Designing a Scaffolding Tool for Data and Process Modeling Courses in Computer Science

Nurul Zawiyah Mohamad*, Dayang Hanani Abang Ibrahim &
Jennifer Fiona Wilfred Busu

Faculty of Computer Science and Information Technology,
Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

Abstract— Data modeling and process modeling courses are compulsory in any computer science programmes. It is important for students to understand the underlying concepts of these courses and to translate the knowledge into a diagram or a model. However, there are so many cases whereby students' understanding were not up to par, they know the concepts, but somehow unable to translate their knowledge into technical designs. The lack of understanding in these courses will affect the more advanced courses with advanced data and process modeling. In this paper, we explain the technique on activating students' prior knowledge before diving into domain knowledge concepts to ensure better understanding without slowing the learning curve. We are using the data collected to propose a design for a scaffolding tool for data and process modeling courses in computer science programmes.

Keywords—data modeling, process modeling, prior knowledge activation, scaffolding

I. INTRODUCTION

DATA and process modeling courses are core subjects of computing thus play a very important role in computer related programmes. Although a lot of exercises have been discussed during classroom learning activities, there are still many students who are having difficulties in applying their conceptual understanding into technical design in data and process modeling. These issues stem from their lack of understanding about certain concepts or their lack of ability to map their understanding into the design model. This paper describes the method we applied in order to scaffold the students, by triggering their prior knowledge and how these prior knowledge will be used in continuation for the semester.

We started our study by having the goal in our mind that we were going to investigate the learning process that the students undergo in order to effectively understand the technical design of data and process modeling and to propose a scaffolding method to facilitate the students. All of data and process modeling courses have a learning outcome that ensures students are able to design models, depending on the courses, for example, data flow diagram (DFD) for System Analysis and Design course, and entity relationship diagram (ERD) for Database Design course.

II. RELATED WORK

Scaffolding in teaching is referring to instructional techniques that support and assist in learning process. Wood, Bruner and Ross (1976) defined scaffolding as "*the process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts*". Scaffolding has been fully developed for reading, writing, mathematics, social sciences and many more. Bakker, Smit and Wegerif (2015) claimed that scaffolding is useful as an integrative concept within mathematics education, and has introduced dialogic teaching to complement scaffolding.

The metaphor of scaffolding always relate to a temporary construction that is used to support a building. Once the building is completed, the scaffolding can be removed. Therefore the support is needed in learning too, to facilitate the students by giving hints and questions that encourage thinking and reasoning, relate and connect it to their lives. Hence, this leads them to the connections of knowledge.

Students' responses are followed up in ways that encourage deeper thinking. Students feel more stimulated when course instructors relate to the students' personal reflection and evaluation (Cahyaningrum, Wahyuni, and Sulistyawati, 2016) to increase quality of students' learning. This is believed can stimulate student interest in the topic for further exploration. Once the students are able to connect what they are learning with prior knowledge, students become involved in the learning, and later they will be able to grasp the knowledge that leads to their own learning.

This is when the support from instructors can be disengaged. Guthrie, Wigfield, and Perencevich (2004) believe that the activation of background knowledge about the topic of a text can motivate the students to increase desire to gain additional knowledge in reading. In addition, Lam et.al (2016) has done investigation whether providing more degrees of freedom in prior knowledge activation might be better for learning. In the findings, they claimed that generating analogies before formal instruction enacts different learning mechanisms. When students are able to make connections to their prior knowledge, their level of understanding for the content knowledge increased. The students will try to make sense of the real examples that are given to them by seeing and understanding how it fits with what they already know. When the course instructors help students make these connections, the learning takes place easily.

III. PROBLEM IDENTIFICATION

Upon discussions and constantly getting feedback from the students, we came to a conclusion that the root of the problem was that they could not relate the examples used in lecture notes and textbooks in order to depict a certain problem and solution. Having this hypothesis, we collect the input from the students who have taken these subjects, asking them for the same feedback and the responses matched highly with our intended audience.

Of course, there is nothing wrong with the examples from the textbooks; they depict examples with great details – yet the textbook covers topics on *business processes* which most of the students did not have any prior knowledge, unless they have a family business in which they are involved in the daily transactions.

Fig. 1 shows a sample of data structure which consists of *customer order, method of payment, credit card type* among other attributes. Lecturers will have no problem in explaining these kinds of examples to the students, but according to the students' feedback we have collected, 76% of the students were unsure of their understanding and stated that they might understand it during lecture time, but they were not able to complete the exercises by themselves later.

IV. METHODOLOGY: TAKING A STEP BACK

The scenario explained in the problem identification section opens the possibility of a scaffolding technique to build or trigger prior knowledge that will support and strengthen the students' conceptual understanding. We are keeping in mind an important question: "*What kind of teaching makes learning happen?"* Any examples used to explain a concept can be real life examples, but the main point is *how relatable these examples are according to the learners?*

Fig. 1 An example of Data Structure for Adding a Customer Order at World's Trend Catalog Division in System Analysis and Design course (Kendall and Kendall, 2014)

We took a step back and decided to let the students suggest types of examples to be used in lectures. For System and Analysis course during the intervention semester, we have 409 first year students enrolled. These students have various educational backgrounds, thus not all technical terms and concepts are familiar to them. We collected another set of responses from our students, to get an overview of their routine, their interest and hobbies. These responses were categorized as familiar topics – the topics that they can relate the most and we divided the familiar topics into sub categories of Quotidian (daily routines) and Non Business Activities (which consist of hobbies, interests, other processes they encounter during their studies). Using these responses we did interventions during lecture hours, and we also collect random experiments data from those who have taken the subjects.

TABLE I
EXAMPLES FROM STUDENTS' RESPONSES: QUOTIDIAN ACTIVITIES

No	Quotidian activities
1	Select what to wear
2	Go to class
3	Answering phone
4	Chat in Whatsapp/WeChat/Telegram
5	Check Facebook (and other social media)
6	Tweet friends

Using the students' own input to become examples to trigger their prior knowledge in lectures created the atmosphere that they are responsible for their own learning. While anticipating for their response to be chosen as the example in class, they remained focused and even voiced out answers without the lecturers calling out their names. The learning environment encouraged the students to ask more questions during class, which is overall considered as a very positive environment as mentioned by Guthrie et. Al (2004), as they are starting to understand the concepts of the topic taught in class and they are ready to tap into textbook examples and solve their own tutorial questions.

TABLE II
EXAMPLES FROM STUDENTS' RESPONSES: NON BUSINESS ACTIVITIES

No	Non Business Activities *Interest/hobbies/other processes*
1	Register courses
2	Bake cupcakes / cakes
3	Play basketball
4	Play e-games [DoTA, CSGo – multiplayer games]

From our observation, the students continued to be more interactive with their peers during tutorials and in discussion during class times.

In learning the data flow diagram (DFD), there are some rules and notation that the DFD designers must adhere (Valacich and George, 2017) for example, a process must be in *verb*, data flows must be in *nouns*, and a process must contain *at least one input and one output.* Before our intervention, students keep forgetting these simple rules – such as writing verbs on data flows and using nouns in a process notation.

By using the examples coming from their own inputs, as shown in TABLE I and TABLE II, automatically they were writing activities as verbs – which will be reflected as processes in DFDs, and from these activities we are able to brainstorm the possible inputs and outputs in class. A significant improvement in understanding are shown when we intervene using this technique and it reflects in their assignments and tests as there were less errors on basic DFD rulings.

V. CASE STUDY: EXAMPLES FROM THE CLASSROOM

From the students' responses, one of the highest responses on *Non business activities / Hobbies* subcategory includes 'baking cake / cupcakes'. Although not all students are familiar with baking, the students who are could activate their prior knowledge and then transfer their understanding to their peers in class. During the lectures, we usually cover 2-3 small examples before looking into the tutorial questions. The flow of our classroom practice is shown in Fig. 2.

In System Analysis and Design, there are basic rules and notations on designing Data Flow Diagram (one of the main learning unit for the course). Fig. 3 shows the example taken from the textbook used as the main reference for the course. A beginner in designing data flow diagram will not be able to imagine how a system should behave during execution. Fig. 4 shows an example by using '*bake a chocolate cupcake'* as a process, which is considered a more straightforward example, according to students.

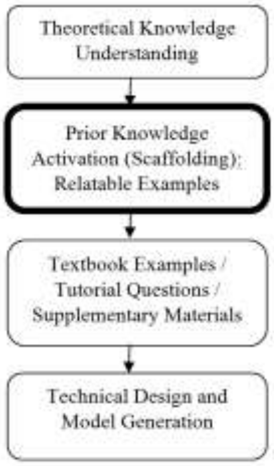

Fig. 2 Suggested Flow in teaching data and process modeling courses

Students who have experience in baking can identify right away the inputs and outputs of this process, and the data used in this example will also reflect the basic rules of designing a data flow diagram, for example to only use nouns in naming the data flow, to use verbs in naming the process, to have at least one input and one output for a process and so forth.

Fig. 3 Data Flow Diagram notations and examples (Kendall and Kendall, 2014)

From the students' input we collected and considering how relatable these inputs are, we will design and develop a scaffolding tool comprising the real example elements to activate students' prior knowledge as discussed earlier. The tool will act as an intelligent tutor for the students to learn and grasp the concepts of data and process modeling subjects and to obtain their learning goal in these subjects. The tool can be used to scaffold from the basic understanding up to complex design of data and/or process modeling diagram. Recent researches have confirmed the benefits of scaffolding students' learning through digital games (Kinnebrew et. al., 2017). Malliarakis et. al.,(2017) have also experimented using educational digital games for other important aspects in learning computer science, which is programming.

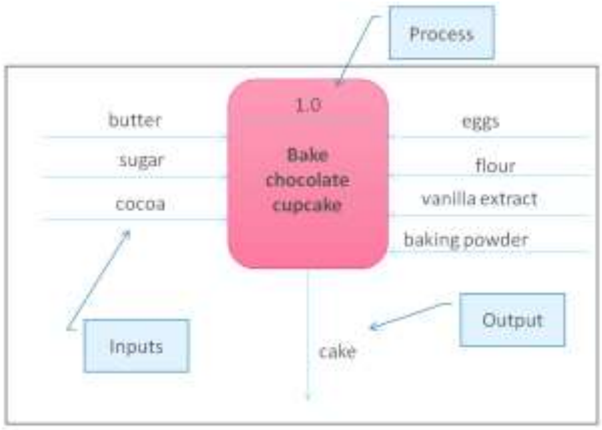

Fig. 4 A more straightforward example using a familiar task as the process

In Fig. 5(a) we proposed a design to develop a scaffolding tool for system analysis and design core model – the data flow diagram (DFD) where the constructs are randomly available in the left side of the interface. The work area in the middle will consist of instruction for the students on what process they need to complete by dragging the available constructs.

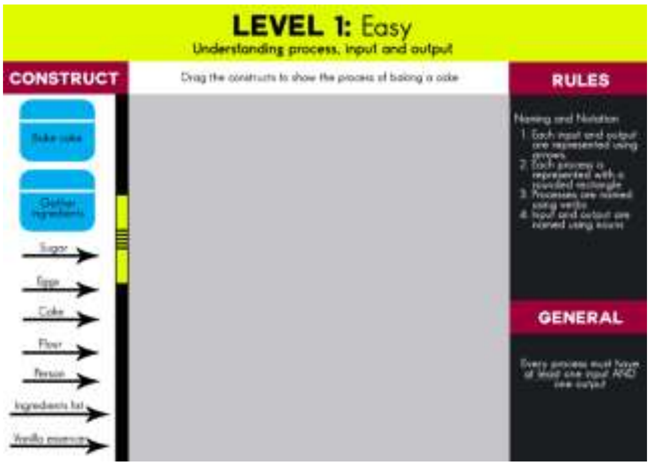

Fig. 5(a) Design of a proposed scaffolding tool for data and process modeling

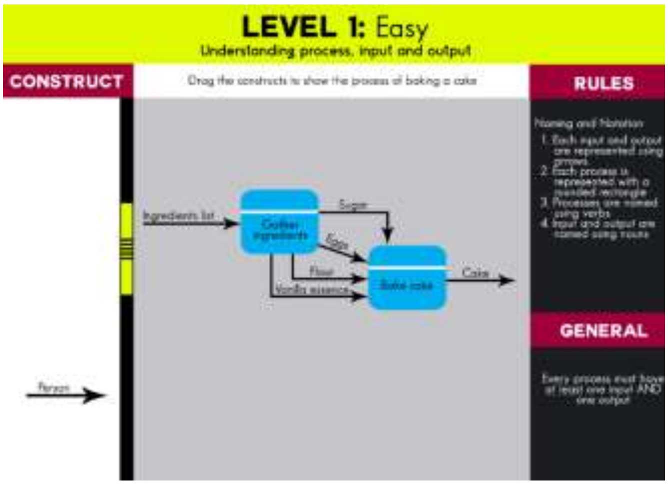

Fig. 5(b) Design of a proposed scaffolding tool for data and process modeling

We are also designing helpful hints which will be available as options only when the students seem to take a lot of time in a session (per level). The scaffolding tool provides random constructs as well, in order to test students understanding in building the instructed data flow diagram. Fig. 5(b) shows how the work area will look like when the students are completing the data flow diagram for 'baking a cake'. Only relevant constructs will be dragged to the work area for submission, while other constructs which are not relevant will be left in the constructs panel.

VI. CONCLUSION

As educators of data and process modeling courses, we agreed that it is important to activate students' prior knowledge with relatable examples as the content knowledge about data and processes are the core of our daily lives. Being able to relate theory with examples has time and time again proved to result in engagement during learning and better understanding among the students.

For the next step, we are completing the design and development of the scaffolding tool for data and process modeling. We hope in the near future we are able to include learning analytics in our tool to implement adaptive scaffolding for different types of learners for this course.

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