2014).

In this paper, we explore how learners' culture is potentially expressed in their game designs within the context of *WearableLearning* (*WL*), a platform for children to learn mathematics by *playing*, *designing*, and *programming* physically active and social educational math games that use mobile phones to support players (Micciolo et al., 2018). *WL*'s accompanying curriculum engages students in the experience of *playing* games, and then later on *designing* and *building* their own games for peers to play. A key part of this process asks students to express game design ideas as drawings and narrations on booklets. These artifacts could mirror learners' cultural values, beliefs, and practices. Understanding the cultural constructs embedded in these designs and artifacts could help us identify ways to better support students' learning, and more broadly, improve the design of ILEs and understand the extent to which learning technologies can be "exported" to other geographies and communities. We present our initial findings on cross-cultural differences in game designs by middle school students from the USA and Argentina and discuss how these findings can be used to benefit the design of ILEs.

Related Work and Theoretical Framework

Our work is driven by key constructs including socio-cultural theory, constructivism, and constructionism.

Socio-cultural theory. Socio-cultural learning theory stresses that learning occurs within a social world and that learners' cognitive development is largely influenced by their surrounding culture, tools, beliefs, and attitudes (Vygotsky, 1978). In the *WL* context, game design artifacts such as written narratives, drawings, and diagrams on rules, physical objects and space, or physicality could mirror aspects of learners' culture, such as their beliefs, values, attitudes, perceptions of time, religion, and material possessions (Hofstede et al., 2005). In a similar vein, Kafai (1996) explored students' game designs and gender differences in them; we continue to build on such research through explorations of cross-cultural differences in the game designs of learners.

Constructivism and constructionism. *Constructivism* posits that learners construct their own knowledge and unique meanings for concepts (Elby, 2000). Related to this is *constructionism*, which states that learners are more deeply involved in their learning if they are constructing something that others will see, critique, and use (Harel & Papert, 1991). Leveraging constructivism and constructionism, *WL* facilitates mathematics and computing learning through learner-constructed math games (Micciolo et al., 2018). Through the *WL* curriculum, learners design and program phone-supported, physically active games, situating themselves within the context of a problem- and project-based game-design activity at the same time.

WearableLearning. *WL* is an ILE that enables learners to create and play mobile math games using a visual programming language based on *finite state machines* (FSMs). FSMs are typically used to teach computer behavior, concepts, and logic in terms of actions and reactions through visual FSM diagrams (FSMDs). The *WL* curriculum promotes computational thinking (CT) through game creation and play that integrate math, physical activity, multiplayer games, and programming. Prior work on *WL* has shown that middle school math teachers cultivated a deeper understanding of math concepts as game creators and players (Smith et al., 2020). Kafai and Burke (2015) noted that learning through game creation improves children's understanding of programming and math concepts. Our work expands *WL's* game design and play embodied learning portfolio through the lens of cross-cultural differences. Specifically, this study aims to answer the following research questions (RQs):

RQ1: What differences in *WearableLearning* game designs between students from Argentine schools and US schools exhibit, along the aspects of (a) social and physical interactions, (b) technology incorporation and dependence, (c) game characteristics, and (d) game representations?

RQ2: What do differences in game designs suggest about how students express their culture in their games?

Methodology

To explore cross-cultural differences in the game designs of students from Argentine and US schools, we analyzed *WL* game design artifacts using Ottmar et al.'s (n.d.) game design coding scheme.

Study design. We ran the six-stage *WL* curriculum with middle school students in US and Argentine schools. Students were introduced to the *WL* platform and were asked to create multiplayer games that use math, physical activity, and mobile phones (phones are used for game prompts and game inputs). The full curriculum is available at https://osf.io/yq49e/. In Stage 2 of the curriculum (a curriculum "stage" corresponds to a day), student teams brainstormed their own math games on paper to draw or map out game ideas. In Stage 3, students were given a short lecture on FSMs and then designed FSMDs on paper to represent the behaviors of mobile phones in their game. Students drew "state" boxes that correspond to game screens on the phone and arrows that specified concrete inputs (buttons, text, color sequences) that game players had to enter to move from one game state to the next. We analyzed game design artifacts from these two curriculum stages.

Participants and data collection. We collected data from a total of 172 students. Students from the US school were 21 seventh and eighth graders who attended a week-long game development summer camp. Students from three Argentine private schools were 151 sixth and seventh grade students who participated in our curriculum activities once a week for 6 weeks. In both cases, the activities were the same and each activity lasted for 60-90 minutes each day. The data collected includes the paper-based game ideation (Stage 2) and FSMD (Stages 3) sketches and the games programmed on the *WL* platform (Stages 4 to 6). Our analyses and discussions in this paper will focus on students' paper-based sketches from Stages 2 and 3 (Figure 1).

Analysis. We used a coding rubric designed by the *WL* research team specifically for analyzing game design artifacts produced by students through the *WL* platform and curriculum (full coding rubric available at https://osf.io/yq49e/). We coded for four game aspects: (1) social and physical interactions (*Collaboration, Competition,* and *Physicality Option*); (2) technological descriptors (*Dependence* and *Incorporation*); (3) game characteristics (*Game Descriptors, Progressive Levels,* and *End Goal*); and (4) game representation components (*FSMD Rules, Physical Objects, Physical Space,* and *Timing*). We used Between Subjects t-tests and Chi-Square tests to analyze differences between students from the US school and students from the Argentine schools.

Results and Discussion

We coded for ten game variables. Table 1 shows a subset of the results from coding the (1) *social and physical interactions* (*SP*), (2) *technological descriptors* (*TD*), (3) *game characteristics* (*GC*), and (4) *game representation components* (*GR*) from students' game design artifacts. We include only the four game variables with statistically significant results due to space constraints (full set of results available at https://osf.io/yq49e/): *Competition Between Teams* is the extent to which a game engages player teams in competition, *Technology Incorporation* indicates whether or not the designed game uses any form of technology (e.g., iPad, computers) within the gameplay, *End Goal* refers to the presence of an end goal for players or teams to win or finish the game, and *Timing* refers to expressions of time within the game (e.g., waiting time for turns). We found that the game designs of students from the US school depicted significantly more *competition* between teams than the game designs of students from the Argentine schools. Conversely, US students' game designs depicted less *collaboration* than Argentine students' game designs. These results suggest an expression of practices from the cultures of students' contexts: the Argentine students may be expressing the collectivist nature of Latin culture and the US students expressing the individualist culture of the US (Triandis & Gelfand, 2012). Game designs of the US students also

Figure 1

Examples of game design (left) and FSM diagram (right) sketches produced by Argentine students.

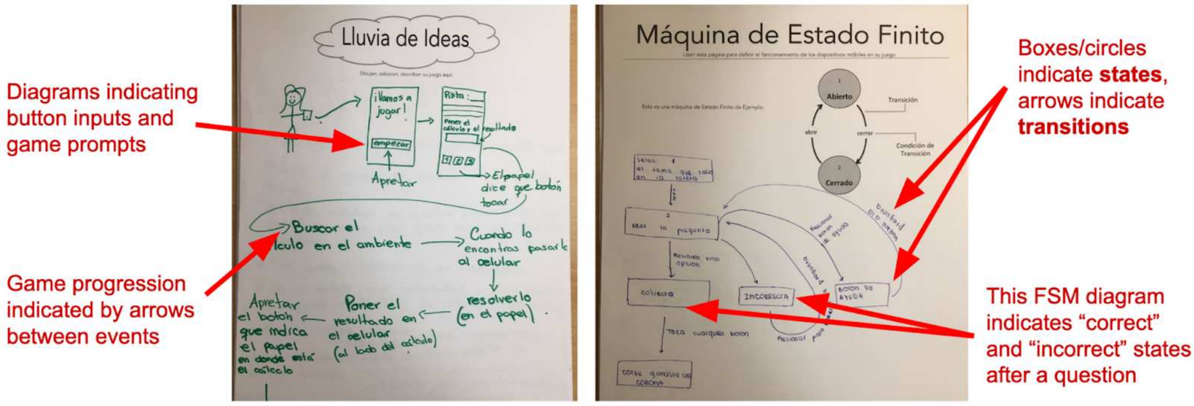

Table 1

*Count and % occurrence (in parentheses) for game variables coded for US (n=7) and Argentina (ARG) (n=41) games. (Chi-Square tests: * indicates significant difference, p<0.05; + indicates significant difference, p<0.1)*

Game Variables Coded	US-Stage 2	US-Stage 3	ARG-Stage 2	ARG-Stage 3
(*SP*) Competition Between Teams	3 (42.9%)*	3 (42.9%)	5 (12.2%)*	8 (19.5%)
(*TD*) Technology Incorporation	7 (100%)$^{+}$	5 (71.4%)	28 (68.3%)$^{+}$	22 (53.7%)
(*GC*) End Goal	5 (71.4%)$^{+}$	2 (28.6%)	15 (36.6%)$^{+}$	14 (34.1%)
(*GR*) FSMD: Timing		7 (100%)*		20 (48.8%)*

incorporated more technology than Argentine students' game designs. Reports (Auxier et al., 2020; Ravalli & Paoloni, 2016) indicate that children in the US and Argentina have access to technology at an early age, so early technology access does not explain the differences in technology incorporation in games. This, however, points to the need to better and more deeply understand our students' contexts. For example, we did not have data on students' use of technology outside of school settings.

In terms of game representations, all game designs of the US students had *timing* components compared to about half of the games from the Argentine students. The expression of timing in game designs may be related to the students' perception of time: Latin cultures tend to be flexible in their use of time, whereas US culture perceives time in a more rigid manner (White et al., 2011). With regard to *end goals*, in Stage 2 of the curriculum, there were more game designs by US students that had specific end goals for their games compared with Argentine students' game designs. These expressions of end goals dropped in Stage 3 in the game designs of both US and Argentine students. We suspect, however, that this drop had less to do with cultural factors, but rather the students' ability to translate from one design representation to another. Stage 2 required students to informally draw and sketch out their game design ideas on paper; Stage 3 required them to create a more formal representation of their game design sketches through FSMDs (also on paper). It is possible that when translating from one representation to another, students could have found that certain end goals they initially sketched out or conceptualized were difficult to formally represent in FSMDs. This hypothesis merits further exploration with bigger populations of students to better understand how expressions of game factors such as specifications of end goals are represented in game designs and potentially relates to students' cultures.

Conclusions, Limitations, and Future Work

Our results show that the game designs by students from a US school exhibited more technology incorporation, competition, specific end goals, and timing. Game designs by students from Argentine schools exhibited more collaboration, relatively consistent expression of game end goals, and less timing components. Aligning these with prior work on individualist and collectivist cultures, our work points to initial insights on how the culture of students' contexts (i.e., a US school and the three Argentine schools) could potentially influence how learners construct game design artifacts, specifically game designs constructed through the *WL* curriculum. This study could serve as a jump-off point for further research on exploring how ILEs and curricula supports, sustains, or hinders learners from expressing their cultural beliefs, attitudes, values, and practices in the artifacts they design and construct. Future work could address limitations in our study. For example, we used the geographic locations of the participating schools as a proxy for culture. This ignores the unique, multifaceted sociocultural identities of the students themselves and does not account for how the cultural backgrounds of each student could contribute to and shape the game design artifacts that they co-constructed with their peers. Interviews or focus-group activities with the students could enable the collection and analysis of more nuanced data to more deeply understand the kinds of cultural expressions that students bring into the constructions of game artifacts. Furthermore, this can provide insights for designing curricula and ILEs (such as *WL*) that engage students in creative design and construction activities for learning that are also grounded in the students' needs and values. Additionally, our analyses are based primarily on our coding rubric, and this study is the first time it has been used on design artifacts beyond ones collected from the US. In future work, we aim to further explore and understand the extent to which our coding rubric can be used to encapsulate the nuanced characteristics of game design artifacts created by learners, especially across different cultures and contexts.

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