On the understanding of students' perceptions of technology integration for group learning in low- and high-embodied activities

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Abstract: Embodied learning activities supported by motion-based technologies are becoming popular in various contexts and settings. However, little is yet known about the technology integration of collaboratively-enacted embodied learning activities in authentic classroom settings, as existing studies have been mostly conducted in laboratory settings. In this work, we examine students' learning and perceptions of technology integration of a highly-embodied, Kinect-based educational game (Condition1, n=24 students), in comparison with the low-embodied, desktop-based version of the same game (Condition2, n=18 students), in a group activity, in an authentic classroom setting. Data collection included questionnaires evaluating students' baseline, knowledge gains, perceptions of technology integration, and post-activity interviews. Findings showed higher learning gains and more positive perceptions of technology integration for the students in the low-embodied condition. Implications are discussed for supporting highly-embodied learning activities for group work in authentic educational settings.

Introduction and theoretical background

Embodied learning, as an application of the embodied cognition theory, constitutes a contemporary pedagogy of learning, which emphasizes the use of the body in the educational practice (Wilson, 2002). Embodied learning environments based on motion-based technologies appear to have gained ground during the last decade, providing new ways in which the embodied cognition theory can be enacted in the field of education. In particular, the widespread population of affordable motion-based technologies and natural user interfaces (e.g., Wii, Xbox Kinect, Leap Motion) have nowadays opened the doors for the design of technology-enhanced embodied learning environments, responding to the need to highlight the aspects of motion and physicality as a crucial part of the learning process (Melcer & Isbister, 2016). As argued by Maliverni and Pares (2014), technology-enhanced embodied learning environments open up new possibilities due to their potential affordances for promoting psychomotor, cognitive and affective learning gains.

From a technology integration perspective, incorporating innovative motion-based technologies and natural user interfaces in the school classroom introduces new challenges; therefore, their incorporation in mainstream education is at very slow pace (Abrahamson & Sánchez-García, 2016). According to Karakostas, Palaigeorgiou, and Kompatsiaris (2017) existing research on embodied learning technologies has been fragmented and is driven largely by technological innovations. Also, it has taken place mostly in laboratory settings focusing on the participants' interactions with the embodied environments, therefore lacking a clear focus on investigating their efficacy in authentic educational contexts (Karakostas et al., 2017). Moreover, while a number of technology-enhanced embodied learning environments have received positive evaluation in highly-controlled laboratory settings (e.g., Homer et al., 2014; Lindgren, Tscholl, Wang, & Johnson , 2016), the limited number of studies conducted in authentic school classrooms have not be as successful as initially expected in promoting students' learning gains, compared to low-embodied, desktop-based environments (e.g., Anderson & Wall, 2016; Hung, Lin, Fang & Chen, 2014). The later warrants further investigation towards shedding light on the efficacy of highly-embodied vs. low-embodied learning environments in authentic classroom settings.

The study adopts Moos (1987)'s conceptual framework of technology integration grounding the experience in three dimensions: "Relationship", "Personal development" and "System maintenance and change". Moos (1987)'s framework was used by Wu, Chang, and Guo (2007) and Maor and Fraser (2005) to derive subscales for the measurement and evaluation of the experience of technology integration. In particular, in this work, we examine students' perceptions of technology integration aimed at a highly-embodied, Kinect-based learning experience (Condition1, n=24 students), in comparison with a low-embodied, desktop-based learning experience (Condition2, n=18 students), in a group activity in an authentic classroom setting. The study sought to answer the following research questions: *(i) Are there differences in student's learning gains between the*

conditions? (ii) Are there differences in student's perceptions of technology integration between the conditions? (iii) What are the main factors affecting students' perceptions of technology integration in the two conditions?
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METHODOLOGY

Participants

Forty-two 4th graders (aged 8-9 years old), who were enrolled in a public primary school in the Eastern Mediterranean, participated in this study. Children were randomly assigned to the two conditions. Group1 (Kinect-based gaming condition) had 24 children (12 boys, 50%) and Group2 (Desktop-based gaming condition) had 18 children (11 boys, 61%).

Research design

This study was grounded in an explanatory sequential design, composed of two sequential phases (Creswell, Clark & Vicci, 2011). During the first phase, we adopted a two-group quasi-experimental design for investigating students' learning gains and perceptions on technology integration per condition. Next, we proceeded with qualitative data collection phase to deepen our understanding of students' perceptions on technology integration in each condition.

The digital game

We employed the "Alien Health" digital game, which was designed to teach 4th-12th grades about nutrition and healthy food choices. The game is well-related to the school curriculum whilst findings from previous studies of "Alien Health" indicated its acceptability by the children and its affordances to improve content knowledge (Johnson-Glenberg & Hekler, 2013). Children's mission in the game is to make the right nutritional choices for the alien to make him feel better as he in charge of stopping the collision of an asteroid with the Earth. During the gameplay, children are presented with combinations of food and are requested to make choices within predefined timeframes, considering a constellation of five nutrients per food (protein, fats, carbohydrates, fiber, and vitamins/minerals). The digital game became available in both a low-embodied (desktop-based) and in a high-embodied (Kinect-based) version.

The interventions

Considering the research goals of this study, an 80-minute intervention was developed for each condition. Children in the low-embodied (desktop) condition were divided in dyads and used the desktop-based version of the digital game. In this version children used the mouse and the keyboard for making a choice and feeding the alien (see Figure 1). Children in the high-embodied (Kinect-based) condition were divided in groups of four (the limited classroom space allowed only six Kinect work-stations of the game) and used the Kinect-based version of the game. In this case, the game was projected on a big screen and there was touchless interaction via the Kinect camera which can identify children's arm/hand movement hovering over a single food item and moving it into the Alien's mouth (see Figure 2). In both conditions the game was contextualized in a collaborative educational activity. In particular, the children took turns in playing (game affords only single player mode); the other child(ren) of the group was/were asked to provide feedback to the player, discuss the selections made, and record their food choices on a structured worksheet.

Figure 1. A group of students in the low-embodied condition

Figure 2. Two group of students in the high-embodied condition

Data collection and Analysis

Data collection included questionnaires evaluating students' baseline, knowledge gains, perceptions of technology integration, and post-activity interviews with eight students from Condition1 (33.3%) and eight students from Condition2 (44.4%).

Baseline data

We collected baseline data aimed at establishing the equivalency of the two conditions in terms of computer and gaming attitudes. More specifically, we used the Computer Attitude Measure for Young Students questionnaire (CAMYS, Teo & Noyes, 2008), which is composed of 12 items on a five-point Likert scale and has a documented reliability alpha coefficient of .85. Gaming attitudes were measured using an 11-item Likert scale (Cronbach's alpha=0.73) validated in the study of Bressler and Bodzin (2013). Differences between the two conditions were examined using the Mann-Whitney U test, given the small sample size of participants in each condition and the lack of normal distribution in the data.

Knowledge test

A knowledge test was administered in pre-post format. The test was developed by Johnson-Glenberg and Hekler (2013) for evaluating students' learning gains in the Alien Health game.

Technology integration survey

Students' perceptions of the technology integration were evaluated at the end of the experience. The questionnaire was composed of five subscales guided by Moos (1987)'s conceptual framework of technology integration, later used by Wu, Chang & Guo, 2007 and Maor & Fraser (2005) to derive subscales for its three dimensions: "Relationship", "Personal development" and "System maintenance and change" as in Table 1.

Table 1: Questionnaire Dimensions, Subscale Details and Individual Items

DIMENSION 1: Relationships	**Student Negotiation (SN): a 5-item subscale assessing the extent to which students have opportunities to discuss their questions and their solutions to questions (adapted from Maor & Fraser, 2005)**	
	SN-1	I get the chance to talk to other students
	SN-2	I discuss with other students how to conduct investigations
	SN-3	I ask other students to explain their ideas
	SN-4	Other students ask me to explain my ideas
	SN-5	Other students discuss their ideas with me
	Student Cohesiveness (SC): a 6-item subscale assessing the extent to which students are supportive to each other (adapted from Wu, Chang & Guo, 2007)	
	SC-1	Students are friendly to each other
	SC-2	Students are willing to help each other
	SC-3	It is easy to find members for grouping
	SC-4	Students share information with each other
	SC-5	Students have opportunities to discuss questions with classmates
	SC-6	Group members complete assignments together in class
DIMENSION 2: Personal Development	**Competition & Efficacy (CE): a 6-item subscale assessing the extent to which students are motivated and confident to compete each other (adapted from Wu, Chang & Guo, 2007)**	
	CE-1	Students care about their own performance
	CE-2	Students work hard to outperform others
	CE-3	Classmates' performances push students to be more diligent
	CE-4	Students set up study goals on their own
	CE-5	Comparisons among groups occur
	CE-6	Students are confident of learning this subject well
	Reflective Thinking: a 5-item subscale assessing the extent to which students have opportunities to discuss their questions and their solutions to questions (adapted from Maor & Fraser, 2005)	
	RT-1	I get to think deeply about how I learn
	RT-2	I get to think deeply about my own ideas
	RT-3	I get to think deeply about new ideas
	RT-4	I get to think deeply how to become a better learner
	RT-5	I get to think deeply about my own understandings

DIMENSION 3: System Maintenance and Change	Complexity: a 5-item subscale assessing the extent to which the program is complex and represents data in a variety of ways (adapted from Maor & Fraser, 2005)	
	C1	It has an interesting screen design
	C2	It is easy to navigate
	C3	It is fun to use
	C4	It is easy to use
	C5	It takes only a short time to learn how to use

Post-activity interviews

Eight students from each condition participated in an approximately 15-minute semi-structured individual interview, which took place right after the intervention. The students were asked to talk about their learning experience with Alien Health, as well as their use and perceptions of the utilized technology. Driven by Moos (1987)'s conceptual framework of technology integration and its three dimensions, the students were particularly probed to discuss the factors affecting their experience in terms of: (a) Personal development (e.g., What were the main factors that help you learn during your participation in this digital game?), (b) Relationships with others (e.g., How was the collaboration among team members structured around the digital game employed?), and (c) Technology use (e.g., Did you encounter any problems while using the digital game? How those problems affected you?). All interviews were transcribed and coded within the three dimensions of our conceptual framework.

FINDINGS

Setting the baseline

A Mann-Whitney U test was used to identify any potential differences between groups in student' attitudes towards computers and digital games (Table 2). Results showed that there were no statistical differences in the student's gaming attitudes ($U_{(40)}$=198.5, z=-.45, p>.05) and attitudes towards computers ($U_{(40)}$=183, z=-.84, p>.05) between the groups.

Table 2: Baseline assessment of students' gaming attitudes and attitudes towards computers

	Condition 1 Kinect-based game		**Condition 2** Desktop-based game		Z
	Mean	SD	Mean	SD	
Gaming attitudes	3.38	0.65	3.28	0.52	-0.45
Computers attitudes	3.93	0.70	3.69	0.84	-0.84

Note. *p≤.05, **p≤.01. ***p≤.001

Knowledge gains

A Mann-Whitney U test was used to identify any potential differences between groups in student' pre- and post-test scores towards (Table 3). Results showed that there were no statistical differences in the student's pre-test scores ($U_{(40)}$=195.5, z=-.52, p>.05). However, focusing on the post-test scores, students in Condition 2, who employed the desktop-based version of the game, outperformed their counterparts in Condition 1, who employed the desktop-based version of the game, and this difference was statistically significant ($U_{(40)}$=139.5, z=-1.96, p≤..05) between the groups.

Table 3: Pre-test and Post-test scores

	Condition 1 Kinect-based game		**Condition 2** Desktop-based game		Z
	Mean	SD	Mean	SD	
Pre-test scores	5.79	2.27	5.89	3.28	-0.52
Post-test scores	5.52	2.74	7.14	2.99	-1.96*

Note. *p≤.05, **p≤.01. ***p≤.001

Technology integration perceptions

A Mann-Whitney U test was used to identify any potential differences in student's perceptions of technology integration across conditions. The results showed that students of Condition 2 had better perceptions with regards to the "Student Negotiation" subscale. Yet, there were no statistical differences between the conditions on all other subscales (see Table 4).

Table 4: Technology integration perceptions

	Condition 1 Kinect-based game		**Condition 2** Desktop-based game		Z
	Mean	SD	Mean	SD	
Student Negotiation	3.36	1.01	3.97	0.60	-2.20*
Student Cohesiveness	3.85	0.97	4.08	0.70	-0.61
Reflective Thinking	3.41	0.95	3.81	0.79	-1.24
Competition & Efficacy	3.53	0.81	3.59	0.93	-0.06
Complexity	4.03	0.93	4.13	0.72	-0.05

Note. *p≤.05, **p≤.01. ***p≤.001

Factors contributing to students' technology integration perceptions

The thematic analysis led to the identification of numerus factors (codes) influencing students' perceptions of technology integration for embodied learning in groups, within the three dimensions of our conceptual framework: "Relationship", "Personal development" and "System maintenance and change". A conceptual map was the result of further organizing the emerging factors into basic themes, namely: (a) Content-related factors, referring to the features of the gaming content, (b) Interface-related factors, referring to the affordances of the gaming platform, (c) Activity-related factors related to the pedagogical setting in which the game was contextualized and (d) Context related factors, referring to the characteristics of the physical environment in which the activity was enacted. All factors were also evaluated as positive or negative in relation to their impact on students' perceptions in the two conditions (see Table 4).

Table 4: Categorization of factors reported as affecting students' perceptions on technology integration

		Highly-embodied condition [Kinect-based game]		**Lowly-embodied condition [Desktop-based game]**	
Framework Dimensions	**Basic themes**	**Positive factors (+)**	**Negative factors (-)**	**Positive factors (+)**	**Negative factors (-)**
Personal development	**Content related factors**	Learning content	Textual information	Learning content	Textual information
		Gaming features		Gaming features	
		Narrative plot		Narrative plot	Repetition of gaming stages
		Integrated scaffolding		Integrated scaffolding	
	Activity related factors	Worksheets	Gaming nature	Worksheets	Gaming nature
	Interface related factors	Embodied interactions	Locomotion		
	Context related factors		Classroom noise		Classroom noise
			Other group interventions		Other group interventions
Relationship	**Activity related factors**	Team-based mode	Large groups	Team-based mode	
		Collaborative writing task	Unstructured collaboration	Collaborative writing task	
		Peer feedback strategies	Waiting time	Peer feedback strategies	
	Interface related factors		Single-player mode		Single-player mode

System Maintenance and Change	**Interface-related factors**	Novel interface	Gaming controls	Gaming controls	Small projection
		Large projection	Synchronization issues		Low graphics interface
		Bodily movement			
		Touchless interaction			

Personal development

Students in both conditions reported how a set of content-related factors such as the *learning nature* of the game, the *gaming features* (e.g. stages, points, rewards), the *narrative plot* on which the game was structured, as well as the *integrated scaffolding* (e.g., hints and prompts) had a positive contribution to their personal learning development. E.g.

> *"I liked the game's narrative plot as there was an alien trying to go back to his planet. We had to feed the alien with healthy foods. I liked the fact that every new planet was a new stage in the game with a new activity to do. It was an educational game because you could learn about nutrients in food."*
>
> *[#Girl -L-, Desktop-based version]*

However, students in the highly-embodied cognition highlighted that there was too much *textual information*, while students who worked in the lowly-embodied condition also added that there was a *repetition of the gaming stages*, which in turn had a negative impact of their interest. E.g.

> *"A negative factor in the game that I can think of was the large text. A box popped up in every new stage writing a lot of text. Text could be limited."*
>
> *[#Girl -E-, Kinect-based version]*

Focusing on the activity-related factors, students in both conditions, added that while the *worksheets* that they were required to complete contributed positively to their personal development, the *gaming nature* sometimes inhibited the learning process, as in many cases the students would deal with the activity as a playful rather than as an educational experience. E.g.

> *"We were carried away when playing the game and were oftentimes forgetting to complete our paper assignment. It was difficult to remember later on what to write."*
>
> *[#Girl -L-, Desktop-based version]*

On top of this, focusing on the interface-related factors, students in the highly-embodied condition reported that while the activity allowed for *embodied interactions* which were valuable for their learning and personal development, *locomotion* was in some cases a negative aspect. In particular, as some of students admitted, in some cases they would be more focused on coordinating their body movements, rather than on the learning content. E.g.

> *"Moving my body did not help me being concentrated but I had a lot of fun. If I was stable in front of a computer I would have been more concentrate because I would focus on the screen and click the correct answer, rather than trying to coordinate my body."*
>
> *[#Girl -E-, Kinect-based version]*

Finally, students in both conditions reported how the *classroom noise* and *other groups' interventions* while working, were two main context-related factors negatively affecting their personal development.

Students' relationships

Students' in both conditions reported how a set of activity-related factors such as the *team-based mode* in which the activity was enacted, the *collaborative writing task* that were assigned (one worksheet to be completed by each group) and the *peer feedback strategies* that were followed, had a positive impact on their collaboration. More specifically, as the students mentioned all these factors promoted productive social interactions, such as exchange of views and ideas, peer scaffolding and assistance. E.g.

> *"I liked working in my group to complete the paper assignment. We worked collaboratively and we were helping each other. We were helping our co-players to choose the correct answer, we were giving instructions and we were encouraging each other to try harder."*

[#Girl -E-, Kinect-based version]

However, students in the highly-embodied condition also negatively elaborated on how a set of activity-related factors, such as working in *large groups* (of 4 students) in combination to the *unstructured collaboration*, affected their relationships negatively. In particular, as the students admitted, both of these factors prohibited their effective collaboration, as it was more difficult to agree on a common strategy and plan their next steps, while there were also many disagreements with children often fighting over turn-taking and roles in the group. E.g.

> *"I wanted to play more but the other members in my team urged me to finish so they could play. There was also a boy taking my turn in the game. He wanted to play instead of me. I couldn't concentrate because my team members were telling me the correct answers, or they were trying to show me how to move. I got confused!"*
>
> *[#Boy -M-, Kinect-based version]*

Finally, students in both conditions, highlighted that in terms of the interface-related factors, the *single-player mode* of the game, transformed the non-player(s) as spectators, and this had also a negative effect on students' relationships. Importantly in the highly-embodied condition, this factor had an increased negative effect given the increased *waiting time* between turns, which resulted in off-task discussions and behaviors amongst the members of the group. E.g.

> *"The game was for a single player. All the other members of the group stayed aside, they had conversations with each other about topics unrelated to the game's content and they were not concentrated in their team members' actions neither on contributing to the group's collaboration."*
>
> *[#Girl -A-, Kinect-based version]*

Technology use

According to the students of the high-embodied condition, the *large projection* (bigger screen providing more heightened sensory stimuli), the *interface* (with the use of novel technologies), as well as the affordances of the gaming platform for promoting *bodily movement* (via the gesture-based interactions), contributed to their experienced immersion and this had a positive impact on their perceptions of technology use. E.g.

> *"There was a large screen which seemed nicer and easier. I could see everything in that big screen. I could have better control of the game and I could feel like being in the game!"*
>
> *[#Boy -I-, Kinect-based version]*

However, the students of the high-embodied condition reported that the *controls* of the game which were rather different from traditional gaming controls, some *synchronization* issues often presented between students' movements and their belated projection on the screen, as well as some technical bugs (provoked by students' proximity to the Kinect), affected their perceptions of technology in a negative way. E.g.

> *"Sometimes there were problems with the technology. The game blocked and our hand signal was not appearing on the screen or was presented in a wrong position. This cost us time as we had to wait for the problem to be resolved!"*
>
> *[#Boy -I-, Kinect-based version]*

Finally, students in the low-embodied cognition reported that the small projection (limited desktop screen) and the low graphics *interface* had a negative effect on their perceptions about the technology use. However, students in the low-embodied condition explained that the game had familiar *gaming controls* (keyboard and mouse) and thus, was more easily integrated in the lesson.

Discussion and Implications

The present investigation examined students' learning outcomes and perceptions of technology integration of a highly-embodied, Kinect-based educational game in comparison with the low-embodied, desktop-based version of the same game in a group activity, in an authentic classroom setting. Findings suggest higher learning gains and more positive perceptions of technology integration for the students in the low-embodied condition.

Are there differences in student's leaning outcomes and perceptions of technology integration between the conditions? In the present work, there was no difference in most dimensions of students' perception of technology integration across conditions; yet, students in the low-embodied condition presented increased knowledge gains in comparison to their counterparts in the highly-embodied condition. In general, the results contradict findings of prior research conducted in laboratory settings in which the prevalence of high-embodied versus low-embodied games in students learning is presented (Homer et al., 2014; Lindgren et al., 2016). Indeed, the present study supports previous evidence (from a limited number of studies conducted in authentic school classrooms) that the highly-embodied experience has not been as successful as initially expected in promoting students' learning compared to low-embodied, desktop-based environments (e.g., Anderson & Wall, 2016; Hung, Lin, Fang & Chen, 2014). That is, while being enjoyable and engaging, the experience with embodied learning technologies used in a typical classroom environment to run learning tasks, did not always produce significant learning gains.

What are the main factors affecting students' perceptions of technology integration in the two conditions? The analysis of students' post-activity interviews shed light to our findings; a series of contextual factors were mentioned by students of affecting their perceived experience in a negative way. For example, common technical issues or a noisy classroom environment, may detract from rather than enhance student learning, which is not a surprising result (e.g., Darling-Aduana, & Heinrich, 2018). The study presented a conceptual map to summarize these factors into content-related factors, interface-related factors, activity-related factors and context related factors affecting the experience in both conditions. The map can be informative in future research and practice in the area allowing to control for some for these factors in the authentic learning environment.

Evaluating the outcomes of the present case study, several limitations should be noted. Conducting scientific research in a functioning school environment was challenging which naturally introduces flaws in the implementation of the study. For example, the overall time students spent on learning was fixed in terms of the school time table which did not allow much time for familiarization with the game mechanisms especially in the Kinect-based condition. The classroom's setting imposed a number of additional constraints as having so many students in groups interacting with Kinect cameras, which in turn created undesirable noise and interference. There is clearly much more work that could be done to explore the best way of integrating embodied learning technologies within a classroom setting. Given the popularity of embodied leaning technologies in the recent days, this work helps to identify issues that are worthy of future investigation within the field of technology integration.

A central question remains to be answered: under what circumstances can embodied technologies be educationally beneficial in authentic classroom settings? Future research may wish to focus on how specific strategies for technology integration designed to be immediately adopted by in-service teachers could be beneficial in increasing technology integration and enabling students' learning gains and positive perceptions of technology use.

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