What Can Bits Teach about Leadership: A Study of the Application of Variation Theory in Serious Games

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Abstract. This study was conducted with the purpose to explore the potential of serious games to utilize systematic learning variation. We employed a methodology that followed the learning study method, while we also introduced experimental and control groups in order to allow for more direct comparison. In this study we did not have control over the employed serious game (vLeader) and thus had to implement our experiment through its supplementary materials. The study explores a systematic approach towards serious games design. This study provides weak evidence of greater stakeholder awareness by the group that has experienced variation. Its exploratory findings provide a valuable contribution that could inform design of future serious games.

Keywords: serious games, learning study, variation theory, leadership.

1 Introduction

Serious games have been widely appreciated as an attractive and accessible form of experiential learning. However, development of such games often is not informed by an established educational theory. In order to investigate this, we have undertaken an investigation in one of the most challenging learning topics – leadership skills. To address it, we have conducted a study with vLeader – a simulation game.

This paper reports the results of a serious game study within a university context. The study aimed to explore the potential for serious games to utilize systematic variation to enhance learning. This research goal was motivated by *variation theory* [1]. According to this theory, students' learning can be supported through controlled variation. By subjecting particular features of the object of learning to variation, these are being brought to the learner's focal awareness. This study aimed to apply this principle within a serious game and to evaluate whether this leads to an improvement in learning.

The study used the single-player game vLeader, developed by Simulearn Inc. The game aims to support learning within the domain of leadership. It was chosen because there is already some empirical evidence that vLeader is an effective learning tool. Sidor [2] reports several studies that show that the game has a positive impact on learning when compared to more traditional methods of learning. vLeader is discussed further in the corresponding section below.

M. Ma, M. Fradinho Oliveira, J. Madeiras Pereira (Eds.): SGDA 2011, LNCS 6944, pp. 49–60, 2011.

2 Method

Use of vLeader was embedded within a masters-level degree course run at UCL. The class consisted of 60 students from different management degree programmes that were taking part in a class titled *Leadership, Ethics and Communication*. The first 5 weeks of the course were dedicated to the topic of leadership. Use of vLeader was embedded within the first 5 weeks. In addition to the game, the course had a number of other activities dedicated to the topic of leadership including lectures (reviewing different theoretic models of leadership), case studies (shedding light on practical complexities and videos (demonstrating leadership behaviours in action).

For this study we used a modified methodology for the evaluation of learning effects in serious games. We chose to adapt the *learning study* [3] in order to evaluate a serious game. As a research methodology the learning study is an attempt to take advantage and combine controlled experimental studies with an incremental improvement method called lesson study. The learning study is used to evaluate by comparison of learning effects between subsequent deployments of a course, introducing improvements over the iterations. In order to fit in a single term we have attempted to provide two comparable learning conditions within a single class.

The study used a *between-subjects design*. The independent variable was variation, which included the conditions variation (the *experimental group*) and no variation (the *control group*). At the beginning of the study, the students were randomly assigned to either the experimental condition or to a control group. The separation between control and experimental group was implemented through the written instructions for each scenario, called *activity sheets*. These are described in detail in the materials section.

2.1 Procedure

The study consisted of three major stages: learning, assessment and post-study interviews. The learning stage was influenced by the available game scenarios, the experimental between-subjects design and the procedure for handling each of the scenarios. The learning stage occurred over 5 weeks. During this period, five hundred-eighty minute classroom sessions were used for teaching. In each of these sessions, only a part was dedicated to the study in order to introduce the game scenarios, to administer study materials, and to facilitate group discussions around the game playing experiences. The rest of the classroom sessions were used for delivering lecture materials on the topic of leadership. The game playing experiences took place individually in between these classroom sessions.

In Week 1, the students were introduced to the game and the study. Students were given 10 minutes to do the pre-test questionnaire. The course tutor then continued with the course lecture. Towards the end of the 180 minutes, the first game scenario was introduced and the students were each handed a paper-based version of the activity sheets. Students were then encouraged to play Scenario 1 of the game at a time of their own choosing prior to the next classroom session. This introduction to the game was disrupted by a fire alarm and subsequent evacuation of the whole building. As a consequence the introductory session was less elaborate than originally intended.

In Week 2, the 180-minute classroom session incorporated a 10 to 15 minutes group discussion that focused on the students' experiences of Scenario 1 of the game and relevant leadership theory. Typical questions in these discussions were addressed to how each of the game characters behaved and whether students could relate these game experiences to real life examples. Towards the end of the session, the tutor introduced students to Activity Sheet 2 (provided online) and Scenario 2. Again, the students were encouraged to play the game prior to the next 180-minute classroom session.

During the remaining weeks, a similar pattern was followed: the game scenario introduced the previous week was discussed in relation to relevant leadership theory in a short 10 to 15 minute session and, at the end of the class, the next game scenario and activity sheet was introduced. However, due to the restricted number of classroom sessions dedicated to leadership, it was necessary to introduce and encourage students to play 2 scenarios in one week (Scenarios 2 and 3). In the final session (Week 5), following a short discussion of the fifth and final game scenario, the post-trial written assessment test was administered.

2.2 Learning Assessment

Written assessment tests are a widely used form of assessment in studies of learning technology [4]. Free-form written assessment methods can be used to measure deep learning [5]. The study employed written assessment tests before and after exposure to vLeader as a measure of learning that took place.

University ethical guidelines meant that the study's learning assessment was extracurricular i.e. it did not contribute to the students' final course marks. Because the students experienced different conditions (one with variation and one without), and we hypothesised that variation would aid learning, it would have been viewed as unethical to incorporate marks from the study assessment in the student's final course marks.

For this study, a bespoke written assessment questionnaire was developed. It consisted of 3 open-ended questions and 7 Likert-scale questions. Responses to open-ended questions were examined via content analysis.

2.3 Post-Study Interviews

After the learning and assessment parts of the study were completed, a series of in-depth interviews were conducted. The aim of these interviews was to further explore students' perceptions of the game and application of variation in particular.

3 Materials

The study used the vLeader game, accompanying activity sheets and the written assessment tests.

3.1 vLeader

vLeader is a simulation-based serious game that aims to provide a practice environment in the domain of leadership skills [6]. The vLeader serious game embodies its own

theoretical framework which also informs the design of the game. An introduction to the framework is available to players via the instructional materials that the learner can access through the menus of the software. Although this framework was not considered important for the purposes of the course, there was no way to restrict students' access to it. Therefore students were told that they are welcome to explore it themselves, but they should consider it only as one of many possible theoretic frameworks about leadership.

Fig. 1. A screenshot of Scenario 4 of vLeader, showing a scenario setting, subtitles (blue area above), red-green opinion sliders and blue idea progress indicatiors. Ideas listed to the left are ones that are not currently brought to discussion, ideas on the right are the ones that have already been passed (agreed). All scenarios feature similar meetings around a table.

The game provides learners with role playing experiences within a series of simulated business meetings (see Fig. 1). The game developers argue that business meetings are prototypical situations for practising leadership. The game dynamics are based on three variables: the player's influence, group opinion towards the player and tension in the meeting. Personal influence determines the power of player's opinion. When the player suggests a new idea, they put their personal authority at stake. If the idea gets approved, their personal authority increases. Group opinion represents the attitude of participants in the meeting towards the player. If a player manages to find an effective balance in their interactions with the characters in the room, the opinion towards the player improves. Finally, tension is measured through player's ability to manage the conflicts in the room. Players get the opportunity to review their performance on each variable at the end of each scenario.

In vLeader, players interact with the game by exchanging positive or negative signals towards character or ideas. Ideas in vLeader represent topics that are being discussed. Progress in the discussion for a particular topic is represented by a progress indicator (see the blue progress bars in Fig. 1). Players can send a positive or negative signal for a particular idea or a particular character using clickable opinion sliders (also see Fig. 1). Each slider is coloured in a red-green gradient. If the player clicks on the green side of the slider for a particular character, their avatar makes a positive comment. The comment is negative if they click on the red side.

The exact utterances that emerge are limited and can often be unrealistically repeated. Simulearn Inc. argue that this issue is of secondary importance and helps students not get distracted from the main learning focus, being the intentions behind

each particular utterance. They have taken a decision to restrict the interaction interface to the intention of what is being said. Simulearn Inc. argue that in leadership situations, it is not as important what exactly is being done, as rather why exactly is it being done.

The game scoring mechanism consists of 6 values (see Fig. 2). These values are grouped in two components: 1) *leadership score*, which combines a *power*, *tension* and *ideas* sub-score and 2) *business score* based only on passed ideas in the scenario, which consists of *financial performance*, *customer satisfaction* and *employee morale*. These are the only immediate feedback that students get for their performance and thus it is expected to influence their behaviour in the game.

vLeader consists of five game scenarios. Students get access to play a scenario only when they pass all previous ones. The first scenario is designed to get the player used to the interface and involves managing one subordinate. In the second scenario, the player is required to manage two subordinates who have a latent conflict between them. The third scenario puts the player in a meeting with both superiors and subordinates in the organisation. The fourth scenario represents a situation where the player has the least formal power in the meeting. The fifth and final scenario features a crisis situation of the company management, after the occurrence of a risk event, and the player is only one of several attending managers.

3.2 Activity Sheets

vLeader is usually delivered together with a Student Workbook. In this workbook, there is a strong coupling between the simulation and the corresponding theory. Within the current study, the workbook was considered too restricting by the course tutor. So, for the purposes of the current study, a set of dedicated *activity sheets* were developed by the researchers – these adapted information from the Student Workbook to make it more relevant to the course requirements. The activity sheets were approved by Simulearn Inc. and the course lecturer. The activity sheets also provide a means of introducing variation into the game experience.

The activity sheets consisted of six sections: learning objectives, scenario background, business scoring tables, goals, hints and reflective questions. The sections were clearly distinguishable, providing students with the opportunity to use them selectively, according to their own preferences.

The *learning objectives* were one-sentence descriptions of the intended learning outcomes for each particular scenario. The activity sheets were used to connect each game scenario with a particular lecture. The *scenario background* section provided students with a written description of characters and ideas in the scenario. These were directly transcribed from the introductory information texts, delivered by the game. The *business scoring tables* provided a transparent scoring mechanism for the value of passing each particular idea. They represented a balanced scorecard of business score points that players receive when they pass certain ideas within the game. They were thus crucial towards high performance along the business score component of the game performance scoring (see details on game scoring below).

The experimental and control conditions were implemented via the performance *goals* and *hints* sections of the sheets. For the control group, the goals and hints were directly transcribed from the vLeader Student Workbook. The goals and hints for the

experimental group were amended for Scenarios 2 to 5 so that they focused mode narrowly on one specific aspect of leadership each. Marton and Pang's [1] variation theory recommendations identify four necessary conditions of learning: contrast, separation, generalization and fusion. *Contrast* stipulates that in order for a quality to be discerned, a mutualy exclusive quality has to be experienced in parallel. *Separation* emphasizes that certain dimension of variation can be discerned only if other dimensions remain invariant or vary independently. *Generalization* complements separation by focusing on the fact that discerning of a certain value in a dimension is easier when this value is kept constant when other dimensions change. Finally *fusion* stipulates that the interplay of two dimensions can only be appreciated when the two dimensions vary in simultaneously. These were brought into practice in vLeader as follows:

For Scenario 1, a decision was taken not to introduce variation because the original scenario already employs contrast in encouraging students to perform different styles of leadership in order to be able to compare them. Students were asked to be directive, participative and delegative in playing subsequent games. This was intended to allow them to compare how different styles influence other participants in the meeting.

In Scenario 2, variation was introduced through the hints section by focusing on the original concept from the Student Workbook and allowing for separation of time planning. The original text focused on keeping in mind the end goal and planning for preparatory work that could pave the way towards it. The introduction of variation to the other group, on the other hand, asked students to initially try to directly aim for the final goal, and in subsequent play that to try to plan for sub-goals as means of preparatory work. When instructed not to plan, the intention was that even those that were naturally inclined to do it, would deliberately postpone such an activity for until after they play. This approach was intended to underline the difference of whether to plan before a meeting or not.

Scenario 3 explored different approaches to the conversation with regard to who dominates it. The original activity sheet suggested first dominating and then letting others dominate, as this was done in all previous scenarios. The introduction of variation provided goals that suggested supporting someone else in the conversation and then subsequently striving for a better balance. This allowed students to clearly distinguish the effects of taking sides in a conversation. The focus of variation in this case was on generalization on the introduction of personal bias in a conversation.

This found its continuation in Scenario 4, where it was intended to allow for clearer generalization on the role of personal influence, specific suggestions for who to liaison with. Whereas the original instructions suggested “building an alliance with one or more characters for a strategic purpose”, generalization was strengthened by explicitly suggesting to ally consecutively with the two different characters that opposed each-other to a strongest degree. This allowed for more controlled and exhaustive variation, focusing on the two opposing sides in the conversation.

Finally, variation in Scenario 5 was intended to allow for clearer separation of performance from business results. To do that, students were encouraged to aim for as balanced business score (regarding its components) as possible. The intention was that while they still play for high results, they would aim for balanced business score components, which would allow the power and tension scores to be separated from the idea-related business scores.

The last section of the activity sheets was designed to encourage students to reflect on what they had learned in the scenario. This included questions that students were asked to answer before playing in order to plan for their success and others that were intended for after playing as a means of retrospective reflection. The success planning involved an engagement strategy for each meeting. It focused on intended ideas to be passed and balance between signals sent to people and ideas. The reflective questions concerned satisfaction with results, what styles of leadership were used and what parallels to reality students could make.

3.3 Written Assessment Test

These tests were developed in collaboration between the researchers and the course lecturer. A mix of open-ended questions and fixed-response questions were used to try to capture different levels of learning [7]. The students were given 10 minutes for the test, so answers had to be short.

The first three questions (Q1, Q2 and Q3) were open-ended. Q1 aimed at capturing the respondent's general conception of leadership. Q2 presented a situation that students were expected to be familiar with. It depicted a situation in which the student was part of a team that had to deliver, but there is tension within the team, a theme covered by Scenario 2. The experience of variation in Scenario 2 was expected to lead to a greater awareness of the need to break down solutions into sub-goals. Those who experienced variation in Scenarios 3 and 4 were expected to recognize their role as only a factor in collective decision making, rather than individual decision maker. Finally, students who experienced variation in Scenario 5 were expected to consider all three aspects that corresponded to the business score: financial performance, customer satisfaction and employee morale. Q3 presented another problem situation. Students were required to explain how they would resolve it. Similar to the previous question, the experience of variation in Scenarios 3 and 4 was expected to lead to greater appreciation for collective decision-making and variation in Scenario 5 – again appreciation for the corresponding three business aspects.

Q4 included 7 statements about leadership: students were required to indicate their level of agreement a Likert style response scale with five options from 'agree' to 'disagree'. For four of the statements (Q4i, Q4iii, Q4iv, Q4v, Q4vi and Q4vii) it was expected that students in the experimental group were more likely to agree. For one statement (Q4ii), it was expected that students in the experimental group were more likely to disagree.

4 Results

The results of this study are reported in three sub-sections: student involvement, in-game performance scoring and answers to the written assessments.

4.1 Student Involvement

While some students played the game quite actively (one student in particular playing as many as 75 games over all scenarios), a number of others did not engage with the game at all i.e. there was no data collected for 14 out of the 60 students (23%).

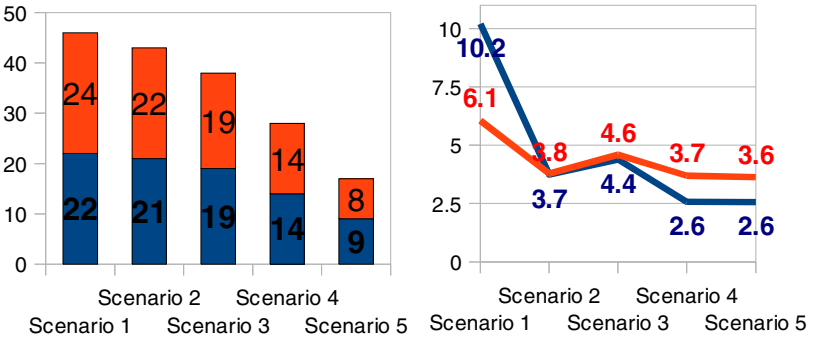

Fig. 2. (left) Number of participants; (right) Average number of plays per participant, according to scenario and experimental group

The students showed gradual reduction in their involvement with the game, both in terms of scenarios played (see Fig 2a) and number of plays per scenario (see Fig. 2b). The number of students that played the game fell from 38 for Scenario 3 to 28 for Scenario 4 and only 17 for Scenario 5. Over the prolonged use of the simulation game, students seemed to prefer to play between 3 and 4 games per scenario.

Since a group of students (23%) did not play the game, it was decided that a third group should be formed. This non-player group is treated as an additional group in the analyses below. In order for variation to work, students had to have at least several different experiences with the game. For this reason, it was decided to include in the non player group also students that played the game just a few times. This was defined as students who played Scenario 1 up to two times and subsequent scenarios no more than once. As this group was not created through random allocation, the results related to this group should be treated with caution e.g. it's possible that differences are due to factors other than game play.

4.2 Written Assessment

Pre- and post-study written tests were used to measure student learning. Of all 60 students on the course, 57 filled in the pre-test assessment sheets. 50 filled in the post-test assessment sheets. A total of 47 students managed to complete both the pre and post-test written assessment. This resulted in the following sample sizes for each of the conditions: 17 students in the experiment group, 16 students in the control group and 14 students in the non-player group. This section presents the results of the analysis of the responses to the written assessment questions.

The first three open-ended questions were analysed using content analysis. Written answers were examined in order to design a bespoke coding scheme that would capture all content within the answers. After that each response was coded with a set of binary codes for each question. The unit of analysis was words for Q1 and sentenced for Q2 and Q3. Non-hierarchical coding was used, meaning that certain content could be assigned several codes.

There was a noticeable change from the pre- to post-test session in the students' answers to the open questions with students providing shorter answers in the post-test sessions. During the in-depth interviews, students have explained this in terms of the gradual erosion of their motivation. Further findings are outlined in the Table 1 below.

Table 1. Questions and corresponding findings after the application of content analysis

Question (unit of analysis)	Finding
Q1. How do you understand leadership? What example could you name? (word)	Mentions of "influence" in responses showed a 32% increase when describing leadership from 15% at the beginning of the study to 47% at its end. A 24% drop in examples of leadership provided – from 62% to 38%. However, there were no statistically significant differences across the experimental groups.
Q2. You are working together with two other colleagues on a project. One of these colleagues regularly skips meetings and seems distracted when you discuss the project. His work has been of poor quality. What would you do? (sentence)	No observable tendency or other findings.
Q3. You work in a start-up with two other people. A major client has delayed a planned payment and as a result the company in turn cannot make a payment due by the end of the day. Your colleagues start an argument whether the company should stop working with that client. What would you do? (sentence)	The group subjected to variation shifted its focus of attention towards the customer, whereas the control and non-playing group shifted their focus in the other direction: towards the company.

Words were used as unit of analysis of Q1. Analysis of the vocabulary, used by students' responses to Q1, showed that the percentage of student responses talking about *influence* has increased from 15% at the beginning of the study to 47% at its end. This change was stronger in the variation and control group (with 47% of students in the variation group using *influence* to describe leadership) and weaker in the non-player group (where the term was used in 21% of the responses). Percentage representation of changes can be seen in Fig 3a.

There was also a noticeable drop in number of students that provided an example in their answers as it was requested. Whereas at the beginning of the study 62% from the considered 47 sets of beginning and end tests provided some form of an example, at the end of the study only 38% did. One possible explanation for this could relate it to the decrease in student engagement by the end of the study.

Q2 and Q3 were problem cases and thus the chosen unit of analysis was sentences. Content analysis of Q2 did not lead to any observable tendency or other findings. Fig. 3b above shows change from the pre- to the post-test session in mentions of each stakeholder type in the responses to Q3. It suggests that those students who experienced variation were more inclined in the post-test session to mention customers and less inclined to mention the team. Students in the non player and control groups showed the reverse trend: they were less likely in the post-test session to mention the customer and more likely to mention the team. Both in the experimental and non player group there were fewer mentions of the creditor in the post-test session.

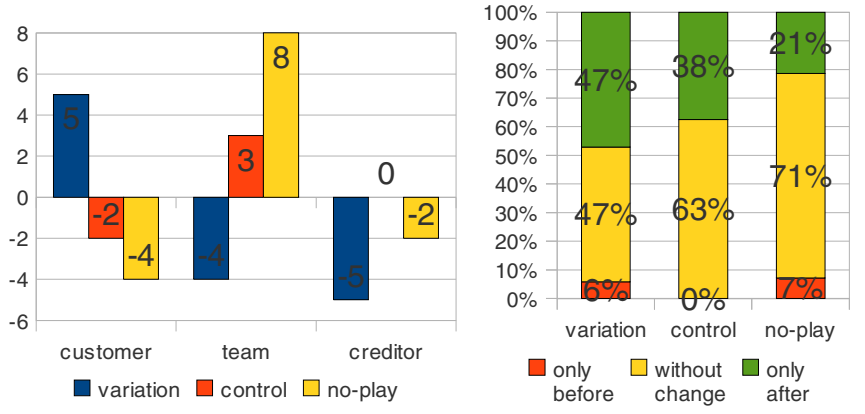

Fig. 3. Change in students responses from pre- to post-test sessions (left) employing influence to explain leadership in Q1; (right) mentioning particular stakeholders in response to the situation in Q3

Of the 47 students that completed the pre- and post- test written assessments, 3 did not provide complete responses to all the Likert-scale questions either. Thus, 44 remained in the analysis. This resulted in reduced group sizes – for the experimental: 15 participants, control: 15 participants, and non-playing: 14. A series of one-way analysis of variances found no statistically significant effects for these questions (the F and P values are shown in Table 2).

Table 2. ANOVA results for the ordinal Likert-scale questions (in all cases, d.f. = 2)

Question	F	P
Q4i. Anyone can become a leader.	2.61	0.0857
Q4ii. Leaders either focus on tasks or people.	0.77	0.4709
Q4iii. The same leadership principles apply in all cultures.	0.02	0.9793
Q4iv. Leadership is about getting people to do the right tasks.	1.06	0.3561
Q4v. Leadership is about gaining influence over people.	0.13	0.8777
Q4vi. Leadership is about involving others in idea generation and decision-making processes.	0.72	0.4906
Q4vii. Leadership is about empathy and objectivity.	0.07	0.9324

4.3 In-Depth Interviews

In this sub-section, we report some qualitative results from the semi-structured interviews. During these interviews, students were asked about the different perceptions and approaches when playing the game.

In the interviews, some students explained why they did not engage with the game as much as expected. Two reasons were identified. Some students said that, initially, they were unsure of the relevance of the simulation game to their final class grades

and, to be on the safe side, they engaged with the game actively. However, later on they realised that their game scores would not affect their class grades. This eased the pressure they felt to play the game. A second reason, reported by students, concerned increased responsibilities as the term progressed, leaving less time to play the game.

During the interviews, two different ways of engaging with the game emerged. Some students took a more exploratory approach to playing the game, trying different strategies to see what happens. Arguably this allowed them to experience greater variation. Others focused mostly on the scores they could achieve which didn't allow them to experience variation in the intended way.

Possibly related to their approaches to the game, the way students approached activity sheets followed in two distinct patterns. Following one of these two approaches, some students, much as it was intended when the activity sheets were designed, read the first activity sheet to understand its structure and from then on used the other activity sheets selectively, according to the perceived value of each of their sections. For different students this would include considering the ideas table, but noticeably goals and hints where variation was embedded. Several students complained that initially they wrote down the answers in their success planning and reflective questions sections, but because there wasn't a dedicated discussion on each of them, they lost their motivation to work on these sections during subsequent weeks. Discussions during weekly sessions were short and thus did not relate to each reflective questions in detail.

According to the other way, reported by students in the depth interviews, some of them played the game ad-hoc and not having considered the activity sheets at all. This had the effect of neutralizing any differences between the groups, related to variation, as introduced within the study design.

5 Discussion and Conclusion

The objective of this study was to examine how variation theory could improve the learning experience of a serious game. It has provided insights into some of the practical and methodological difficulties that can be encountered in this process.

Answers to Q1 showed that students were more inclined to describe leadership in terms of influence, which indicates how their way of thinking of the subject has come closer to that of researchers in the field, see in e.g. [8]. Although this was a common trend between all the groups, it was stronger with those playing the game, which indicates that the game could have helped them to reconfirm what they've been taught in the class.

These results in Q3 could be attributed to experiencing variation in scenarios 3, 4 and 5. The first two of these scenarios emphasized the role of others in the decision-making process whereas Scenario 5 focused on awareness about the three business aspects: financial performance, customer satisfaction and employee morale.

In this study, we employed the activity sheets as supplementary materials. One problem was that many students ignored these sheets and thus those in the experimental condition did not experience variation at all. One particular way to overcome this is to embed variation more directly into the game. At least for the purposes of studying the effects of variation, it is important to ensure that variation is embedded directly into the game, so students cannot find a way around it.

Another clear problem in capturing the effects of variation concerns the declining levels of student involvement over time. This meant that the sample size was declining for later the scenarios where some of the variation was employed.

Some students indicated that they were disinclined to participate given the fact that their game-based learning would not be assessed in the final course assessment, especially when the amount of work from other courses increased. It would not be easy to change this fact in future studies. University ethical guidelines require that students are assessed only on learning experiences they all have equal access to. If students are allocated to different conditions in a study design, it is not possible then to assess them on the content of the learning experiences in those conditions.

An alternative solution would be to use other kinds of incentives. For example, in certain contexts, it may be possible to give the students course credits for fully participating in the study. The reduction in the length of supplementary learning materials (like the activity sheets) would be a straightforward way to help increase student motivation. According to student feedback, activity sheets need to be made shorter, preferably restricted to one page. The sections about learning objectives, scenario background and context and learning refection could be removed from them and, if found necessary, communicated to students in a different way.

Acknowledgements. The research reported in this publication has been undertaken within the TARGET project, which is partially funded by the European Community under the Seventh Framework Programme (Grant Agreement IST 231717). The authors would like to thank all students who participated in the research as participants. We would also like to thank Pierre Thiault, Graham Courtney and Mike Venn for their support on behalf of SimLearn Inc. and Nina Seppala for including the reported study in her course at UCL.

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