USING LEGO® SERIOUS PLAY® TO ARTICULATE UNDERSTANDING AND SHARE MENTAL MODELS

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Abstract

Knowledge sharing is at the heart of pedagogy and there are a wide range of methods to assess understanding, retention and application of knowledge. Identifying gaps in understanding, where misunderstanding or misinterpretation of knowledge has occurred remains challenging. This paper focuses on the question: how do we measure the differences and similarities between the mental model in the head of the tutor and the mental model in the head of the student?

LEGO® Serious Play® is a structured method of using LEGO® bricks for problem solving and sharing tacit knowledge based on the Piaget's constructivism theory. The method encourages participants to externalize their understanding, building a physical representation of their mental model. Participants share their mental model by explaining its physical representation in the LEGO® model.

This paper presents the results of a pilot study to explore how LEGO® Serious Play® may be used to assess the extent to which the mental model in the head of the tutor has been successfully shared with students. The work focuses on how the method can be used to identify whether students have developed a similar mental model in their heads and how similarities and differences can be surfaced.

The initial pilot study suggests that LEGO® Serious Play® is an effective method for creating a safe environment to externalize and share mental models, promoting meaningful discussion. This research will be of interest to tutors who are seeking novel ways of encouraging students to share their thoughts and build richer mental models.

Keywords: Mental Models, Sharing Knowledge, Knowledge Transfer, LEGO® Serious Play®.

1 INTRODUCTION

A mental model is a person's internal representation of a network of concepts [1] that form understanding. Mental models are multimodal, constructed from comprehending and organizing perceptions of the world, gained from the five senses, to explain verbal and visual understanding [2]. Knowledge construction occurs as mental models are created [3]. A person uses a mental model to guide their behaviour [4]. Mental models are dynamic [5], "working models" [1] that evolve and enable a person to run mental simulations before taking action [6]. Individuals have different mental models based on their "personality, preferences, knowledge and experience" [7]. Insights can be gained by understanding the mental models of others [5] and how it might affect their behaviour in situations.

In LEGO® Serious Play® mental models are formed as physical LEGO® bricks are connected [8] in the hands of participants. LEGO® Serious Play® is a structured method comprising of three stages referred to as three build levels [9]: (1) Participants are first introduced to building symbolic or metaphorical models; (2) Participants then work together to develop a model that represents a combined view of a situation; (3) finally, system models are created by groups of participants to build a model of a systems solution to a given problem or challenge.

Previous work has compared knowledge structures of experts and trainees in learning and found it to be a viable indicator of learning; however further work is needed on the methods used [10]. This paper reports on a pilot study to explore how LEGO® Serious Play® may be used as a method to compare mental models of students and tutors as a means to assess levels of understanding.

1.1 Mental Model Elicitation

The process of externalizing a mental model is elicitation [5], extracting a model from the head of a person and representing it in a form that can be viewed by others.

Elicitation can be:

- **Direct or indirect:** Direct elicitation is where participants extract their mental model and structure the external representation of their mental model themselves using visual tools with the support of a facilitator. Indirect elicitation occurs by interviewing participants, transcribing the interviews and then conducting a content analysis of the transcriptions to extract and document the mental models expressed in the text [11], [5].
- **Situated or nonsituated:** This refers to the setting where the elicitation takes place. Situated elicitation occurs in the natural setting where the mental model is constructed and used; nonsituated elicitation occurs at a different physical location. The setting may impact the number of concepts identified [5] as the natural setting provides situational cues.
- **Oral or visual:** Oral elicitation relates to capturing mental models through the use of semi-structured interviews [12]. This contrasts to the independent construction or co-construction of visual representations of mental models through the use of, for example, concept maps. Visual representations can help an individual to explore their mental model [13].
- **Freely-defined or predefined concepts**: The use of freely-defined concepts give participants more freedom to express their models, although the diversity of concepts can hinder analysis [14]. Predefined concepts provide a common vocabulary for participants to articulate their mental model. This makes it easier to compare mental models but it is based on the assumption that participants have a shared and agreed understanding of the concepts being used.
- **Individual or team-based**: Individual elicitation externalizes one person's mental model through, for example, individual interview [14]. Team-based elicitations may be conducted in workshops [14] to explore common understanding [15].

There is a lack of research on how to elicit mental models [5]. This paper contributes to research in the field by exploring the potential for LEGO® Serious Play® to be used to elicit mental models.

1.2 Eliciting Mental Models with LEGO® Serious Play®

LEGO® Serious Play® is founded on Piaget's constructivism theory, mental models constructed as physical bricks are put together [8]. Trained facilitators take participants through a series of steps in three build levels that enable participants to externalize and share the mental models in their heads. After an individual has built a LEGO® model, the indiviudal shares their mental model with others by verbally explaining the physical model, pointing to specific bricks and sections, narrating the model. Telling the story of the LEGO® model gives the model meaning "making the invisible visible" whilst also facilitating reflection-in-action [8] as the mental model is externalized.

In build level 2, participants work together to construct a single LEGO® model that represents the participants shared mental model. The shared model is achieved through a series of cycles. Each cycle comprises building, storytelling, and reflection. Components from individual physical models are extracted for inclusion in the shared model with further bricks added or changed as needed. The story of the model is then narrated; this clarifies and reinforces the mental model represented in the bricks. Participants then reflect on the model and assess whether a further cycle of changes and storytellig is needed. The cycles continue until consensus is reached that the physical model and narrated story represent the shared mental model of participants. LEGO® Serious Play® enables different perceptions to be shared, making the perceptions visible, which can be difficult to reconcile [16]; however, surfacing where differences in mental models occur is important to identify where any misunderstandings may have occurred in learning.

1.3 Mental Model Analysis

When mental models have been elicited, the models need to be standardized for analysis. Analysis of mental models identifies what is important to each person, reflected in their mental narrative [14] and identify misperceptions [17]. Differences in individual mental models are mental model disconnects [18]. Disconnects can relate to differences in information, evaluations of information or unexpected actions [19].

Approaches to present mental models and explore shared knowledge embedded within them include: content analysis (frequency of words), procedural mapping (procedures in a task), task analysis, cognitive mapping (visualizing concepts and the relationships between them) and statistical analysis [1].

Caution is needed when comparing the number and frequency of concepts in mental models. For example, an error in understanding may have occurred when differences occur between the mental models of instructors and students [1]. However, errors in understanding could have resulted in the creation of more concepts in a student model [1]; the inclusion of the concepts in a model does not necessarily mean a student understands the concepts [1].

Although content analysis is widely used it only focuses on the concepts in the model. Content analysis reflects “a text’s fundamental building blocks, but not the structure in which those blocks are arranged” [1]. In LEGO® Serious Play®, the bricks represent the concepts and the physical arrangement of bricks is used by a participant to structure the narrative of their mental models, providing richer externalized models to analyse and explore understanding. LEGO® Serious Play® may therefore provide a means to elicit, share and analyse mental models of students and tutors.

2 METHODOLOGY

A pilot study was undertaken to explore how LEGO® Serious Play® may be used to identify disconnects between the mental models of students and a tutor. Table 1 outlines the research design used to elicit and analyse mental models using build level 1 and build level 2 of LEGO® Serious Play®. Although a mental model can be considered as a conceptual representation of a system [20], build level 3 was not used in this pilot as building an interactive systems model was out of the scope of the study.

Three postgraduate students and their tutor were selected to participate in the study as they were familiar with the LEGO® Serious Play® method. This provided four individual mental models and one shared mental model to analyse.

Table 1. Overview of Research Design.

Stage	**Method**	**Tasks**
1. Individual Mental Model Elicitation (Visual, Direct, Unsituated)	LEGO® Serious Play® Build Level 1	1.1 Build Individual Models 1.2 Narrate Individual Models
2. Mental Model Analysis	LEGO® Serious Play® Build Level 2 Visual, Direct Analysis	2.1 Observation of Physical Models and Reflection
3. Team Mental Model Elicitation (Visual, Direct, Unsituated).	LEGO® Serious Play® Build Level 2	3.1 Iterations of: • Building Shared Model • Narrating Shared Model 3.2 Agree Shared Model 3.3 Reflect on Process
4. Mental Model Analysis	Indirect Content Analysis	4.1 Transcribe and Code Narratives 4.2 Statistical Analysis 4.3 Content Analysis

The topic chosen for the mental model elicitation was an assessment process. A process was chosen for analysis rather than content knowledge in order to provide a neutral topic to elicit understanding. The postgraduate students undertake six monthly reviews where they present their work to an assessment review panel to monitor progress. The students had different levels of experience with the review panel process. Student 1 was preparing for their first review, student 2 was preparing for a repeat review following an unsuccessful review panel and student 3 had experience of both successful and unsuccessful review panels.

An initial discussion class was held to revisit the review panel process. A week later, an online workshop with a certified facilitator of online LEGO® Serious Play® was held to elicit and share mental models. The online workshop was recorded for later analysis. In stage 1, students were asked to build an individual model of a successful review panel (build level 1). The tutor also built their model of a successful review panel. This is in keeping with the principle of the LEGO® Serious Play® method, that everybody builds and everybody shares [21]. The students and tutor then shared their LEGO® models, narrating the story of their model. The models were visually analysed discussing the similarities and differences between the physical models (stage 2). LEGO® Serious Play® build level 2 was then followed to build a shared model of a successful review process (stage 3). In a physical workshop, this would involve participants working together to remove parts of their individual models from build level 1 to be included in the shared model built together. As this was an online workshop, the 'magic-hands' approach [22] was used, where the facilitator built the physical model, following instructions given by the participants to incorporate their components into the shared model, following the LEGO® Serious Play® Online Facilitation protocols. Each student took turns in explaining the shared model. It went through several iterations until a consensus was reached that the model was an appropriate representation of the collective view of the participants of a successful review panel. The workshop ended with a brief reflection of the process with participants. After the workshop, the recording was transcribed and coded to compare the mental models elicited (step 4.1). This enabled comparison to be made between direct analysis (step 2.1) and indirect analysis: statistical analysis (step 4.2) and content analysis (step 4.3).

3 RESULTS

Fig. 1 shows the individual LEGO® models from build level 1 during the workshop. Fig. 2 is the shared model from build level 2. Some of the models include the same concepts represented in different ways, such as student, which is explained as the story of the model was narrated during the LEGO® Serious Play® session.

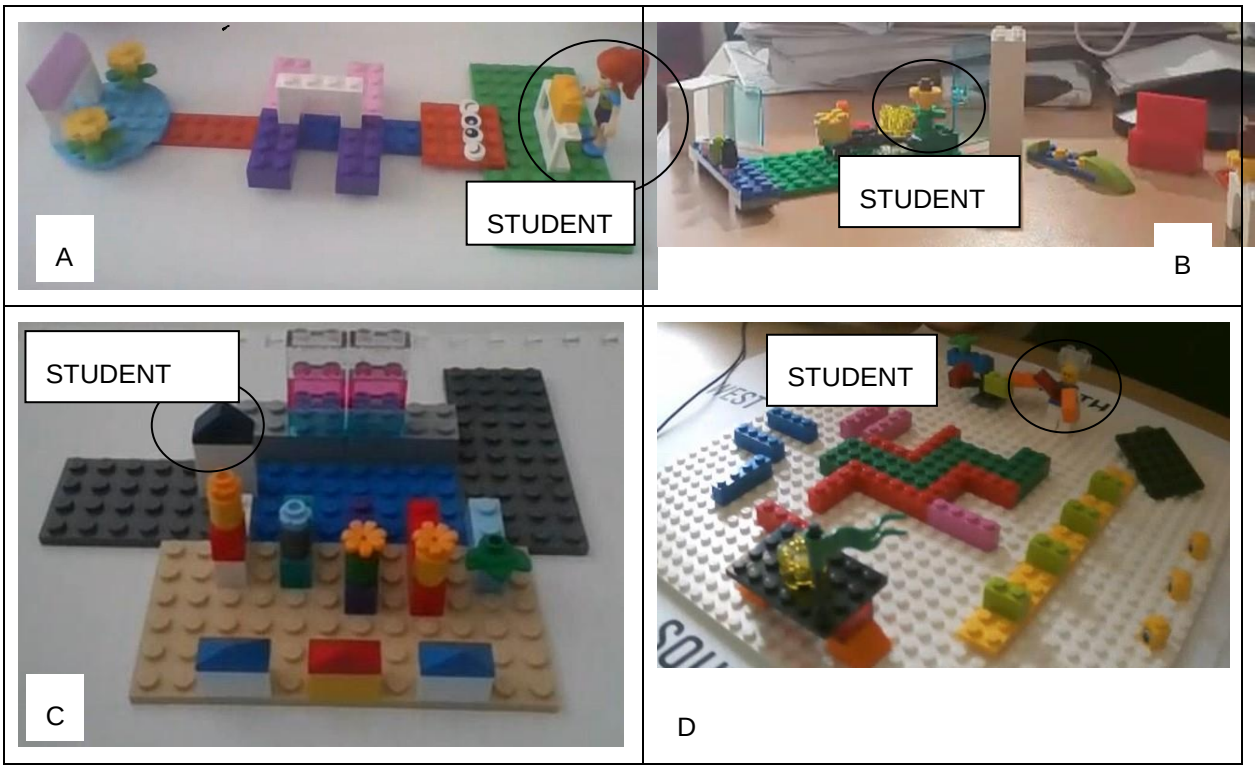

Figure 1. Individual Models of a Successful Review Panel (Build Level1).

Figure 2. Shared Model of a Successful Review Panel (Build Level 2).

From coding the narratives (stage 4.1), Table 2 presents the number of concepts identified within each mental model. Table 3 shows the number of concepts found in more than one model. Only two concepts were common between the tutor's model and all three students, and these were the actors in the situation (the student and the panel members). As the concepts were freely-defined, counting the number of concepts in each model had limited usefulness in determining mental model disconnects.

Table 2. Number of Concepts in Mental Models.

Mental Model	Model A (Student)	Model B (Student)	Model C (Student)	Model D (Tutor)	Shared Model
Number of Concepts	17	27	16	15	13

Table 3. Number of Occurrence of the Same Concepts Included in Individual Models.

Mental Model	Model A (Student)	Model B (Student)	Model C (Student)	Model D (Tutor)	Shared Model
Model A (Student)	17	3	3	6	10
Model B (Student)	3	27	3	4	10
Model C (Student)	3	3	16	4	8
Model D (Tutor)	6	4	4	15	7
Shared Model	10	10	8	7	13

Disconnects occur where individual mental models are unaligned [28]. Analysis of the disconnects within the models revealed:

- Gaps in student knowledge: Missing concepts that explained gaps in student knowledge affecting performance. For example, model B did not include the goal of the review panel. The student had previously had an unsuccessful review panel review and the lack of understanding of the goal of the panel may explain this.
- Misunderstanding between student and tutor: Additional concepts in the models revealed students were focusing on the wrong things. For example, model C focused on preparing for the panel review and the artefacts to bring to the panel review. This revealed that the student saw the panel as an opportunity to show the panel all the work they had done , rather than selecting the key information that the review panel was focusing on.
- Student concerns: Additional concepts included in models also revealed previously unexpressed anxieties. For example, model B included the door, entering the room of the assessment and being alone in an intimidating environment. This highlighted how the student's mental model of the assessment process was clouded by anxiety of the process and lacked clarity on the requirements for a successful review panel.

The results from step 3.3 found were that the shared model provided a "good visual depiction of every aspect" (Student 1), "combining all the thinking and the most important things from different people. It demonstrates a complete plan of how a panel should be" (Student 3).

The process helped students gain a deeper understanding of the review. For example, Student 2 commented that "The process has helped me a lot. I was looking into specific things regarding the panel…but this envisioned my view of how the panel is and how many things there I should consider… it helped me a lot, just to see there are other elements that I should look into.."

From the tutor perspective, "It was surprising to see how students had interpreted the panel, giving me an insight into how much they had understood so that I can help them" (Tutor). This supports the findings of [5] that insights into mental models improve understanding of behaviour.

4 CONCLUSIONS

The pilot study shows that LEGO® Serious Play® is a useful method for enabling students to construct, externalise and share their mental models.

Building and sharing the physical models enabled insights into the mental models to be gained for both students and the tutor. The process enabled the tutor to identify disconnects between the tutor's mental model and that of the students. Perhaps more importantly, the use of the LEGO® bricks and the focus on the model rather than the student, created a safe space in which to freely share ideas. The individual models gave the tutor greater access to the thoughts and feelings of the students, than they would have perhaps otherwise have shared. For example, whilst the focus was intended to be on the basic components of a successful review panel, students' feelings about the panel were expressed in the models.

The four individual LEGO® models represent four different views of the same situation, which are combined in the shared model. This can be compared with the work of [23] in which the soft systems method involves the exploration of individual worldviews that are combined through a process of consensus modelling. A separate project is being undertaken to analyse the models built using the LEGO® Serious Play® method using techniques from the soft systems method. This aims to explore the worldviews embedded in the LEGO® models and how they influence the formation of the individual and shared mental models.

Participatory modelling challenges beliefs and reconstructs knowledge [3]. This was visibly shown as the shared model was constructed. The shared model included bricks and elements from some individual models. In addition, new concepts were formed by the students during build level 2. New elements were constructed with bricks and included in the final agreed shared model of a successful review panel. The process of externalizing individual mental models, sharing individual mental models and constructing a shared mental model was a valuable learning experience for the students and the tutor. Disconnects in the mental models were able to be identified, in addition to providing greater insight into the thoughts and feelings of the students.

The statistical and content analysis of the models from the transcribed and coded narratives (stage 4) provided limited initial value. Visually the shared model had similar elements and structure to the individual models. However, the content analysis of the final shared model suggested that the shared mental model contained less concepts than most of the individual models. This may be due to larger richer concepts being noted in the shared model. Content analysis is limited by the subjective judgement of the analyst determining whether two similar words or phrases represent the same concept. This pilot study suggests that visual direct analysis of mental models using LEGO® Serious Play® is more useful that indirect content analysis or statistical analysis of mental models; however, it is noted this is a small sample and further work is needed to validate these findings on a larger scale.

In future work, it is proposed to ask participants to take part in extracting the component parts from the models more explicitly to identify the individual concepts and the relationships between them, prior to including them in the shared model. This deviates from the LEGO® Serious Play® method in how a shared model is constructed. However, in LEGO® Serious Play® a shared model is constructed to meet the need for all participants to share a common view of a problem, solution or vision. In this research, the process of building the shared model is part of the educational experience to explore concepts and their relationships. The students noted how their understanding of the subject evolved through the process of sharing their models in build level 1 and constructing the shared model in build level 2. Research is needed on how knowledge structures change during acquisition, retention and transfer [10].

This was a small pilot study that set out to explore how LEGO® Serious Play® may be used to help compare the mental model in the head of the tutor with the mental model constructed in the head of students. The study demonstrates that the method provides an effective means of encouraging students to share the mental model in their head and assists the tutor in identifying disconnects between the mental models. This provides a novel approach for the tutor to gain greater insights into the mental models of students.

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