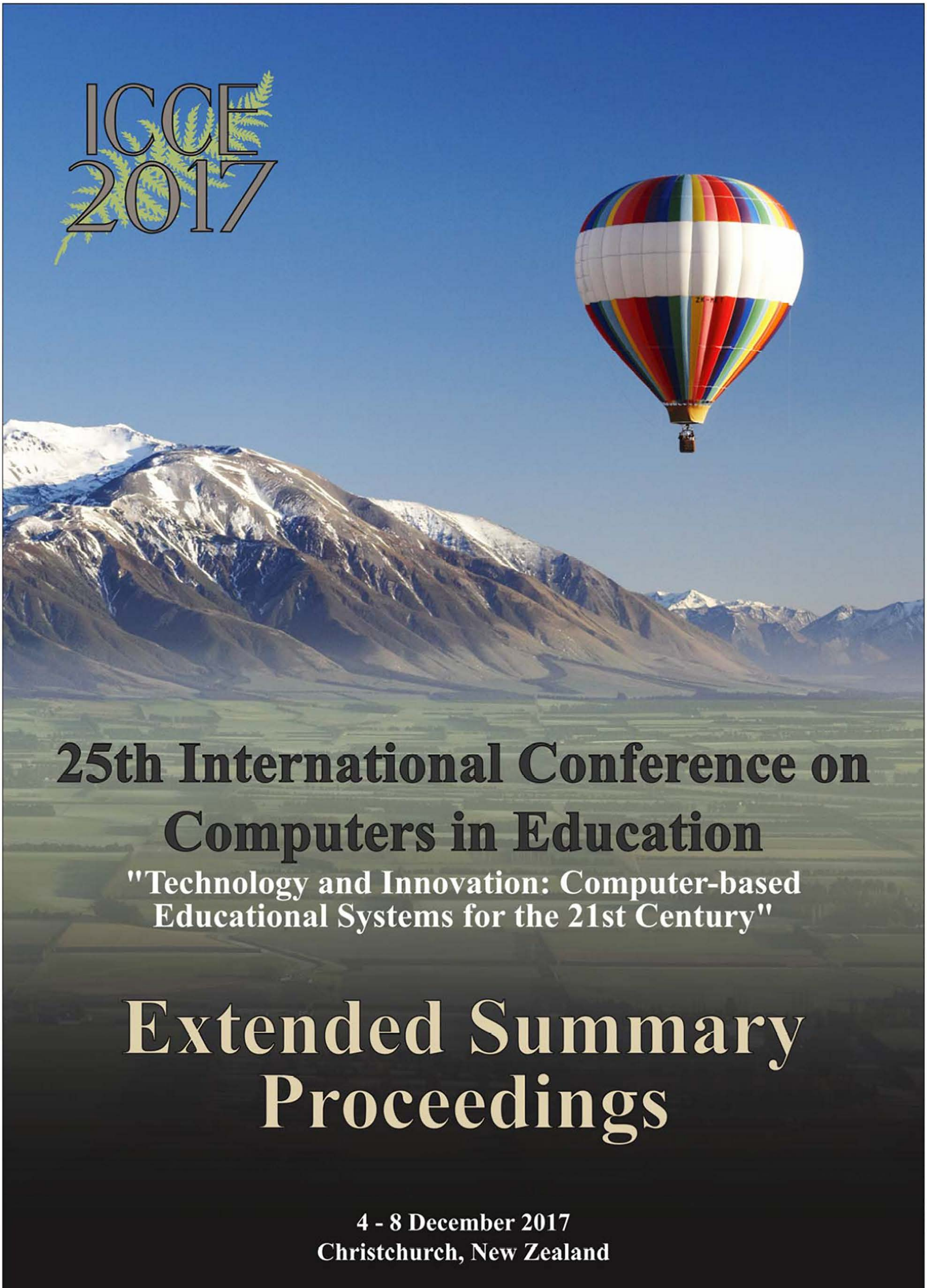

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A Taxonomy of Minecraft Activities for STEM

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1. Minecraft: Popular and relevant for education

With over 110M players, 241M logins per month, and 2B+ hours played on Xbox alone[1], in 2016 the video game *Minecraft* ascended to be the second most popular game in history, passing Grand Theft Auto V but still well behind Tetris (Peckham, 2016). One way to think about its reach and appeal is that millions of children worldwide decide on a daily basis to interact deeply and meaningfully with a game that is essentially a simulation of the natural world. We believe it is likely that this vast amount of time spent playing *Minecraft* is influencing the way children think about science, technology, engineering, and math (STEM), and are engaged in a research project that explores this question.

Because of its flexibility, appeal, and inherent connections to STEM learning, *Minecraft* has seen a dramatic rise in its adoption by educators worldwide who are using it as a platform for student projects, sharing, and learning (Schifter & Cipollone, 2013; Schwartz, 2015). Interactions in *Minecraft* involve a broad range of educationally relevant content (Lane & Yi, 2017):

- Exploring and investigating different biomes and climates that match those on Earth, including deserts, forests, jungles, taigas, and many others.
- Navigating in and around different types of terrain, such as hills, mountains, caverns, caves, oceans, and more.
- Interacting with a wide variety of wildlife and agricultural content, including animals, fish, birds, wheat, grass, fruits, vegetables, and a long list of fictional content.
- Searching for, mining, collecting, and combining many different resources such as different kinds of wood, stone, metal, dirt, and more.
- Building electrical circuits, switches, complex machines, and automated farms.

Players have even reconstructed world wonders, many of which can be found online (e.g. YouTube, dedicated servers). For example, the Taj Mahal is a popular project, as are fictional places, such as Westeros from the *Game of Thrones*. To achieve such feats of engineering, players often work collaboratively by planning and coordinating their tasks. They assume roles (e.g., mining for resources, planning a base/fort, crafting tools and weapons, etc.), work iteratively to refine their creations, and of course, share their work with friends, family, and the online community. Thus, not only is there a need to better understand how *Minecraft* may frame STEM learning generally, there is also a need to provide research-based support for its use in specific contexts and educational settings.

2. Top level categories of Minecraft activities

Soon after its release in 2009, educational uses of Minecraft quickly appeared online via teacher blogs, YouTube videos, and in educational technology news sites. Arguments for its appeal for STEM learning were often intuitive and compelling (Short, 2012), and its rapid adoption ultimately lead to Microsoft's release of *Minecraft: Education Edition*, a version of the game that comes prepackaged with tools specifically for teachers and classroom uses.[2] However, despite the success and rapid rise of *Minecraft* as a learning environment, very little effort has gone into formalizing its various connections to STEM. If the game continues to be popular in educational settings and we are to work towards evidence-based practices, it will be important to provide a substrate for the activities learners perform while playing. The goal of our taxonomy is to act as one possible foundation for more rigor in

[1] http://www.wired.com/2015/05/data-effect-minecraft/
[2] https://education.minecraft.net/

examining *Minecraft*. We seek a thorough, although certainly not comprehensive, overview of everything you can do in *Minecraft*.

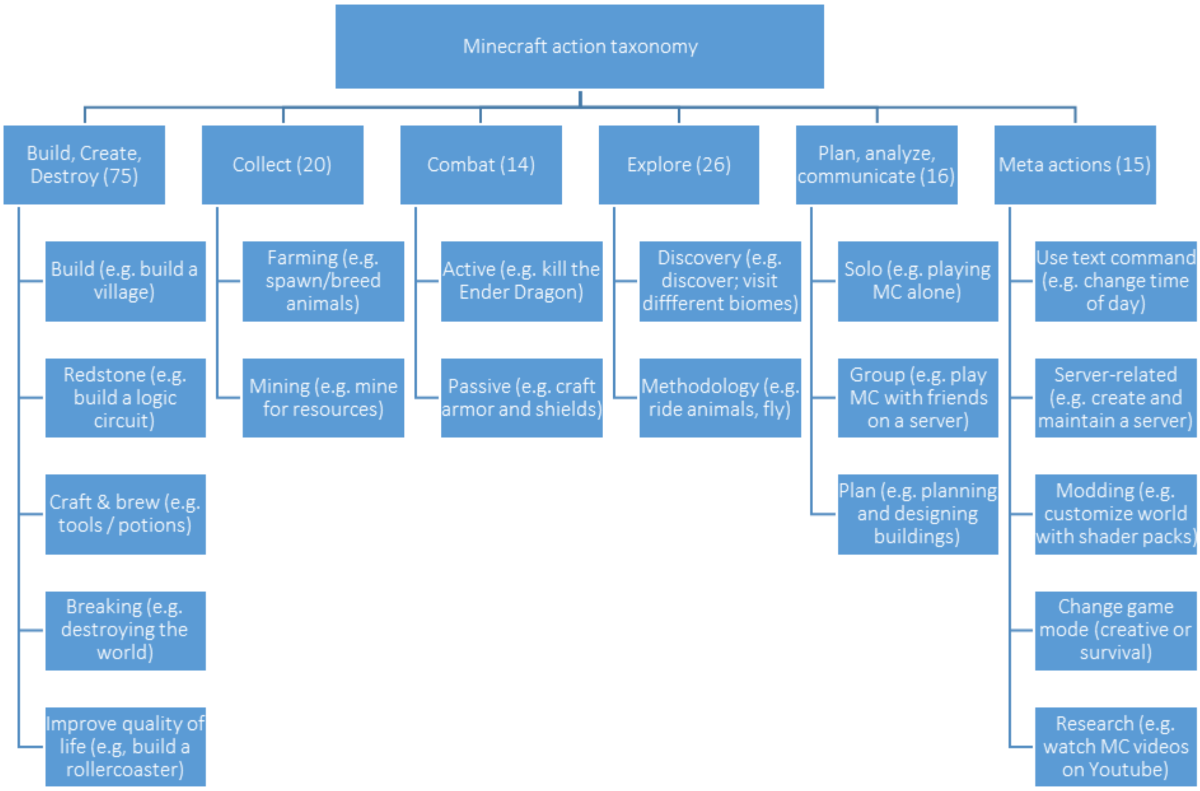

Figure 1. Top two levels of our *Minecraft* taxonomy. The number of actions in each top level is shown in the figure, with 166 total distributed across the sub-categories.

To begin, we reviewed documentation, research literature, discussion boards, *Minecraft* wikis, and interviewed expert players to create a master list of actions. The first three authors independently organized the actions into groups, then came to consensus on the overarching structure showing in Figure 1. Six major categories emerged, showing in the top row of the figure, followed by 2-5 subcategories for each. Common but significant in-game actions were selected for inclusion in the taxonomy, as well aspects of the game that may technically be more as a "way" of playing, rather than a specific action. For example, we have very common activities like "Exploring a new map" as well as "Playing with friends". Some additional examples are shown in Table 1, along with their corresponding sub-categories and hypothesized STEM relevance codes (assigned by the authors; see section 3).

3. Linking Minecraft to STEM

To map Minecraft actions into STEM, we leveraged the 2010 Classification of Instructional Programs (CIP) Codes from the US Department of Education and National Science Foundation.[3] CIP codes provide structure for STEM fields, skills, and professions, also in the form of a taxonomy. The purpose of the CIP is to support the tracking and reporting of fields of study and program completions activity. When combined with our *Minecraft* action taxonomy, the resulting tags become our claims of relevance to those STEM fields. The links trace each action taken to specific STEM fields. For example, building a functioning clock from scratch in *Minecraft* requires an understanding of circuitry, the ability to make the appropriate calculations, and the ability to craft and design a model. Therefore, in accordance with our taxonomy, building a clock would relate to electrical engineering, mathematics, and mechanical engineering (from the greatest to the least significance). Other examples are in Table 1. Furthermore, as the table reveals, some actions are not directly related to STEM, but have important roles to play, whether it be with 21st century skills, or as important mediating roles to play for pathways into STEM.

[3] https://nces.ed.gov/ipeds/cipcode/

Table 1: Example actions in the taxonomy with STEM codes.

Action / activity (leaf node)	Sub-category	STEM codes
Build structures that can be found in the real world (e.g., Taj Mahal)	Build	ARCH (architecture); CIVE (Civil Engineering)
Build and use a piston	Redstone	MECHE (mechanical eng)
Brew a water breathing potion	Craft	CHEM, MBIO (marine bio)
Plant seeds and harvest a crop	Farming	AG (agriculture); PLS (plant sci.)
Explore caves and undergrad structures	Discovery	GEOL (geology)
Play Minecraft with friends	Group	n/a
Create and maintain a server	Server-related	CS (computer science)
Watching YouTube videos about building	Research	n/a

4. Evaluation of the taxonomy and future work

The most debatable aspect of our approach lies in the accuracy and utility of the STEM tags. For example, does interest in Redstone genuinely mean a learner is drawn towards mechanical engineering? Thus, we view our current set of tags as a set of claims worthy of evaluation. In ongoing work, we are collecting data that seeks to show correlation between STEM interest and Minecraft play, working first with surveys (based on the taxonomy) and in the near future with logs of Minecraft play. In other words, we pursuing the question "To what extent is *Minecraft* a proxy for identifying player STEM interests?"

In addition, we are also pursuing the use of *Minecraft* as a vehicle for *triggering* and *sustaining* interest in STEM (Renninger, Nieswandt, & Hidi, 2015). Specifically, our approach involves the creation of unique maps and "mods" (which are variants on the basic game) that invite learners to explore scientifically valid, but hypothetical versions of Earth. Known as "What-if? Scenarios (Comins, 1993), our approach involves using Minecraft to allow learners to explore and explain the science behind observed differences. For example, if they are on a map modeling earth with no Moon, they may see different terrain than usual, creatures, plants, and more. Support for making observations will be accomplished via signs and educator facilitation (e.g., in summer camps). Also, building on the search for exoplanets that might sustain human life, we also discuss how different variations could or could not support life. The work reported here is intended to provide a substrate for further exploration.

Acknowledgements

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Learning to Think Critically: Technologies for Debiasing

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1. Introduction

Critical thinking is hailed as a key 21st century skill, and is also a main ingredient of deeper learning approaches (Adams Becker et al., 2017; Buder & Hesse, 2016). Critical thinking encompasses the ability to think in a clear, rational, and open-minded manner that is well-informed by available evidence. Educational researchers have long discussed the importance of critical thinking, and they also argued that the necessary skill sets for critical thinking are teachable (Halpern, 1998).

However, the question is how well-equipped our brains are to successfully engage in critical thinking. In fact, psychological research strongly suggests that our natural ability to think clearly, rationally, and in an open-minded and well-informed manner is prone to several biases.

Based on the cognitive and social psychological literature, this paper lists some of the most important biases that hamper the development of critical thinking. Subsequently, some debiasing techniques will be reviewed. They lead to design features of digital technologies that can be used to implement debiasing techniques. The overall connections of elements in my argumentation are depicted in Figure 1.

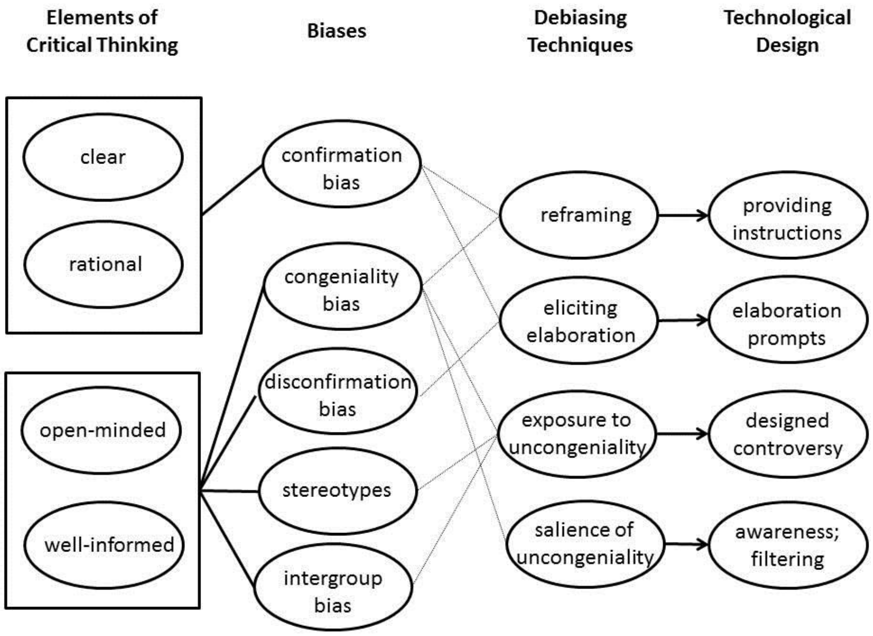

Figure 1. Elements of critical thinking, list of cognitive and motivational biases, list of debiasing techniques, and technological means to implement the techniques.

2. Evidence for Biased Information Processing

There is evidence that human information processing is prone to two general types of bias that I will refer to as cognitive biases and motivational biases. A cognitive bias refers to the tendency to engage in faulty reasoning in the absence of any particular motivation to do so. Nickerson (1998) discusses cognitive biases at some length, and concluded that human information processing overwhelmingly is guided by confirmatory processing (confirmation bias). Of particular importance to critical thinking are difficulties that learners have in the proper testing of hypotheses, a task that requires clear and rational thinking (e.g., testing the rule "If a card has a vowel on one side then it has an even number on the opposite side" by selecting from a set of cards; Wason, 1966).

Moreover, human information processing is also colored by strong motivational biases (Kunda, 1990), which comes in two broad varieties. While people might be motivated to bias their information processing in order to achieve social approval (impression motivation), the most important motivation in the context of critical thinking is the tendency to prefer information that is consistent with an existing worldview, and to avoid or derogate uncongenial information (defense motivation). Defense motivation prevents an open-minded and well-informed view on a state of affairs. Based on the literature, I propose a distinction between four types of bias that can be related to defense motivation. First, there is a strong tendency to select congenial over uncongenial information, for instance in information seeking (congeniality bias; Hart et al., 2009). Second, while learners often scrutinize uncongenial information and seek for flaws in it (a sign of critical thinking), they fail to show a similar scrutiny with regard to congenial information which is often accepted at face value (disconfirmation bias; Buttliere & Buder, 2017). Third, information processing is often colored by the activation of stereotyped thought about persons (Greenwald et al., 2002). This can also introduce bias. And fourth, as people strongly identify with particular social groups, they also exhibit a tendency to favor their ingroup and/or derogate outgroup members (intergroup bias; Mackie & Smith, 1998).

3. Debiasing Techniques

From reviewing the literature, I propose four general classes of debiasing techniques. The first technique is *reframing*. For instance, framing the Wason card selection task in a social context can prompt non-confirmatory strategies of hypothesis testing. Moreover, the congeniality bias can be reduced by framing the importance of identifying a correct solution (Hart et al., 2009). A second technique involves *eliciting elaboration*. For instance, asking people to provide reasons for their attitudes makes people question their beliefs and is associated with more critical evaluation of congenial information (Wilson, Hodges, & LaFleur, 1995). Moreover, simple prompts like "consider the opposite" can have debiasing effects (Lord, Lepper, & Preston, 1984). The third technique is *exposure to uncongeniality*. Coming into contact with uncongenial information, meeting with outgroup members, or requesting learners to take a counter-attitudinal stance are known to reduce strong attitudes, stereotypic thinking, and intergroup bias (e.g., Pettigrew, 1998). Finally, the fourth technique is *enhancing the salience of uncongenial viewpoints*. This can be accomplished through a focus on uncongenial information of high quality (Hart et al., 2009), or through uncongenial social recommendations (Schwind, Buder, Cress, & Hesse, 2012).

4. Technological Design for Debiasing

All four debiasing techniques lead to considerations for technological design. First, reframing a task can be accomplished by the provision of instructions which can then engender debiased mindsets. Technological design should be informed by knowledge about the subtle effects that reframing can have on critical thinking. Second, elaboration of information can be elicited through situationally adapted prompts, or by reminding learners of the use of particular strategies (e.g., Berthold, Nückles & Renkl, 2007). Digital technologies are particularly suited to identify situations which would require the elicitation of prompts, for example via learning analytics. Third, digital environments can be designed to engender coming into contact with controversial viewpoints, for instance through two-sided representational formats (Hart et al., 2009). Alternatively, through proper selection of learning partners in a CSCL scenario it could be ensured that learners will come into contact with uncongenial viewpoints, thus fostering controversies. And fourth, there are strategies to make uncongenial information more salient. One of these strategies is to request learners to rate their discussion contributions on an agreement dimension, and visualizing discussion posts via a group awareness tool

(Buder, Schwind, Rudat, & Bodemer (2015). Another strategy that has been shown to improve critical thinking is to recommend preference-inconsistent rather than preference-consistent information in a recommender system (Schwind et al., 2012).

5. Concluding Remark

Critical thinking is a key skill not only for many learning contexts, but also in a broader sense of becoming an informed citizen. However, in order to become adept at critical thinking learners need to overcome some cognitive and social biases. Psychological research has identified a number of biases, but also pointed at several ways how biases can be counteracted. Through proper technological design, debiasing strategies can be implemented, thus helping learners to act in a clear, rational, open-minded and well-informed manner that has been the hallmark of critical thinking.

Acknowledgements

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Functions of Cognitive Group Awareness Tools

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1. Introduction

Cognitive Group Awareness Tools (CGA tools) provide textual or visual information about others' knowledge, interests, or opinions. They make users aware of the provided socio-cognitive information that can be used in different ways (cf. Bodemer, Janssen, & Schnaubert, in press; Ogata & Yano, 2001). In the learning sciences, such tools are particularly popular for providing implicit guidance (in contrast to explicit guidance: e.g., collaboration scripts) to learners, that is triggering collaboration and communication behaviour intended to be beneficial for learning.

The tools' effectiveness for collaborative learning is usually evaluated on an overall tool level and with a focus on learning outcomes instead of underlying processes. On this basis, research generally indicates that the use of CGA tools can be beneficial for learning (cf. Bodemer & Dehler, 2011). On the other hand, there is also a well-founded reasoning for minor effectiveness and efficiency of information-based guidance approaches (cf. Kirschner, Sweller, & Clark, 2006). In order to identify how CGA tools work, they have to be investigated beyond an overall level and under consideration of the processes potentially affecting the learning outcomes. With a differentiated view, various functions of CGA tools can be identified and distinguished that may trigger cognitive processes.

For example, as a core function, providing knowledge-related information on learning partners might facilitate grounding and partner modelling processes during collaborative learning. However, such information does not only comprise information on a person but also refers to specific and often preselected content (e.g. a learning partner's hypothesis regarding a single element of the learning material), thereby cueing essential information of the learning material and constraining content-related communication. Moreover, CGA tools frequently provide information in a way that allows for comparing learning partners (e.g. adjacently presenting information of two learning partners), thereby guiding learners to discuss particularly beneficial issues, such as diverging perspectives).

Three consecutive experimental studies have been conducted that systematically disentangle these functions for collaborative multimedia learning scenarios by varying only one of the tool features in each study (see Table 1).

Table 1: CSCL challenges and CGA tool support.

CSCL Challenge	Tool Feature	Support/Function	Study
connecting communication and learning material	information cueing	constraining content-related communication	1
establishing a common ground	providing partner information	partner modeling	2
structuring the learning discourse	visualizing knowledge constellations	socio-cognitive guidance	3

2. Method

In each of the three experimental studies, learning dyads were individually provided with interdependent learning material comprising either visual or algebraic information about the ANOVA.

Afterwards, learning partners collaborated in two subsequent phases instructed to collaboratively elaborate on statistics concepts and interrelations by means of multimedia learning material presented on a joint multitouch tabletop (Samsung SUR40 with Microsoft PixelSense): static multiple external representations (MER; phase 1), and dynamic and interactive visualizations (DIV; phase 2; cf. Figure 1).

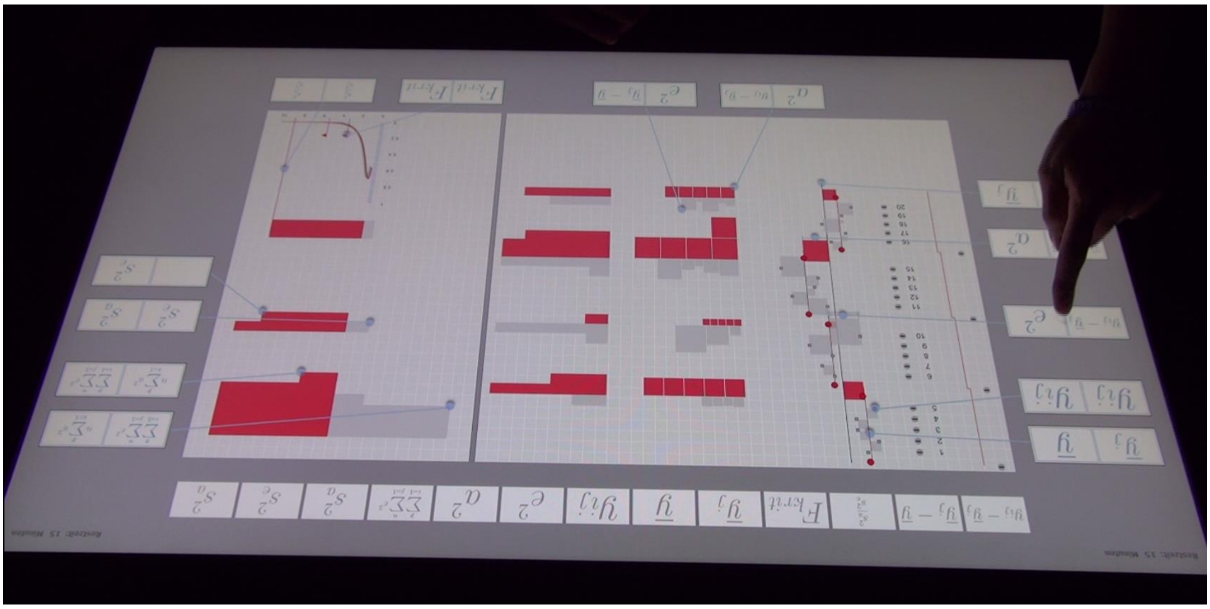

Figure 1. Multitouch tabletop with multimedia learning material (ANOVA).

Additionally, in each collaboration phase, one of the three differentiated CGA tool features was provided in two of four experimental groups, thus leading to four different experimental groups per study (MER0_DIV0 vs. MER1_DIV0 vs. MER0_DIV1 vs. MER1_DIV1; see Figure 2). Knowledge-related CGA information was gathered prior to each collaboration phase by requesting both learning partners to indicate their individual assumptions on the relationship of different elements of the joint learning material.

Individual knowledge tests were conducted before (KT 1) and after each collaboration phase (KT 2 and 3; see Figure 2). Each knowledge test comprised three different subtests to measure conceptual knowledge, representational transfer (Bodemer, 2011) and intuitive knowledge (Swaak & de Jong, 2001). All test items were designed as multiple choice questions, including one correct answer and three distractors.

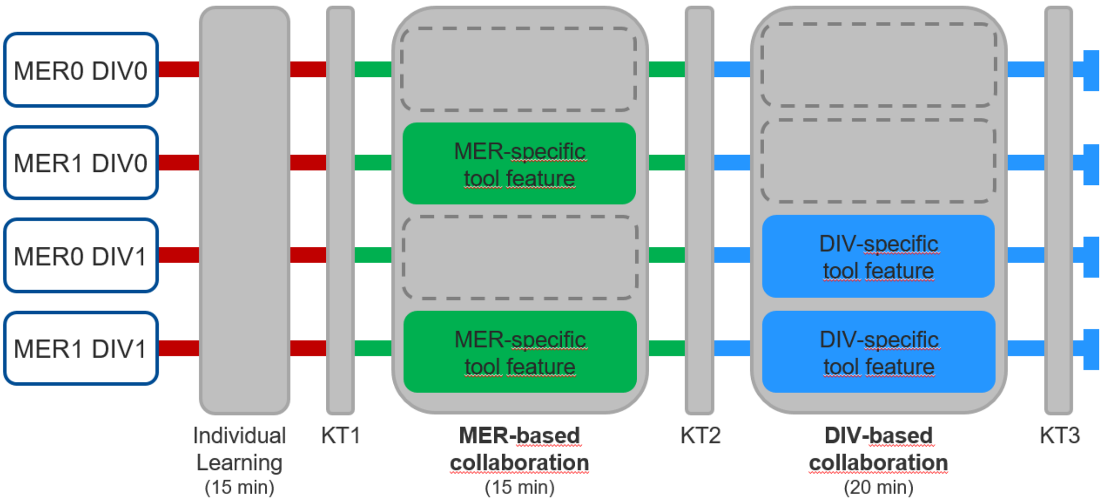

Figure 2. Experimental design and procedure.

3. Results

Study 1 (N = 172) showed better learning outcomes for learners that were provided with information cueing support in terms of highlighted elements and relations in the learning material (phase 1/MER: $F(1, 168) = 9.32$, $p = .003$, $\eta^2 = .05$; phase2/DIV: $F(1, 168) = 18.04$, $p < .001$, $\eta^2 = .10$). Moreover, in analogy to signalling effects in multimedia research (e.g., Mautone & Mayer, 2001), supported learners reported lower mental effort during collaboration. A contrasting exemplary analysis of audio-visual recordings indicates that supported dyads discussed more essential components of the learning material and connected multiple representations more often and more deeply, whereas unsupported learners rather focused on surface features of the representations.

Study 2 (N = 120) also showed benefits of the tool support. Learners provided with knowledge-related information on the learning partner performed significantly better than learners without additional collaboration support (phase1/MER: $F(1, 116) = 4.55$, $p = .035$, $\eta^2 = .04$; phase2/DIV: $F(1, 116) = 29.84$, $p < .001$, $\eta^2 = .21$). Regarding underlying processes, analyses of reminded assumptions of the learning partner indicate that providing cognitive partner information directly facilitates partner modelling during collaboration. However, analyses of the learners' interactions do not support former findings of reduced grounding effort and more elaborated communication.

Study 3 (N = 104) did not reveal a beneficial effect on learning outcomes when learners have been supported by visualized knowledge constellations (phase 1/MER: $F(1, 100) = 0.02$, $p = .894$, $\eta^2 < .01$; phase 2/DIV: $F(1, 100) = 0.01$, $p = .943$, $\eta^2 < .01$). However, process analyses show that learners resolved controversial views more often when provided with visualized constellations and that particularly those learners used this tool feature for elaborated discussions on controversial views that generally perceive complexity as challenging.

4. Discussion

Various functions of CGA tools can be identified and distinguished that may trigger cognitive processes. Three of them have been systematically disentangled and investigated in three consecutive experimental studies for collaborative multimedia learning scenarios: content-related information cueing, providing partner information, and visualising socio-cognitive constellations.

The studies reveal that CGA tools can comprise effective functions that are 'automatically' implemented, such as highlighted information cues that can help learners to connect communication and learning material (study 1). On the other hand, the missing effects of visualized knowledge constellations (study 3) show that well-recognized tool features are not necessarily required in order to trigger the intended learning processes. However, learners were able to make use of the core function of CGA tools for implicitly guided learning processes and better learning outcomes (study 2). Connecting the studies and findings from former research, it seems that the high complexity of the investigated multimedia-based statistics learning scenario rather promoted facilitating tool functions and impeded effects of functions requiring additional mental effort such as comparing and discussing different perspectives.

Beyond the three supporting functions investigated here, effects on learning processes and outcomes can potentially be ascribed to further functions of CGA tools that may affect learning on other levels. For example, on an individual level, collecting and providing knowledge-related information may prompt learners to (re-)evaluate or refocus their individual learning processes (cf. Järvelä et al., 2016). Or, on classroom level, knowledge-related information can be used by teachers to determine and suggest homogeneous or heterogeneous small groups. Other functions may address larger communities and connect cognitive and social group awareness information (cf. Lin, Mai, & Lai, 2015).

Overall, independent of group awareness support, this series of experimental studies demonstrates that disentangling CSCL tools and systematically identifying and evaluating potential functions and processes can help to gain further insights that go beyond overall tool effects.

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Investigation on the shared mental model and team performance of teacher design team for technology integration in education

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1. Introduction

There is an increasing demand for teacher to design technology integration courses since the more and more digitized society and education. However, many challenges and issues have emerged such as considerable time might be spent on course design and development, adapting to new online forms of learning activities. In the professional development field, the collaboration between teachers have been as a main method for teacher learning.

Although the value of teacher collaboration for professional development has been recognized in many western nations, it has not been systematically investigated, particularly in Asian contexts (Yeh, 2007). Therefore, the need arises to generate insights into aspects of teacher collaboration for technology integration.

2. Research Background

In China, even though there are many teachers' trainings about basic technology skills, continuous education that focuses on the pedagogical use of technology in instruction missing. Therefore the potential of technology in the classroom is hardly realized. Voogt et al. (2011) indicated that teacher education needs to be situated in authentic contexts such as the community of teacher and the school environment. One way to comply with these features of effective teacher professional development is to engage teachers in collaborative design team for technology-enhanced instruction (Handelzalts, 2009; Simmie, 2007; Voogt, 2010). Developments in the learning sciences (Bransford, Brown, & Cocking, 2000) have shown that people could benefit from situated contexts, when they are actively involved in the learning process and collaboration with others (Cobb, 1994; Greeno, 1998). This review of the literature emphasizes that teams operate complex tasks that are too complex to be done by individuals. It is clear that people who work in teams and share the same goals perform better than people working by themselves. Researchers in the teacher professional development field (Borko, 2004) have initiated these findings for teacher professional development by organizing teacher design team.

Although teacher design team has been seen as a promising method for teacher education, Bell et al. (2005) indicated that the collaborative inquiry was also a demanding way for performance improvement. Teacher design teams (TDTs) are defined as teams of more than two teachers who collaboratively design instruction process and materials, with the aim of improving their own instructional practice (Handelzalts, 2009). It is necessary to examine the collaborative processes in teacher design teams that promote teacher learning: the interaction with peers, facilitators and external stimuli, the experimentation in classroom practice, and the factors in the environment that hinder or facilitate teachers' collaborative design. Therefore, we focus on the processes of collaborative design in teacher designs teams that foster teacher learning and development.

3. Methodology

3.1 Research Objectives

The conceptual framework is illustrated in Figure 1. Team process includes the shared mental model and team interaction. Shared mental model (SMM) are organized mental representations of knowledge about team's environment that are shared by team members (Johnson et al., 2007). It has been used interchangeably with team mental model and shared cognition to explain team functioning. As team members work with each other, they start to develop shared mental models about the team and the task. Team interaction, which mean the communication and coordination between teammates, have a critical influence on the development of team shared mental model as well as team performance. Understanding the team process advances our understanding of teamwork and team decision-making that correlates with the team performance. This framework also focuses on the transformation of team performance to individual technology-integration teaching behavior.

The following research questions guide our study:

1) What has teacher team actually done for design technology-enhanced learning for students learning?
2) How is the team process related with the team performance?
3) How does the outcome of teacher design team benefit teachers' following technology integration teaching behavior?

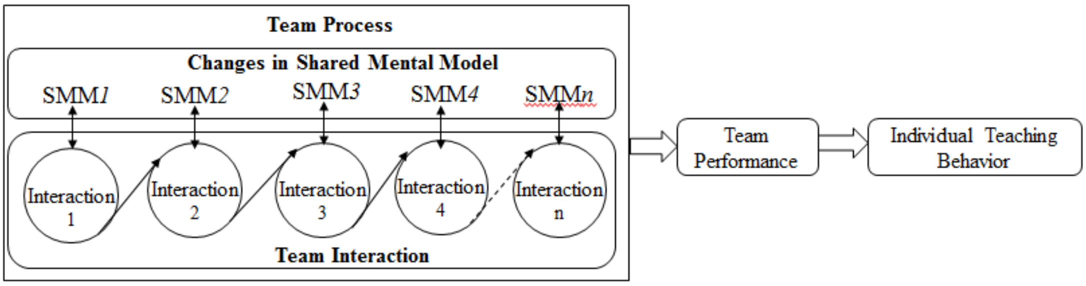

Fig. 1 Conceptual Framework

3.2 Participants

We conducted this study in an educational master's class. 46 student teacher (21 males and 25 females) formed this class and all of the them had less than 5 years teaching experiences in Chinese K-12 schools. During this class, they would design online inquiry course on WISE (Web-based Inquiry Science Environment) platform in groups. Each group had a detailed schedule for discussing how to design the course, for example, they will have a meeting every one or two weeks.

3.3 Instrument

After every two-week period, participants were asked to complete a team assessment diagnostic instrument (TADI) and a team communication tracking instrument (TCTI) (Padmo, 2013). The goal of the TADI is to measure each team member's shared mental models (SMM). Johnson et al. (2007) identified five team and general task SMM factors in the TADI: (1) task and team knowledge, (2) communication skills, (3) attitude toward teammates and task, (4) team dynamics and interactions, (5) team resources and working environment. The SMM factors were measured using a 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The TCTI records the types and frequency of communication used by team members as they design instruction that integrates technology. Teams could use a variety of communication channels such as face-to-face, telephone, email, audio computer conference, letters, or other means of communication. The TCTI questionnaire records type of communication channels that were used and how frequently team members communicate with each other over a two-week period.

As for the team performance, our research will use the task completion instrument and team performance product quality instrument (TP-TCI/PQI) to measure task completion and design quality (Padmo, 2013). Task completion was measured by comparing the number of tasks that were actually completed to the number of tasks that should have been completed. The TP-TCI contained a checklist of “yes” and “no” responses for product completion overall, as well as by sections (i.e., the introduction section, content section, and closing section). The product quality instrument (TP-PQI) used a Likert-type scale ranging from 1 (poor) to 5 (very good) for each criterion. The internal consistency of the instrument produced a Cronbach alpha coefficient of .69 for the introduction section, Cronbach alpha coefficient of .73 for the content presentation section, and a Cronbach alpha coefficient of .59 for the closing section.

In addition, we also recorded the talk of teacher group. The design task would be separated into several sub-tasks such as analyzing, planning, constructing and reflecting.

3.4 Data analysis

The data analysis will involve assessing the differences interaction and SMM in among different stages. The data will be analyzed using SPSS 22.0. Paired t-test is used to compare the changes in shared mental model and team interaction. Mediation multiple regression is used to test whether the team interaction mediates the relationship between SMM and team performance. The correlation analysis will be used to test the relationship between team performance and individual teaching behavior.

4. Contribution of the work

The main contribution of this study is the synthesis of the coding scheme from different perspectives, which will allow the possibilities for gaining deep investigation for the teacher collaborative design for ICT integrations.

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Authentic Learning in a Technology-Rich Classroom: Innovative Education in the Classroom

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Abstract. A recurring challenge in nearly every education is how to effectively integrate new and emerging technologies into existing curricula and existing learning places. In this paper, what is not new is the general approach to learning and instruction – namely, authentic learning. What is new and innovative are the ways and means to make authentic meaningful and effective using new digital technologies. To state the case briefly, what is not new is how best to support learning. What is new is putting that knowledge into practice in the technology-rich classrooms of the 21st century. We describe the basic principles of authentic learning and illustrate how they can be effectively integrated and supporting using state-of-the-practice technologies.

Keywords: Authentic learning, Educational innovation, Technology integration

1. Introduction

Authentic learning refers to learning that takes place in actual situations likely to be encountered outside the educational context or simulated situations that are realistically life-like in terms of look and feel and their compelling nature (Dewey, 1938; Howland, Jonassen, & Marra, 2012; NRC, 2000). John Dewey's "Experience and Education" is perhaps the classic work in the area of authentic learning. However, the concept dates far back to apprenticeship training with learning taking place in the actual workplace (Klein, Spector, Grabowski, & Teja, 2004). More recently, computer-based simulations and virtual reality devices have made it possible to create realistic settings in support of learning, especially in aviation, decision science, economics, medicine, and technical training (Clark, 2005). Moreover, the so-called Maker Movement that is now integrate 3D printing into many courses involving design, engineering and manufacturing is an example of how the early principles of authentic learning can be harnessed in support of effective instruction. An excellent of a large-scale effort in this area is the Beijing National Day School (BNDS; see https://www.facebook.com/pages/Beijing-National-Day-School/104061536296380).

2. Principles of Authentic Learning

A number of basic principles comprise authentic learning; these principles can be found explicitly or implicitly in the references already cited (Clark, 2005; Dewey, 1938; Howland et al., 2012; Klein et al., 2004; NRC, 2000).These principles include:

- Meaningful contexts – the situation surrounding the learning task should be one that is familiar or at least believable as possible or even probable to occur in a particular discipline or domain;
- Realistic and feasible tasks – the task to be learned or the problem to be solved should be realistic and relatable to actual tasks or problems known to occur in an area of inquiry;

- Expert guidance – a person (or computer-based agent0 with relevant experience and insight is available to demonstrate how to proceed and provide guidance to the learner;
- Informative feedback – timely and informative feedback on the learner's performance is provided during or immediately after the learning activity; and,
- Progression of tasks – problems and tasks are sequenced from simpler to complex to foster the progressive development of knowledge and understanding (Milrad, Spector, & Davidsen, 2003).

Several approaches have evolved that embody these principles which in somewhat different ways support authentic learning. These include (a) problem-based learning that originated in the medical domain (Barrows & Tamblyn, 1980), (b) situated learning that adds the notion of a community of practice (Lave & Wenger, 1990), and (c) cognitive apprenticeship that contributes the notion of progressive development (Collins, Brown, & Newman, 1987).

3. Examples of Effective Authentic Learning with New Technologies

There are many examples of effective authentic learning activities that could be cited based on the principles previously described. Space allows for the elaboration of just two: (a) A LEGO Mindstorms robot construction effort (Somyürek, 2014), and (b) DIGS – digital interactive globe system developed at National Taiwan Normal University (DD0933005251, 2016)

3.1 LEGO Mindstorms

An interesting piece of educational technology history is the general failure of Logo to deliver the promised improvements in learning advocated by Seymour Papert (1990). In spite of the marginal impact of Logo, the overall impact has been significant as shown by the subsequent successes of Scratch (Resnick, 2007) and the promotion of Papert's later work involving *mindstorms* and LEGO kits for constructing robots (Papert, 1993). LEGO preceded the maker movement but employed the important principles of learning by doing that thread throughout nearly all authentic learning approaches.

In a study by Somyürek (2014), students were engaged in constructing a robot using LEGO Mindstorms NXT. Students were engaged in a structured and active learning process involving challenging. However, students were allowed to learn by doing while in engaged in what they considered play. Students were given multiple tasks such as making predictions, developing hypotheses, and presenting their solutions. The results showed that students found the activities fun yet engaging in terms of their imaginations. The results showed improved motivation and the likelihood of improved critical thinking.

3.2 DIGS

The digital interactive globe system developed in Taiwan is also engaging and fosters problem solving in the domain of geography and thinking about the world in which we live. DIGS is a low-cost but relatively high-tech system to support learning geography and earth science. DIGS involves a data processing unit, a wireless control unit, an image capturing unit, a laser pointing device, and a 3D hemispheric body imaging unit – a kind of 3D screen. The system can be envisioned as a Google Earth on 3D steroids. A quasi-experimental study involving 105 junior high school students in a four-week experiment showed that the students in the experimental group learning with DIGS improved more than the control group. Moreover, the role of the teacher naturally changed in a way consistent with what was previously described with regard to cognitive apprenticeship.

Because DIGS is a low-cost but high-tech educational technology with evidence of effective support for improved learning of higher-order reasoning skills, it should be considered an innovative educational technology solution, along with LEGO Mindstorms and others too numerous to be included in this short piece about how emerging technologies can improve learning when aligned with the principles of authentic learning.

4. Summary

Our main point in this short piece was to remind researchers and practitioners of the significance of authentic learning when devising ways to take advantage of the many affordances of new technologies. For something to be considered innovative, we believe it needs to be effective, so we cited two examples that are aligned with authentic learning principles that have supporting research to show evidence of learning effectiveness. We encourage others to report learning gains that clearly indicate how technology can improve learning, which we understand to involve stable and persistent changes in what a person knows and can do. In the case of authentic learning, it is the doing that leads to knowing.

Acknowledgement

We are indebted to our mentors, and especially to Wei-Kai Liou, Chun-Yen Chang, Robert Gagné, and Dave Merrill, and others who have developed genuinely innovative educational approaches and solutions.

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The Impact of Analytics Within the Institutions of Higher Education in New Zealand

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1. Introduction and literature

Analytics, as a suite of mechanisms for extraction and processing of data, has the capacity to transform massive and diverse amounts of data into meaningful and valuable information (Johnson, Levine, Smith, & Stone, 2010). As a core concept in Data Science, underpinned by the paradigm of Big Data that we have come to associate with modern business, analytics in higher education is still a relatively new field (Van Barneveld, Arnold, & Campbell, 2012). Notwithstanding, analytics represents an enormous opportunity for academic institutions struggling with operational and strategic imperatives associated with the changing landscape that has become indicative of the future of higher education (Bichsel, 2012; Daniel, 2015; Daniel & Butson, 2013; Siemens & Long, 2011). Its principal contribution lies in its ability to inform the development of predictive models (Wagner & Ice, 2012). As Siemens (2011) pointed out some time back, institutions of higher education need to engage with predictive analytics in order to meet the demands of a changing educational world. Similarly, an OECD report (2013) just two years later, also highlighted the potential of Big Data and analytics within the higher education sector to leverage this new evidence to better support decision-making about educational outcomes and performance. Today, analytics is seen as essential in the quest to perform analysis of student data through predictive models in order to examine students at-risk and hence provide the needed intervention (Adam et al, 2017; Sclater, Peasgood, & Mullan, 2016; U.S. Department of Education, 2012). This study explores the extent to which institutions of higher education in New Zealand are engaged with analytics and the likely impact analytics is expected to play on the quality of decision-making across various functional areas.

2. Method and procedure

An online survey was used to examine the impact of analytics in seven research-intensive public universities in New Zealand. Participants included senior executive responsible for executing operational and strategic initiatives, as well as individuals whose portfolios were related to the management of data and analytics (n=82). The questionnaire was derived from (Goldstein & Katz, 2005) framework for examining institutional use of analytics. In particular, the questionnaire included questions pertinent to functional areas across their institutions. The items were measured on a 5-point Likert scale (1=strongly agree, 2=agree, 3=neutral, 4=disagree, and 5=strongly disagree). The questionnaire was tested for reliability, revealing a high Cronbach's alpha of 0.90. Participants responded to open-ended questions at the end of some Likert scale items, elaborating their ratings on the Likert scale measure.

3. Results

3.1 Impact of analytics within higher education institutions

Participants reported the possible impact of utilising analytics in their institutions primarily in two principal categories of outcomes at the institutional level and functional level.

3.2 Institutional outcomes

To examine that how institutions are influenced by the use of analytic, participants were asked to indicate their agreement with statements related to the use of analytics. For instance, in response to the statement that 'institution's analytics capability is helping to meet strategic objectives', a significant number of respondents (91%) reported that analytics can be utilized as mechanisms to achieve strategic objectives. Others (85%) mentioned that analytics can help and enable institutions to address main contemporary challenges facing higher education sector such as student diversity, student retention, governance and management, learning and teaching quality, funding. A summary of results on the potentials of analytics in achieving various outcomes is summarised in table1.

Table 1: Institutional outcomes from the use of analytics (n=82)

Outcomes	Supported n (%)	Neutral n (%)	Not supported n (%)
Meeting strategic objectives	68 (91)	5 (7)	2 (3)
Addressing major challenges	61 (85)	6 (8)	5 (7)
Institutional success in future	63 (79)	12 (15)	5 (6)
Decision-making improvement	32 (46)	25 (36)	13 (19)

Data also revealed that with the right forms of analytics decision makers can improve the quality of their decision-making on issues affecting institutions. From this study, it was apparent that respondents value the role and possible impact of analytics, particularly in achieving institution's strategic objectives and addressing challenges facing the sector.

4. Conclusion and significance

This study has provided an overview of the influence of analytics within research-intensive public universities in New Zealand higher education. The key findings from this study suggest that institutions of higher education in New Zealand value the potential use of analytics. However, the use of analytics on a wide institutional scale across the sector is at early stages. There are a number of limitations with this study. Outcome of the study cannot be generalised across various units within an institution, since the key respondents were senior executive and those perceived to be closely working with analytics. As an emergent phenomenon in higher education, future work is required to develop a consolidated framework for the deployment and possible impact of analytics on teaching, learning and research.

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Temporal Aspect Analysis of Video Log on Flipped Classroom

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1. Introduction

In this paper we indicate some preliminary analysis results of lecture video log on real "flipped classroom" activities, focusing on when and how long these videos were watched.

Lage et al. (2000) defined the flipped classroom as "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa". Also, Bishop & Verleger (2013) showed a survey of flipped classroom research. They indicated a table that lectures and exercises are reversely located on traditional style and flipped style classroom activities.

At the moment of watching lecture videos, a streaming video server records detailed log including information when, who, what and how long the contents were watched (sort of logged information depend on servers). It is still under research process what information are useful to identify learners' status and helpful to give useful feedback to them.

There are some preceding researches. Watanabe (2014) utilized YouTube to deliver video contents, which is often impossible to identify watchers. In order to grasp learners' video watching, he used questionnaire. More automatically, Dorn et al. (2015) calculated session numbers of learners from video server log. Marchand et al. (2014) calculated average viewing time of the contents from server log. Phillips et al. (2016) evaluated student perception and time spent on asynchronous online lectures in a blended learning environment. He extracted time stamps from a local video server and assessed time spent on the uploaded video contents.

The goal of this paper is to report collection and analysis of video server logs on real flipped classroom activities, including when, who, what and how long the contents were watched. As a result, quantitative and objective video viewing tendency has been clarified. Also, some problems of flipped classrooms have been exposed.

2. Method

2.1 Target Class and Units

The target class of this experiment is named "Learning Technology", a specialized class for third-year students of Department of Information and Communication Sciences, Sophia University, Japan. In this class, the authors picked up three units indicated in Table 1. It also shows length of lecture videos.

Table 1: Target Units and their Video Contents

Unit	Unit Title	Date Operated	Video Length (min)
Unit 1	Introduction of Learning Technology Research	June 6, 2017	33
Unit 2	Investigation of Preceding Researches	June 13, 2017	45
Unit 3	Originate your Research Idea	June 20, 2017	33

2.2 Technical Setup

The authors utilize Moodle, a major LMS. All learners were pre-registered on the Moodle at the time of entrance of the university, with attribute of student numbers. Also, we adopted a streaming server of Panopto, bundled with video recording client software. Both Moodle and Panopto have independent authentication schemes, but it is troublesome to link their logs. In order to do that, we utilized LTI communication scheme. LTI (Learning Tools Interoperability) is a set of server function and HTTP-based communication / information exchange scheme between network connected servers. LTI specification has been published from IMS Global Learning Consortium, and now version 1.2 specification is available in public. Because LTI is publicly available, some LMSs and video servers have started to support LTI. In this experiment, this LTI communication scheme was implemented and activated on both Moodle and Panopto. Because both Moodle and Panopto support LTI, Panopto is able to know the student number from Moodle when logged-in, via LTI-based information exchange.

Panopto server provides a simple Dashboard to show summary of its video logs. However it is insufficient for fine-grained analysis. In order to do this, Panopto also provides Web API interface to pick up log information. So we utilized this Web API, which is downloadable from GitHub.

3. Results and Discussions

3.1 Video View Counts

For the three units described in Section 2.1, we executed flipped classroom activities. Video view counts of these units are shown in Table 2. Checking the log, there was no one to view the videos more than 2 times. So, the View Count numbers in Table 2 are equal to number of learners to view the videos. Since registered student number of this class is 79, we can calculate the percentage of learners who viewed the contents. Unit 1 shows high percentage, but Unit 2 and 3 are low.

This number implies a mistake of unit elements on Moodle. We disclosed links to video contents and PowerPoint slides, which were used in the video. The learners might learn that they need not view the video to understand whole contents, but just to check PowerPoint slides.

Table 2: View Count

Unit	View Count	% of Learners Viewed
Unit 1	60	75.9%
Unit 2	27	34.2%
Unit 3	26	32.9%

3.2 Remaining Day(s) and View Count

Next we analyzed when learners watched videos. Logs show that all learners watched videos only once, so starting dates were equal to finished dates. An instructor always indicated the videos and assignments in the previous units (7 days beforehand), so learners had 7 days to view videos. Resulted distribution is shown in Figure 1.

Since unit 1 was the first time to introduce this flipped classroom activity, many learners were interested to view videos during the previous unit. However, gradually they learned that their video viewings were enough just before the target units.

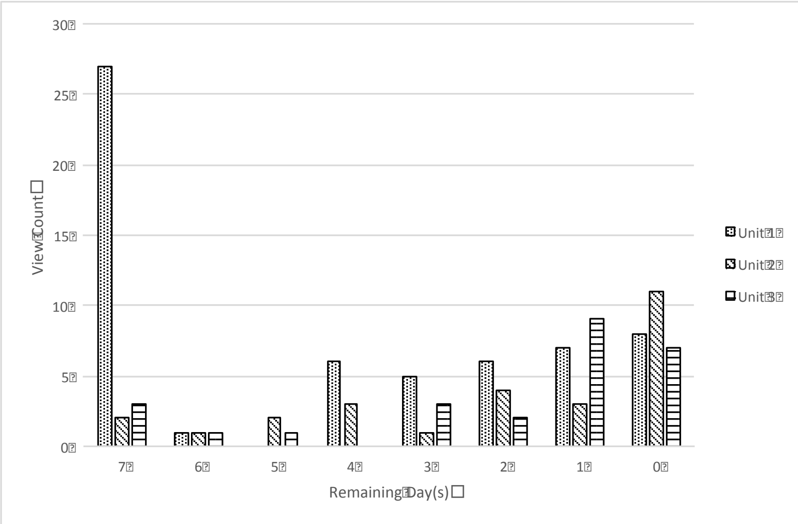


Figure 1. View Counts per Remaining Day(s)

3.3 *"% Viewed" per Remaining Day(s)*

Next, we focused on how long the learners viewed the video contents. The number "% Viewed" means 100% when a learner watched full length of the video. When he stopped watching at 10 minutes for full length of 40 minutes contents, the number would be 25%.

We set a hypothesis: when a deadline of video watching was approaching, many learners would cut short their viewing. If so, average % viewed will decrease according to remaining day(s). The result is shown in Figure 2. From the figure, there is no obvious tendency to support the hypothesis.

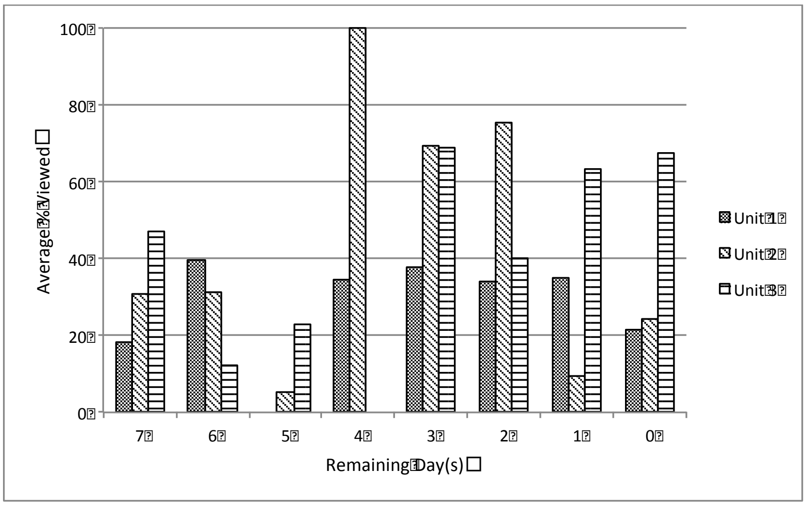
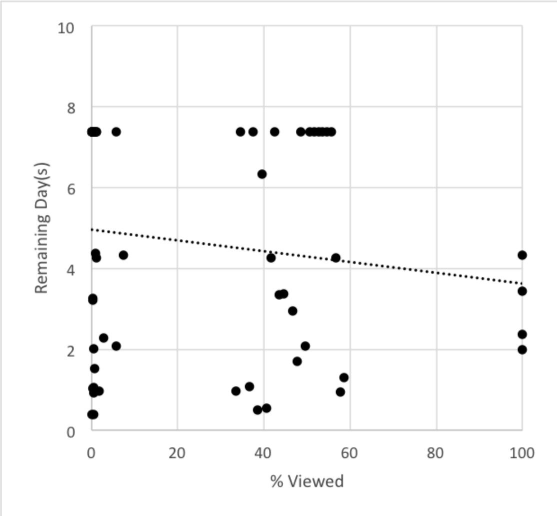
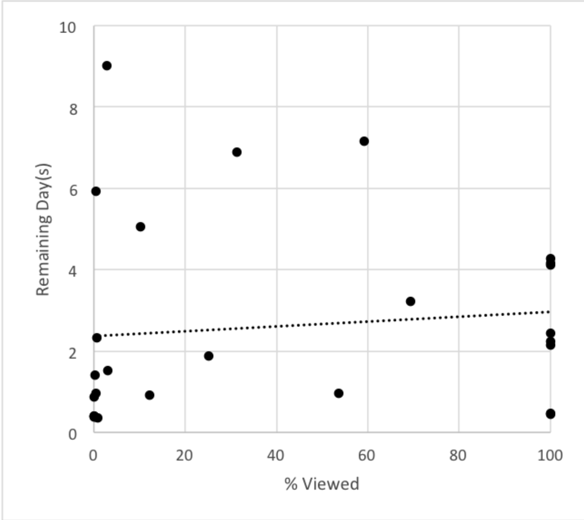


Figure 2. Average % Viewed per Remaining Day(s)

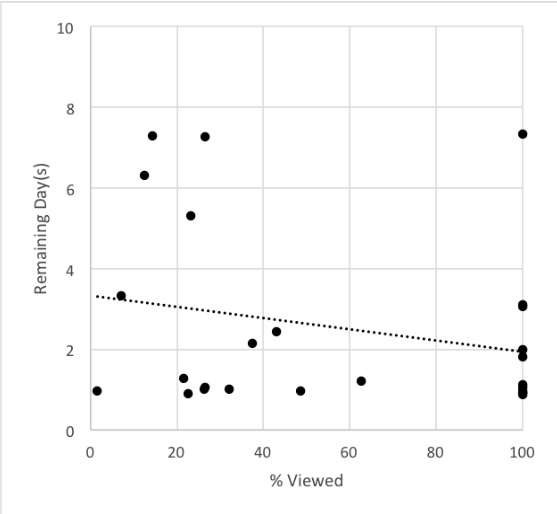
Then we proceeded detailed analysis: we drew graphs the distributions and assessed the correlations between remaining day(s) and % viewed. Figure 3 shows the results of distributions.



(a) Unit 1



(b) Unit 2



(c) Unit 3

Figure 3. Distribution of % Viewed and Remaining Day(s)

From Figure 3 (a)-(c), we can find some signature. First, all units include many video logs which stopped viewing in 5%. At the same time, they include some logs with 100% viewing. Also, Unit 1 (Figure 3 (a)) shows a significant group of 35%-60% viewing. In order to clarify these tendencies, we drew a histogram in Figure 4. From this figure, except for Unit 1, we can see a polarized tendency, groups near 0% and the others near 100%.

Figure 3 also indicates approximate lines for the correlations. Coefficients of these correlations are shown in Table 3. Only Unit 1 showed significance for minus correlation of -0.2582. It means negative correlation for the hypothesis above.

4. Conclusion

In this paper, a preliminary video log analysis was indicated, including correlations between remaining days and % viewed. For "last minute" learners, metacognitive training to schedule their tasks might be useful. The possible next step is to consider other key aspects of learning (in-class activities, achievements etc.) beyond currently treated data items.

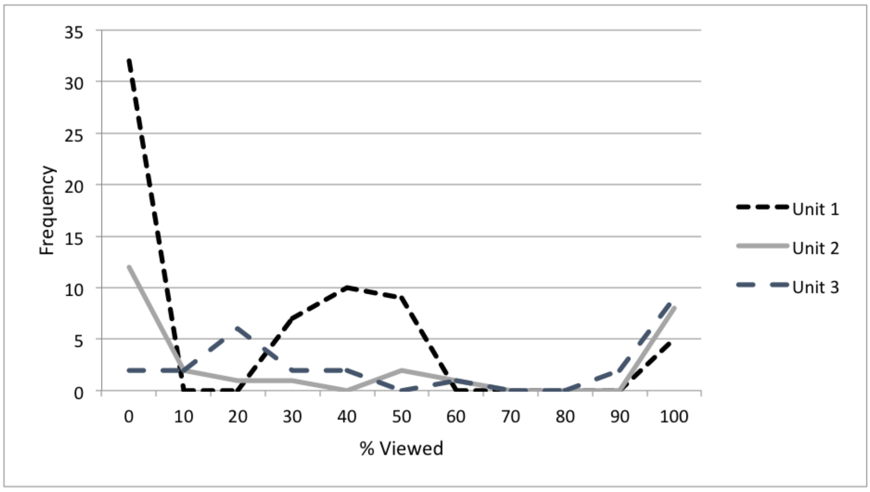


Figure 4. Histogram of % Viewed

Table 3: Coefficient of Correlation

Unit	Coefficient of Correlation	Significance Probability
Unit 1	-0.2582	0.0410
Unit 2	0.1081	0.5915
Unit 3	-0.2409	0.2358

Acknowledgements

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Analysis of Students' Peer Assessment Processes

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1. Introduction

In recent years, there has been an increasing trend for students to present their work during classes and to mutually evaluate each other. We have introduced presentations and peer assessments to classes in the courses of various grades in charge. Our main objectives to adopt peer assessments are as follows:
• Purpose A: To encourage students to better understand the evaluation criteria and to promote the student's presentation ability to improve
• Purpose B: To use it for grades when teachers are unable to see all presentations in large classes

Meanwhile peer assessments by students have problems of reliability and validity. Fukazawa (2010) organized related researches on the reliability and validity of peer assessments by students. According to Fukazawa, the related researches are roughly divided into following two: peer assessments by students is reliable as evaluation by teachers, and there is doubt about reliability and validity. As an example of the former, Fukazawa cited three studies that showed a high correlation by analyzing the correlation between evaluation by teachers and peer assessments by students (Miller (1996), Hughes (1993), and Stefani (1994)). On the other hand, Fukazawa cited two studies as examples of the latter (Stefani (1994) and Freeman (1995)).

However, all of these related researches are basically discussing reliability and validity based on the score of peer assessments. In this paper, we focus on this fact. In many previous studies, the reliability of peer assessment is basically determined by whether students' evaluations are consistent with each other, and the validity is basically judged based on whether the evaluation by teacher and by students are consistent. We thought that there might be evaluations in which the evaluated timing was totally different, even though the evaluations are regarded as being "consistent with each other" in previous method of the score-based judgment.

For this reason, we set the purpose of this research as to discuss the necessity of analyzing evaluation timing and temporal behavior in students' peer assessment processes. In this research, we focused on students' peer assessment of oral presentation.

2. Materials and Methods

2.1 Data Acquisition

In order to acquire evaluation timing in peer assessment, we developed a peer assessment tool with the function to detect students' temporal behavior. This tool is a kind of web-based form implemented in HTML, JavaScript and PHP. This form consists of list of evaluation items and radio buttons corresponding each score (1-5). When reviewers evaluate presenters, they select score of each item by clicking these radio buttons. Reviewers can change their scores until they click submit button. Assessment process logs and other information are sent into Learning Record Store (LRS), when each reviewer clicked the radio buttons or submit button. In order to distinguish between the evaluation log of the intermediate evaluation sent by pressing the radio button and the log of the final evaluation sent by pressing the send button, we defined "submit type": "onClick" is the former and "submit" is the latter. The items stored in LRS are as below: Reviewer's student ID, presenter's student ID, date and time, evaluation item ID, score, and "submit type".

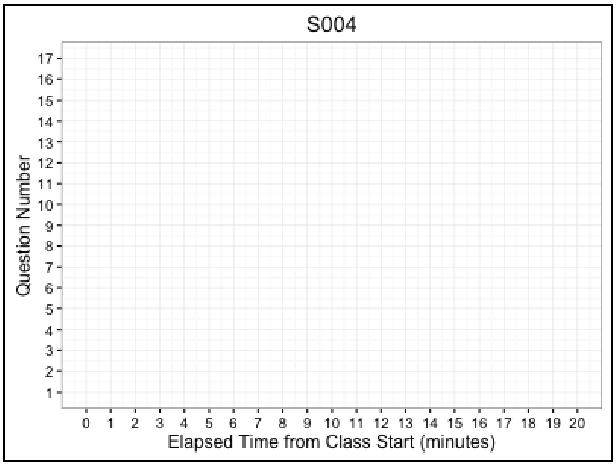
2.2 Target Course, Unit, and the Number of Participants

We set one target course for the experiment. This course was held in Sophia University, Japan, and one of the authors was in charge. The target course was mainly for students of the third year, and the number of participants was 72 students. The students were divided into six groups, and one student selected from each group made a presentation. Each group was given a total of 15 minutes, consisting of a 10-minute presentation and a 4-minute question and answer session. Six groups presented the presentation in one class. In the first week, group A to F made presentations, and in the second week group G to H made presentations. Of these two classes, we targeted the first week as an experiment. In the experiment, we requested the students to conduct peer assessment using the developed tools and got a log of the evaluation behavior.

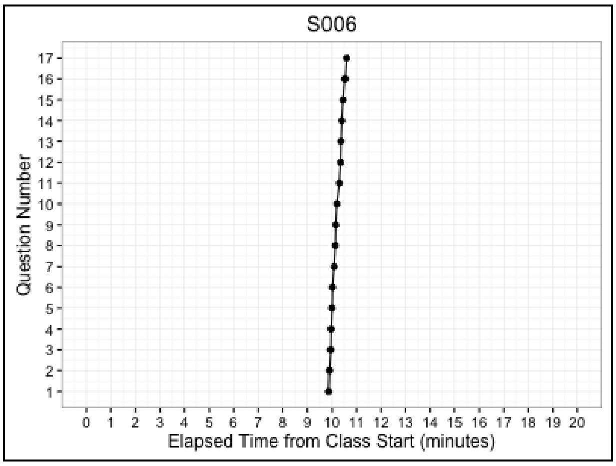
3. Results and Discussion

3.1 Examples of Evaluation Behavior during Evaluation for One Group

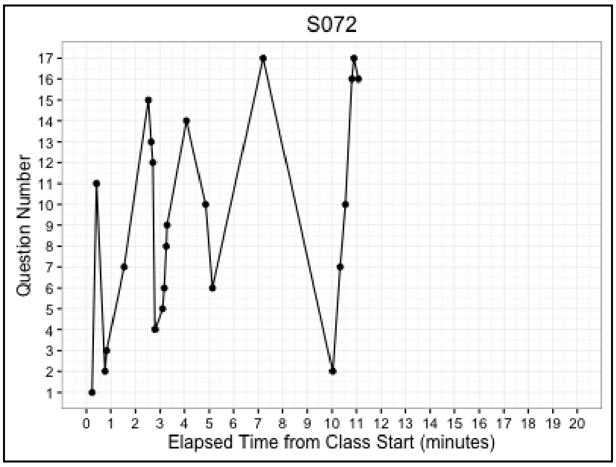
Examples of plotting log of the acquired evaluation behavior are as shown in Figure 1. The horizontal axis of the figure is the elapsed time from the start of the presentation (maximum 20 minutes), and the vertical axis is the evaluation item number (question number: 1-17). The three examples in Figure 1 are the logs of the evaluation for the group A.



(a) Log of student S004



(b) Log of student S006



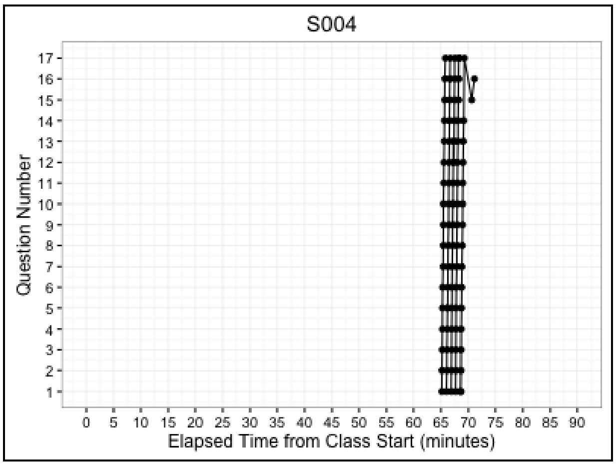
(c) Log of student S072

Figure 1. Examples of Evaluation Behavior during Evaluation for One Group

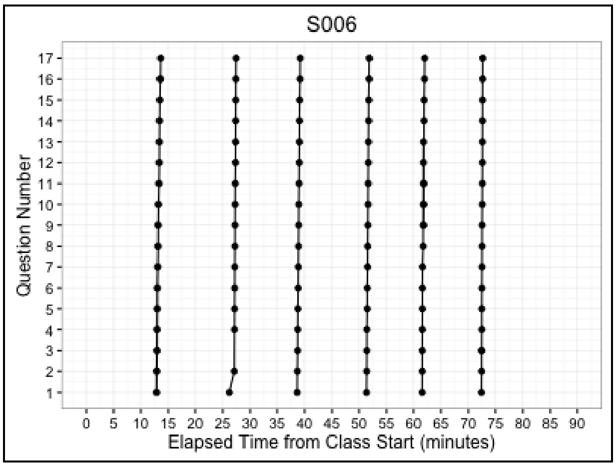
As it can be seen from the Figure 1-(b) and (c), while some students, like student S006, evaluated in a short time, some students, like student S072, came back and forth, or changed the score once evaluated. Also, as in the graph of the student S004 (Figure 1-(a)), there were some students whose graphs were empty. Such students are students who did not make an evaluation during the presentation.

3.2 Example of Evaluation Behavior during Evaluation for All Group

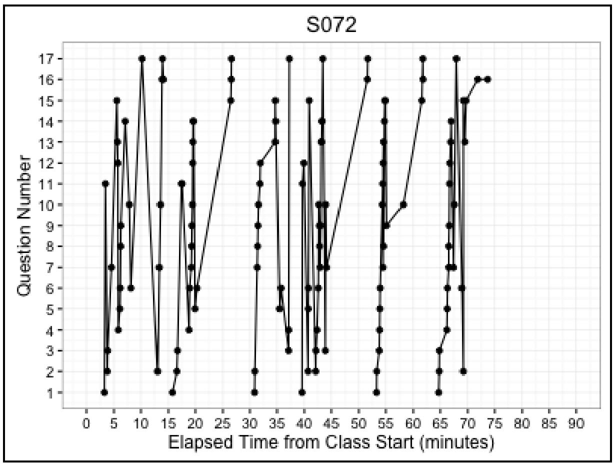
Figure 2 shows logs of evaluation behaviors of evaluation for all groups on a single graph. The horizontal axis of the figure is the elapsed time from the start of the class (maximum 90 minutes).



(a) Log of student S004



(b) Log of student S006



(c) Log of student S072

Figure 2. Examples of Evaluation Behavior during Evaluation for All Group

As it can be seen from the Figure 2, the evaluation behavior is greatly different for each student. Student S004 evaluated all the groups at the end of the class regardless of which group is presenting the presentation at the moment. Student S006 is similar to student S004 in that he evaluated in a short time, but he or she evaluated during each group's presentation. Student S072 seems to have evaluated by seeing and listening to the presentation in all groups.

3.3 All Students' Evaluation Behavior during Evaluation for All Group

Figure 3 shows all students' logs of evaluation behaviors of evaluation for all groups on a single graph. The horizontal axis of the figure is the elapsed time from the start of the class (maximum 90 minutes).

As it can be seen from the figure 3, there are other students like the student S004 who evaluates after a long time since the presentation was over. Furthermore, in the evaluation for group F, there are students who end the evaluation before the presentation starts. As a worse case of that, the student represented by the line at the right end of the figure (S004) has erroneously ended the evaluation of group G, as he or she completed evaluation of many groups in a short time. Despite this group's presentation scheduled for the next week.

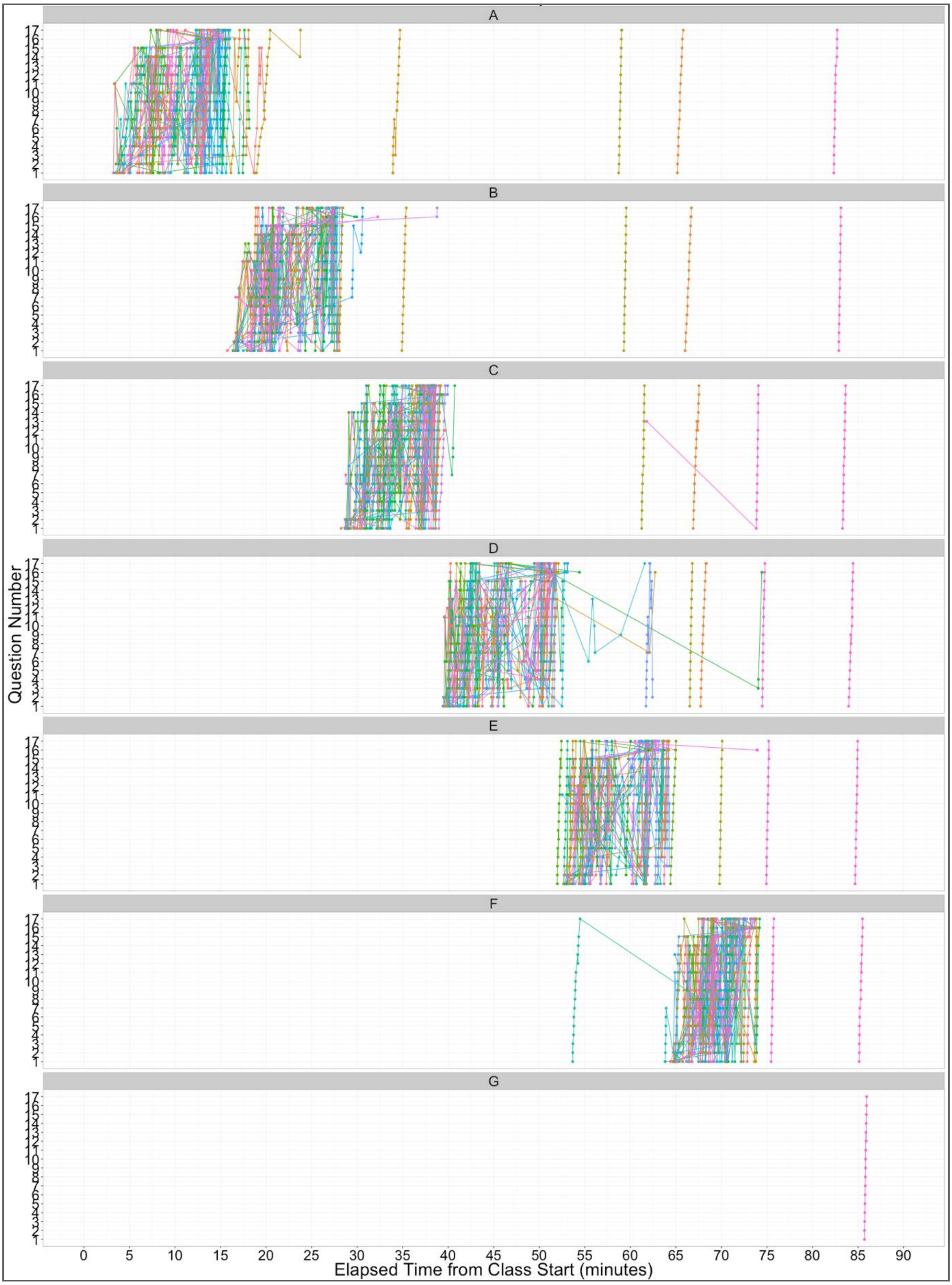


Figure 3. All Students' Evaluation Behavior during Evaluation for All Group

4. Conclusion and Future Works

The purpose of this research was to discuss the necessity of analyzing evaluation timing and temporal behavior in students' peer assessment processes. As the results show, we found a characteristic behavior that students evaluated after a long time since the presentation was over, or on the contrary, before the presentation starts. Other students evaluated many items in a short time.

Conventionally, reliability and validity of peer assessment were often judged by the degree of consistent of assessment scores. However, by visualizing the evaluation timing, we found that students' peer assessments include those evaluated during time periods not during presentation. As suggested this time, if the students did not seriously evaluate, no matter how much the evaluation results are consistent, it might be mere coincidence.

We only touched on the outline of evaluation timing in this paper, for analysis on more detailed evaluation behavior remains as future works. In the future, we would like to clarify the followings: (a) whether students understand the evaluation timing suitable for each evaluation item, (b) relationship between degree of consistency of score and evaluation timing, comparison between teacher's evaluation behavior and student's evaluation behavior, (c)conditions that makes it difficult to implement appropriate mutual evaluation.

Acknowledgements

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Supporting Face-to-Face Class with Mobile Device

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1. Introduction

Most higher educational institutes such as university attempts to introduce ICT education system called e-Learning or MOOCs (JMOOC, n.d.; gacco, n.d.). Teachers attempt to be continuous processes of trial and error to go toward high efficiency in learning by ICT, e.g. new type class called blended learning by incorporating face-to-face lesson with ICT.

On a technology front, the term "Internet of Things" (IoT) is a fashionable trend recently. In order to build a mechanism to exchange data each other, various things connect to the Internet more than ever by enhancing the ubiquitous computing. The things of IoT include the smartphone and the tablet that most students uses on a daily basis. Exchanging data among computers in a classroom, e.g. PCs, routers and home appliances leads to supporting learning activity in a classroom. In a face-to-face class, a teacher gives lessons with a handout, a black/white board or a projection equipment.

In order to provide teaching material in a class with ICT, the teachers have two plans. One is using a server on Internet called Learning Management System (LMS). Students uses LMS by PCs or smartphones. The other one is a network service on LAN. The network service provides teaching materials to students' mobile devices in the classroom.

Mobile devices such as smartphone or tablet provide various functions with apps. The users introduce a purposeful apps. The feature of mobile device is to be able to operate the apps with touch panel intuitively.

We are trying to support a class with mobile device by a small PC. In the class, a Wi-Fi network are built to provide the teaching materials to students' own mobile device as Bring Your Own Device (BYOD). In order to deliver teaching materials such as slide or movie to mobile device, we focus Digital Living Network Alliance (DLNA, n.d.) based on UPnP (Universal Plug and Play) (UPnP, n.d.) that is used for digital appliances. In this paper, we describe our practical system and discuss the use of mobile device in a face-to-face class.

2. ICT in a Class

2.1 Learning Design

We aims to realize an IoT oriented education system by BYOD. In this practice, we focus on mobile devices such smartphone, tablet and note PC that most students have widely. In the IoT, the system should provide the fit information in students' location and the situation. Therefore, we employ UPnP, DLNA as a platform for the service.

In this research, we focus on a face-to-face class to provide teaching material with BYOD. Most general education system realize to provide teaching materials. It is easy to compare with between the general system and the IoT system. In this practice, we use DLNA that realize to the function by installing an application and connecting network without authentication. By way of comparison, we employ the Moodle with a WWW browser.

However, it is difficult to get the logs in the DLNA. Therefore, we gather the communication packet by the packet capture software. By clarifying the students' learning situation from the log, we try to define the IoT oriented learning function and to provide the suitable feedback in the face-to-face class.

2.2 *Style of Class*

In the trial, we focus a professional education of the faculty of information technology in university that is for 3rd grade students. The number of students was 48. The classes consists of 15 lectures and the term-end examination is conducted in the final lecture after being summarizing the all lessons.

The teacher held in a general lecture room without Wi-Fi network and PC as a classroom. The instruction style is lecture, which the teacher lessons with PC and a projector. In the class, the teacher gives some mini-examinations every section of the lecture as a means of motivation and students' level of understanding by description format. In order to answer during the class, the mini-examination is shown with the projector each time.

2.3 *Utilization of Students' ICT*

We had a questionnaire because we cared about the utilization of students' ICT before the practice. The result are: the most 86.5% of students brought smartphone as mobile device in class. In addition, the 56.8% of half students brings note PC. In order to use the tethering to connect to internet, the 88.9% (n=36) of students brings mobile router such as WiMAX/3G/LTE because the classroom do not give Wi-Fi network service. Then, we asked about the DLNA service in this practice (n=28). The 7.1% of the students have utilization experience and the 46.4% of the students do not know about DLNA.

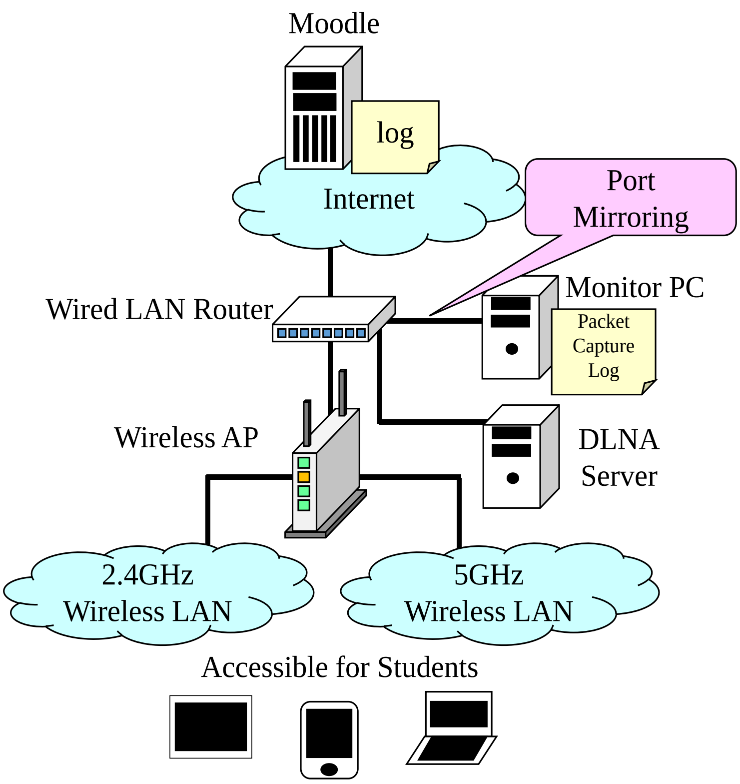

Figure 1. Overview of the System

3. Overview of the Support System

3.1 ICT in a face-to-face Class

We focus on a face-to-face class with a projector and a PC. In order to take notes of a lecture, the teacher shows students teaching materials not only as projector but also as handouts. The handout has some restrictions such as not color printing or small-size slide. In order to provide the easy-to-read handout and to support absentees, we prepare the Learning Management System (LMS) by web-based service called Moodle. The LMS provides handouts and mini-examinations. The overview of the system is shown as Figure 1.

Figure 2. Showing teaching material

Most students have smartphone with a large-size touch screen. The students can use watching the handout such as magnifying the handout and looking over previous lesson in face-to-face class. However, it is difficult for the teacher to develop and to prepare a system. Therefore, we focus the DLNA that is easy for the teacher to prepare the system. It is also easy for students to operate to get teaching materials with installing an app. The usage example is shown as Figure 2.

4. Result

We gave lessons with the system and become clear as follows: (1) The system should be made user-friendly. (2) A teacher should give explanation of the system usage suavely.

The affirmative impression of the students are: “It is easy to operate with smartphone.” “It is convenient because the handout is not needed.” However, some students says about the system as follows: “It is difficult to turn back at once because an operation to the system is renewed.” “It is hard to see the slide because it seems to be mixed all lessons.” “I hope to remove unnecessary folders.” with this in mind, we provide further information about the manner of operation. After that, students’ impressions become better.

In comparison with Moodle, some favorable answers are gotten as follows: “DLNA is better suited for seeing slides.” “It is convenient because we do not have to login.” “I can see the slide quickly.” “It is convenient when I get used to operate it.” “It takes no time to access it.” In addition, “It seems to be convenient if I can submit the mini-examination by the system.” We think that students feel the user-friendliness of DLNA.

However, we have the opinion: “Moodle is easier to see teaching materials than DLNA.” We think the difference by students’ application experience. It is important to use for different purposes with considering the students’ need and the learning effect.

5. Conclusion

In this paper, we describe the trial that is to provide the teaching materials to students by DLNA. The system is used with the technology of the digital appliance. In order to discuss the requisite learning functions, we continue to practice the system and make a study on the analytics by the log.

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Exploring the Relationship between Gameplay Self-efficacy and Anxiety when Playing the Puzzle Game

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1. Introduction

Gestalt is related to the visual domain, and have to find out the complex objects from local elements (Navon, 1977; Cooper & Humphreys, 2000; Riddoch & Humphreys, 2004). Gestalt perception results in an emergent manner from top-down, and recurrent network processes are built from the known low-level mechanisms. (Herzog, Thunnell, & Ö gmen, 2016). Based on the Gestalt perception, a puzzle game that have to recognize particular objects by inferring the whole picture from a few segments of that picture is designed for this study.

2. Literature Review

2.1 Gameplay Self-efficacy

Based on the research result of Brunet and Sabiston (2011), task self-efficacy beliefs have been considered as possible mediators of the association between cognitive-affective factors. It has also support for considering pathways from task self-efficacy beliefs to motives (Howle, Dimmock, & Jackson, 2016) which may positively align with learning behavior. Task self-efficacy beliefs may positively predict the construct of performance motives and goals. In line with this, it is important to consider players' game self-efficacy as the role of mediators between cognitive factors and game performance (Howle et al., 2015).

2.2 Gameplay Anxiety

Anxiety has been recognized as a cognitive response to a threat to the one's self-concept, by his or her subjective, consciously perceived feelings of tension (Spielberger, 1970). The state-trait anxiety theory has been introduced by Spielberger (1972), and described state anxiety as a "here and now" transitory feeling of tension that varies in intensity and fluctuates over time. Trait anxiety refers to a stable susceptibility to experiencing state anxiety. Trai anxiety is stable, and represented for the individual's experience of game playing.

2.3 Perceived Value

Expectancy beliefs are subjective perceptions of competence and confidence about future success in a task (Vekiri, 2013). Value-expectancy model also provides an understanding of game behavior (Vekiri, 2013). So, we would like to find out the relationship between gameplay self-efficacy and anxiety in this study.

3. Research Design

3.1 Hypotheses

This study aims on find out the relationship between gameplay self-efficacy and anxiety. Followings are the three hypotheses of this study.
H1: Gameplay self-efficacy is related to gameplay anxiety
H2: Gameplay self-efficacy is related to perceived value
H3: Gameplay anxiety is related to perceived value

3.2 Research Instrument

The puzzle game of this study is designed by cutting images into 25 parts (see figure 1) and using the Fibonacci series (e.g., 3, 5, 8, 13) to add parts of each image for players to identify. The more parts the players needed to identify from the object, the lower score they get.

Figure 1. The puzzle game

3.3 Research Participants

This research employed purposive sampling to select participants from elementary school located in New Taipei city. There were 60 students who participated in this experiment; 30 were male (50% of the total sample), and 30 were female (50% of the total sample).

4. Research Results

4.1 Correlation Matrix

Table 1 show that there were significant correlations between gameplay anxiety, gameplay self-efficacy and perceived value. The correlation coefficient between gameplay anxiety and perceived value was -.70, between gameplay self-efficacy and perceived value it was .81, and between perceived value and gameplay performance it was .40.

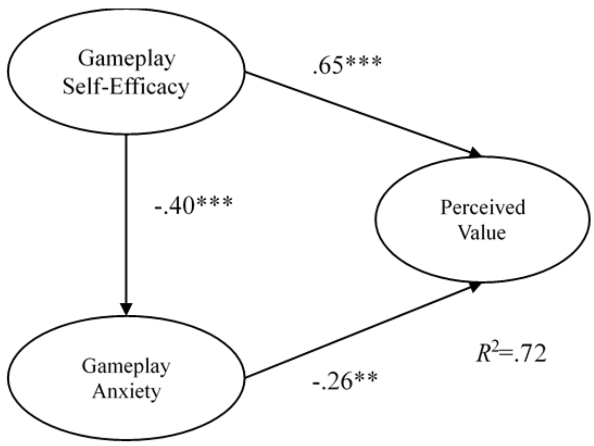
Table 1: Construct discriminative validity

Constructs	Gameplay anxiety	Gameplay self-efficacy	Perceived value
Gameplay anxiety	1		
Gameplay self-efficacy	-.70**	1	
Perceived value	-.71**	.81**	1

4.2 *Structural Equation Modeling*

This study used SEM with Amos 20 to test the goodness of fit for the model. We adopted Hair's recommendations to set chi-square /df< 5 as an acceptable level, together with multiple indicators to obtain a more objective conclusion to avoid power problems that arise using the Chi-square test in a large sample. The model was hypothesized as chi-square = 137.08, , RMSEA=.06, GFI=.87, AGFI=.82, in which GFI and AGFI were more than .8 and RMSEA was lower than .05, to represent that this model fit the data best.Hair et al. (2009) proposed that researchers should not only pay attention to the Chi-square values but should consider other fitness measures at the same time. The values of fitness were all larger than .9: NFI=.92, RFI=.91, IFI=.93, TLI=.95, and CFI=.94. Overall, judging from the comprehensive indicators, the theoretical model fit the overall pattern of the data.

Figure 2 shows the results of the path relationship among the hypotheses. It is evident that all hypotheses were supported. Figure 2 also indicates and supports that the test of gameplay self-efficacy influenced gameplay anxiety and perceived value with standardized regression coefficients of -.40 and .65. The test of gameplay anxiety influenced and supported perceived value with an standardized regression coefficients of -.26. The R^2 value is the percentage of variation as explained by the exogenous variable to the endogenous variables, thus, representing the predictive ability of the research model. Path coefficients and R^2values indicated the fit of the structural models with the empirical data. In addition, the explanatory power of this study was 72%.



Notes：*p < .05；**p < .01；***p < .001

Figure 2. Verification of research model

5. Findings

The result of this study shows that students' gameplay anxiety is influenced by gameplay self-efficacy. When the student has higher gameplay self-efficacy, they will have lower gameplay anxiety. The result also shows that students' perceived value may influence by their gameplay self-efficacy and gameplay anxiety. It reveals that students' perceived value is influenced by their feeling of gameplay self-efficacy and gameplay anxiety. If the students have higher gameplay self-efficacy, they will have higher perceived value, and if they have lower gameplay anxiety, they may also have higher perceived value.

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Effect of immersive digital gaming experience on elementary students' L2 learning

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1. Introduction

Availability of portable computing devices and advancement in immersive computer technologies have given rise to a recent spurt of research interests in leveraging benefits of digital games in educational contexts. In contrast to conventional approaches of technology enhanced learning, key advantages of incorporating digital games into second language (L2) learning are its affordances to provide immersive and motivational experience for situated language learning.

2. Theoretical foundation

Interactive and immersive learning environment is considered to be beneficial to L2 learners because of their efficacy in providing sensory input, interaction, task-based learning and output production (Cheng, She, & Annetta, 2015; Lin, Chen, Huang, Huang, & Chen, 2014). Researchers emphasize that some aspects of videogames, such as intrapersonal and intrapersonal factors, could promote intrinsic motivation. Highlighting games' role in transforming language learning as an experience to derive "situated meaning," Gee (2013) argues that games associate words with images, actions, goals and dialogue, allowing learners to understand new words in context, rather than as abstract symbols.

2.1 Player involvement, flow, and game immersion

Motivational theories ascribe engaging learning experience to high degrees of player involvement. The primary goal of digital games is to create visually satisfying and intrinsically motivating experiences for students to interact with the virtual world with high player involvement. Player involvement may be referred to by various terms such as presence, immersion, engagement, and flow (Calleja, 2011; Norris, Weger, Bullinger, & Bowers, 2014; Herrewijn, Poels, & Calleja, 2013). In Csikszentmihalyi's (1990) conceptualization, flow signifies a peak experience accompanied by optimal performance and a state of concentration and satisfaction when players are engaged in activities that are of intrinsic interests to them.

It is of practical significance to differentiate various levels of player involvement distributed along a continuum. Studies suggest that immersion, rather than flow, might be a more appropriate term to describe user's degree of involvement playing video games, because flow as a culminated experience is typically preceded by engagement with challenging tasks that require extended hours of practice, and that flow occurs only when some basic criteria are satisfied, such as clear goals, direct feedback, good balance between skill and challenge. Some games simply cannot have these criteria met, because they may not have clearly defined goals, or provide direct feedback to the player. By contrast, it does not require extended hours of practice to achieve immersion. Furthering the progressive nature of immersion, Jennett et al. (2008) argue that while flow and immersion overlap in the sense of distorting time and providing challenges, immersion is a precursor of flow, with the latter being the extreme end of the former, as a player can be immersed in a game while still being aware of other things they need to attend to, without reaching a state of flow. In other words, immersion does not necessarily warrant flow, and a player can be immersed in a game but still not reaching the state of flow.

2.2 Immersive game-enhanced L2 learning

Studies note that visual effects of a video game help create immersive sensory experiences when interacting with visually appealing objects in the virtual world. Ivory and Kalyanaraman (2007) argue that innovations in sound and graphics can drastically change key variables of player experience, such as presence, involvement, and immersion. Järvinen (2002) identifies three graphical styles that have dominated video game design since its inception: Photorealism, Caricaturism, and Abstractionism. As all three styles have their distinctive roles in gameplay, how visual appearance of games could affect a game's aesthetic value and player's experiences is a question remains to be examined.

In the game that we use for this study, scenes are presented in photorealistic 3D renderings, which allows the players to interact with game objects that look more realistic. When navigating through the game scenes, players could build up a sense of place, which enhances the sense of presence, thus would be conducive to the experience of immersion, which in turn may benefit learner's performance.

3. Methodology

This study investigates how perceptions of immersive gaming experience derived from realistic-looking visual elements correlate to L2 learners' learning performance in a digital educational game.

3.1 Design and participants

This study employs a quasi-experimental design that involves an experiment and a control group to be compared regarding the participants' learning performance before and after the intervention. The participants are two classes of elementary students randomly selected from a pool of eight classes at the third grade. The two classes are similar to each other with respect to age, social economic status, and their academic performance as a whole. The experiment group consisted of 38 students, and the control group consisted of 25 students. The learning content of the two groups is the same, the only difference is that the experiment group learnt with the digital game, while the control group learnt with conventional DVD-based interactive learning system.

3.2 Instruments

To examine the player's involvement in relation to immersion, this study employs the Immersion Questionnaire (Jennett et al., 2008) to analyze the participant's perception about their learning experience. The questionnaire consists of 30 questions in five dimensions, including cognitive involvement, real world dissociation, emotional involvement, challenge, and control. To assess the participants' learning performance, we developed a set of quizzes based on the textbook used by the elementary school at which the experiment was conducted.

3.3 Procedure

The two classes of students are assigned to either the experiment or control group condition according to the recommendation of the teacher in charge of their English class.

4. Results and conclusions

To examine whether the learning performance of the two groups of students differ from each other before and after the intervention, a paired sample *t*-test was performed. Although both groups achieved some progress in terms of quiz scores, the students in the experiment achieved their progress on a statistically significant level ($p<.001$), while those in the control group did not. These results indicate that the students learning with the immersive digital game demonstrated greater potential in their language performance than their counterparts learning under non-game setting.

To understand how the students' learning performance is correlated to different dimensions of immersion, a regression test was performed. The results indicate that among the five dimensions of immersion, three of them (real world dissociation, challenge of tasks, and control) were found to be significantly correlated to the students' performance, with a marginal correlation between emotional involvement and learning performance.

This study presents empirical evidences that confirm the positive role of immersive game experience to language learning. Furthermore, it provides some nuanced insights on how specific aspects of immersion are correlated with learning performance in digital game-enhanced language learning.

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Exploring the Effects of Interactive Game with Situational Animation to Facilitate Primary Students in Learning Nature and Life Science

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1. Introduction

As young people spend a prodigious amount of time playing video games either by themselves or with friends, game-based learning has received much attention from educators and researchers (Gee, 2003; Kiili, 2005; Oblinger, 2004). Hwang and Wu (2012) gives a review of the papers published between 2001 and 2010 and shows that game-based learning has been applied to subjects such as mathematics, computer science, geography, and language, mainly because this mode of learning raises the students' interest and motivation. In a well-designed game-based environment, students apply their prior knowledge to the activity while the engaging design heightens their motivation (Papastergiou, 2009; Tao, Huang, & Tsai, 2016; Van Eck, 2006), and supports an active, experiential, and problem-oriented learning environment (Meluso, Zheng, Spires, & Lester, 2012).

To be effective, game-based learning needs a design that is interesting and challenging and steeped with meaning; it induces responses from students (Chuang et al., 2012) and cultivate qualities such as courage, curiosity, self-control, competitiveness, cooperation, and validation (Prensky & Prensky, 2008). For example, Huang, Wu, Chen, Yang, and Huang (2013) investigates the effect of using games on mobile devices to teach addition and subtraction to second graders and finds that this method aids in the students' understanding of the subject and raises their performance.

In addition, multimedia animation is often used in digital learning because it can tell stories with vivid characters and situations (Issa et al., 2013; Liu, Lin, Tsai, & Paas, 2012). Moreover, the dual-coding theory asserts that the learner separates outer stimulations into verbal and visual types and stores them in memory; the connection between these two types of stimulation helps the learner knowledge building during the learning process (Clark & Paivio, 1991). The dual-coding theory has spawned many digital learning materials with multimedia animation (Issa et al., 2013; Liu et al., 2012; Rodicio and Sanchez, 2012). Ghanizadeh and Razavi (2015) shows that when multimedia animation is used to help eighth graders learn English, they show a marked improvement in performance and familiarity with the subject and are more motivated to master the content.

In this vein, this study aims to develop an interactive game in learning subject of nature and life science which equips with situated animation to express the natural theory. This tool facilitates students to question the natural phenomena they learn and lets them interact with objects during playing game. In order to evaluate the effects of the interactive game, the learning performance of fourth graders were conducted in this study.

2. Methods

This study seeks to help elementary school students learn the theories of natural phenomena. The multimedia animation explains the abstract concepts while the interactive game tests the students' knowledge in theories and phenomena.

2.1 *Interactive Animation Game*

The study proposed an interactive game with situated animation, which based on the Water Movement, a learning unit for fourth graders, complete with 2D characters and props. The unit has three sections: (1)capillary motion, (2)siphon, and (3)u-tube.

The script of the animation is about a kid robot, Xiaobo, and his family. The story starts with Xiaobo playing paper airplanes on the bed. His mother calls and tells him that she is coming home. Xiaobo stops playing and rushes to do the things that his mother asked him to do before she left the house: cleaning up the spilled soda, putting fresh water in the fish bowl, and adjusting the pictures on the wall.

Figure 1. Animated Scenes: (Left) Room before Clean-up; (Right) Room after Clean-up

Figure 1 shows the room before and after Xiaobo cleans it up. Xiaobo wipes the spilled soda with a kitchen towel (Figure 2, left). To show how absorption works, we create a water droplet flowing into a crevice to explain capillary motion (Figure 2, center). When the kitchen towel has absorbed most of the spilled soda, there is less soda on the table (Figure2, right).

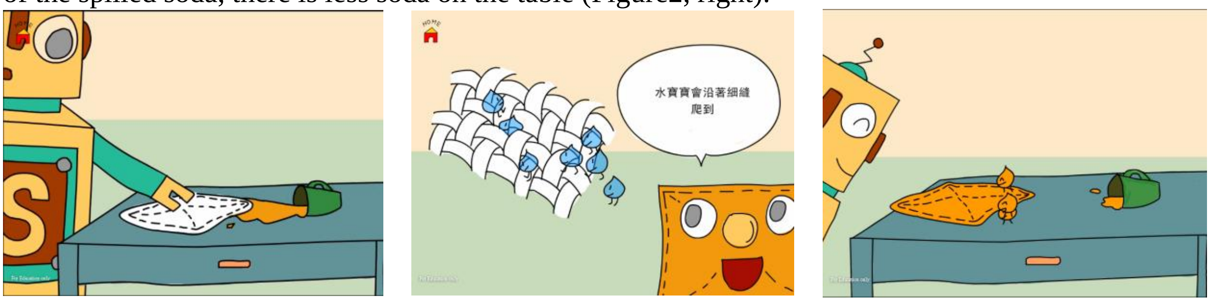

Figure 2. Left: Xiaobo Wiping Table; center: Water Droplet and Capillary Motion; right: Water Movement

2.2 *Participants and Activity Procedure*

The participants were a total of 52 fourth-grade students at an elementary school in northern Taiwan, divided into an experimental group (n = 28) and a control group (n = 24). The regular teaching for each learning unit was three periods per week and lasted for three weeks. Both experimental and control groups were taught by the traditional classroom and lab activity. Besides, the participants in the experimental group would conduct game learning activities.

2.3 *Data Collection and Analysis*

The learning outcome was investigated from the pre- and post-tests to find out the changes in participants' learning achievements. Prior to the experiment, both experimental and control groups took a test as the pre-test. After the experiment, both groups were given a test related to the learning contents as the pro-test. The single-factor analysis of covariance (ANCOVA) was used to analyze the changes of the participants' pre- and post-test scores. The pre-test score is considered to be a covariance to analyze the difference between post-tests within the two groups.

3. Results and Discussion

According to the ANCOVA statistical method, the variance homogeneity test was conducted first. Levene's test yielded $P > 0.05$ ($F(1,48) = 3.227$, $P = 0.079 > 0.05$), which means it did not reach the standard and thus did not violate the hypothesis of variance homogeneity. Applying covariance analysis to the performance of the two groups, the F-value is 3.348 and p-value = 0.073>.05, which is not statistically significant. Thus, the performance of students in the experimental group is not significantly higher than those in the control group. After the adjustment, results of the means and SDs of the post-tests were obtained (control group: M = 86.70, SD = 2.10; experimental group: M = 91.94, SD = 1.94). Even though the ANCOVA did not demonstrate the significant learning improvement between experimental and control groups, the mean of the experimental group reveals progress in learning effects while the control group does not. Moreover, the experimental group's score range is smaller than that of the control group.

The positive influence game-based learning exerts on performance has been testified, while the dual-code theory asserts that imagery improves verbal memory when the mind processes outside stimulations. This game-based leaning model compels the students to have a real-life experience in viewing the multimedia animation while the interactivity tests the students' knowledge. It suggests further study on the experimental group to ascertain the degree to which game-based learning with multimedia animation has positive effect on learner autonomy, attention, and confidence in learning materials.

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Measuring stress in doctoral research: a case for reality mining across psychological, physiological and environmental dimensions

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One night during the third year of my PhD program, I sat on my bed with a packet of tranquilizers and a bottle of vodka. I popped a few pills in my mouth and swigged out of the bottle, feeling them burn down my throat. Moments later, I realized I was making a terrible mistake. I stopped, trembling as I realized what I'd nearly done (Walker, 2015).

1 Introduction

Stress levels in doctoral students have long been of concern (Bélanger et al., 2015; Hill & Smith, 2009; Offstein, Larson, McNeill, & Mjoni Mwale, 2004). Not only do they affect doctoral completion rates and retention (Kearns, Gardiner, & Marshall, 2008), they have been found to have a detrimental impact on students overall wellbeing (Haynes et al., 2012; Ross, Bathurst, & Jarden, 2012). There are signs that a growing number of students are experiencing levels of stress that appear to be higher than any time in history (The Faculty Advisory Council of the Illinois Board of Higher Education, 2007). A recent study by Ickes, Brown, Reeves and Zephyr (2015) of 1,139 college students revealed 80% of graduate and undergraduate students reported they struggle with stress. The U.S Associated Press survey on stress and mental health of college students (Associated Press & mtvU, 2009) found 85% of students surveyed experienced stress on a daily basis. Of these, six in 10 reported having felt so stressed that it interfered with their academic work.

It is interesting to note that many of these studies are focusing not on the psychopathology of the individual but on the influence of the academic environment. For instance, the 2013 National U.S. College Health Assessment, where the average age of those surveyed was 21 years, reported that almost half (46.3%) of all undergraduate students surveyed felt traumatised or overwhelmed in regard to their academic responsibilities. Similarly, a study by Waghachavare, Dhumale, Kadam and Gore (2013) of 1,224 students undertaking professional courses found 24% regularly experienced prolonged negative stress as a result of academic factors. These studies reflect a growing realisation of the stressful demands contemporary educational environments can place on students (Bélanger et al., 2015; Meriläinen & Kuittinen, 2014). Given this, it seems reasonable to accept institutions have an obligation to ensure that educational environments operate in a manner that mitigates rather than promotes factors associated with stress or burn-out.

To date, studies of student stress in higher education have been based on student self-reports of stress through various punctuated collection methods. As a result, measures of stress are typically bound to individuals and guided by post-event recollections as opposed to measures situated at the time of the stressful event: they reflect perceptions of stress and perceptions of stressors. Non perception based measures, such as environmental and physiological, have, until recently been impractical to capture in 'real-life' contexts. However, recent developments in wearable biometric devices and auto-camera technology, offer new opportunities to capture in real-time continuously digital traces across psychological, physiological and environmental dimensions.

2 Method

The aim of this study was to explore psychological, physiological and environmental factors associated with stress through the use of devices that afforded the capture of continuous naturally occurring data.

Four doctoral students from various disciplines took part in the 3-month study which captured three core datasets.

Physiological Data: Each participant wore the biometric wristband (Figure 1) during awake hours; Monday to Friday. The device captured four core measures required for analysing sympathetic arousal through analysing electrodermal activity (1) photoplethysmography (BVP-blood volume pulse & HRV heart rate variability), (2) EDA-electrodermal activity (variation in electrical characteristics of the skin), (3) peripheral skin temperature, and (4) movement (of the wrist, along X, Y and Z axes). Each person wore the band for approximately 15 hours per day over the study period (15 weeks) generating 1,600 - 2,000 hours of biometric data.

Figure 1: Empatica Biometric E4 wristband sensor

Environmental Data: A small wearable auto-camera (Figure 2) set to activate every 30secs was used to capture continuous environment/context data. Over the period of time approximately 100k images were generated for each participant. Middleware was developed that mapped these images by date and time against the *Physiological Data* in order to identify core environmental stressors.

Figure 2: Narrative clip wearable auto camera

Psychological Data: Weekly interactions were scheduled with participants as a feedback technique to explore the data compared with the student's conceptions. The graphical time sequences middleware was used in order to assist in context recall through the use of the photographic data. The biometric wristband also allowed the wearer to self-record (physiological measure) stress through activating a button on the top of the wristband which adds a marker to the data. These data points were also included in the weekly discussions.

3 Preliminary Findings

Although the study is in the early stages of analysis, early data from two core measures will be discussed in the presentation. Firstly, stress as it relates to activity of the sympathetic nervous system (SNS), in particular the extent to which each participant experiences variations in SNS load.

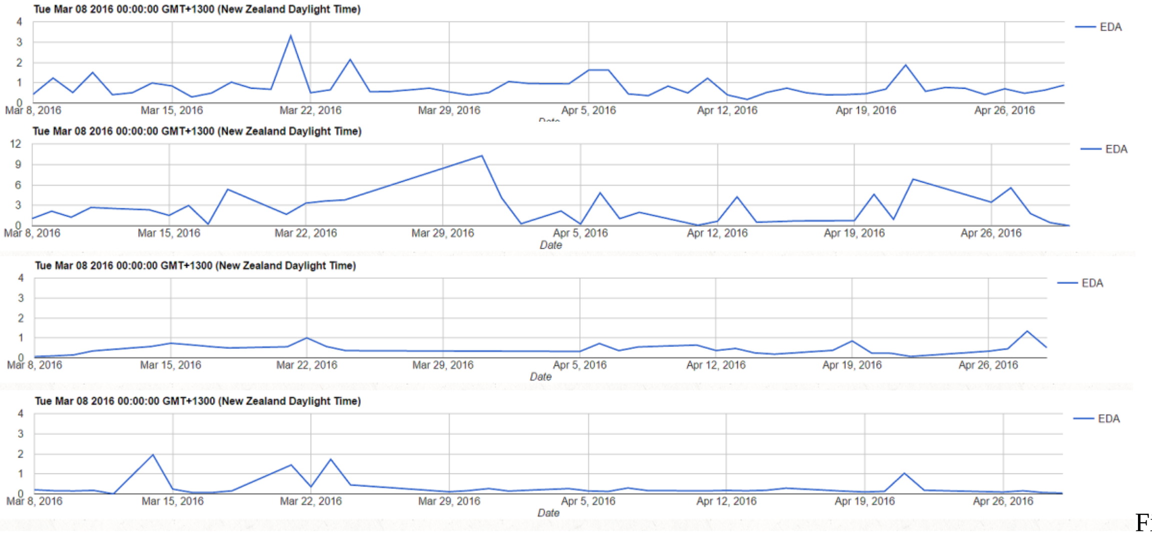

Figure 3: time sequence of EDA measure across the study period for each participant.

Secondly, I discuss various environmental contexts that surfaced as stressors. Examples of three of these are presented in Figure 4 below. These events will be reviewed by incorporating physiological, environmental and participant accounts (psychological). These will also include the curious phenomenon of misalignment that regularly occurred between EDA measures of an ‘event’ and the participants account (psychological) of an event. In many cases participants were amazed to see that particular events rendered no physiological signature.

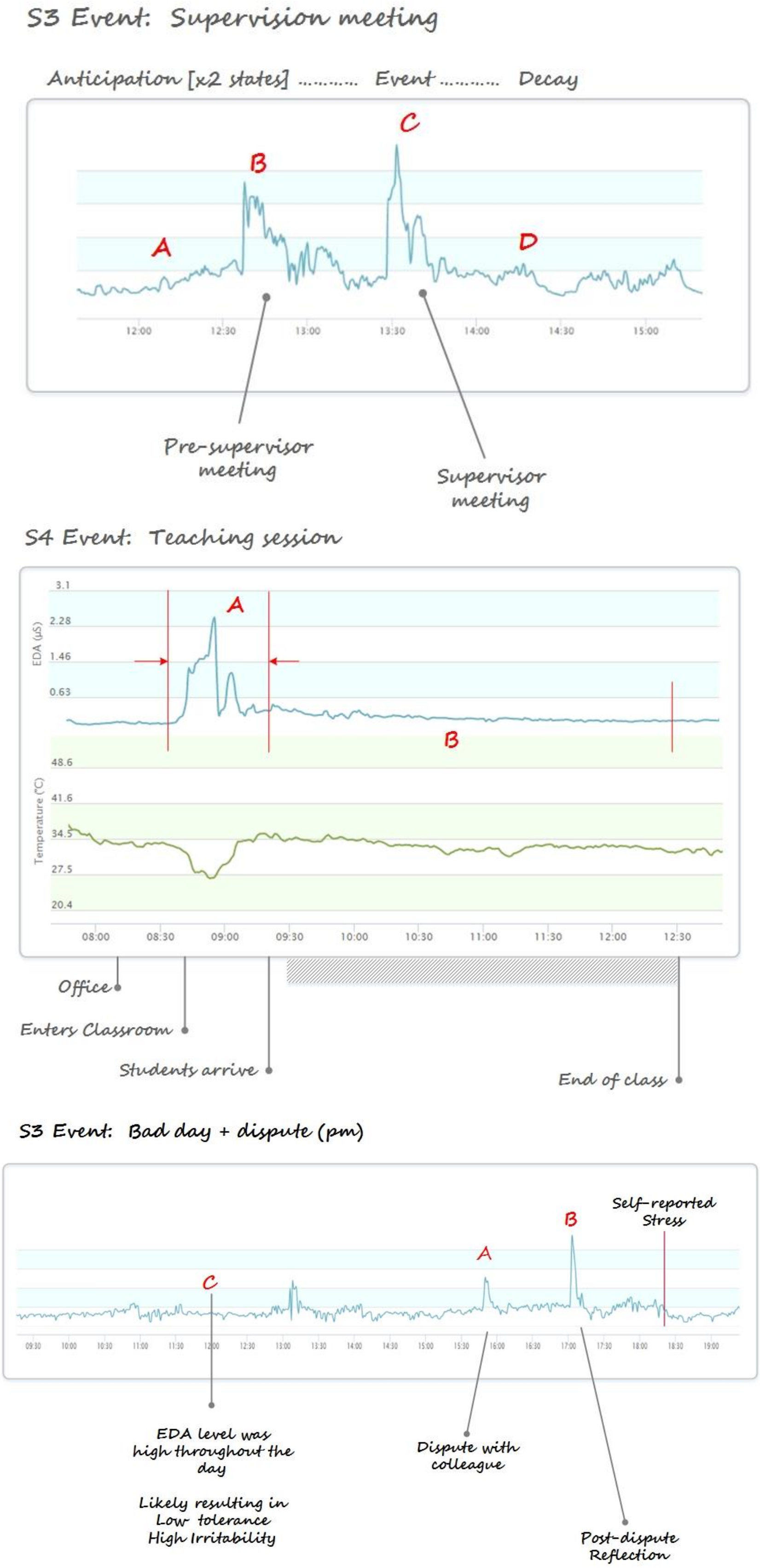

Figure 4. Three examples of EDA mark-up data with context information supplied by photos and participant accounts.

4 Conclusion

While still in the early stages of analysis, it is clear that physiological measures had a profound impact on the participants understanding of stress. In particular, it raised a new tension for them as they grappled with the relevance and validity of the physiological data as a new reality over their conceptual or psychological understanding. An important point that surfaced early in the participant discussions, as a result of lower than expected EDA activity, was the idea that they adopted the 'construct of being stressed' as a condition of being a doctoral student.

From a methodological perspective, it became obvious early on in the data analysis that the act of seeking meaning from the data has been greatly improved by the coupling together of psychological, physiological and environmental dimensions. I would go so far as to suggest that this capability is likely to revolutionise the way we undertake behavioural research.

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