A WEB-BASED LEARNING SYSTEM FOR RECONCEPTUALIZATION: BASIC ELECTRIC CIRCUITS

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ABSTRACT

This paper describes a learning system using an approach to induce hierarchical cognition for reconceptualization in Basic Electric Circuits. The concept-building model, which ascribes interactive multimedia to cognitive processes, is built upon the knowledge framework as a basis to design learners' interaction at the interface. Cognitive processes are systematically activated over increasing levels of cognition and matched with learner activities of increasing complexity. The four-phase learning approach, namely, (i)cognitive conflict, (ii)testing presented new knowledge, (iii)discriminating new and old knowledge, and, (iv) declaring and articulating new concepts, is included in the cognition hierarchy of the concept-building model. Sensory activities of reading and observing an interface which are predominantly text, graphics and animations, of electrical phenomena stimulates conceptual recall as preparation for subsequent metacognitive activities involving increasing physical interactions at the interface. High learner-controlled activities include encompass reading text guide, dragging and dropping graphical objects to specified coordinates, observing effects of construction, and entering input of voltage measurements. Interactive discussions of question and answer options buttons with explanatory feedback prompts help learners to mentally discriminate and clarify their new knowledge. As a final measure for cognitive consolidation, learners write opinions to contend true or false assertions of the different aspects of electrical concepts.

1. INTRODUCTION

Recent progress in the use of interactive multimedia in education prompts the need for learning strategies to be integrated into the development of learning software for meaningful learning. Many educators working with interactive multimedia have emphasized the importance of cognitive processes to be considered in the development of a learning system [1, 11]. Other researchers in multimedia learning [4, 10] have shown that an interactive learning environment can generate effective instruction and learning.

This paper describes a learning system based on a learning approach adopted from the concept-building model [5] which is built on a knowledge framework in building an interactive multimedia learning system on the world wide web. The learning approach specially addresses a set of globally common misunderstandings [2,3, 6,7,8,9] found also to be prevalent amongst students of Electrical Engineering Diploma course in a Malaysian university.

2. BUILDING CONCEPTS

In the design of the interactive multimedia learning system, the multimedia components are selectively categorized into three conglomerated sets to evoke hierarchical cognition, namely, the low, medium and high cognitive levels, for scientific concept-building. The concept-building model, which ascribes interactive multimedia to cognitive

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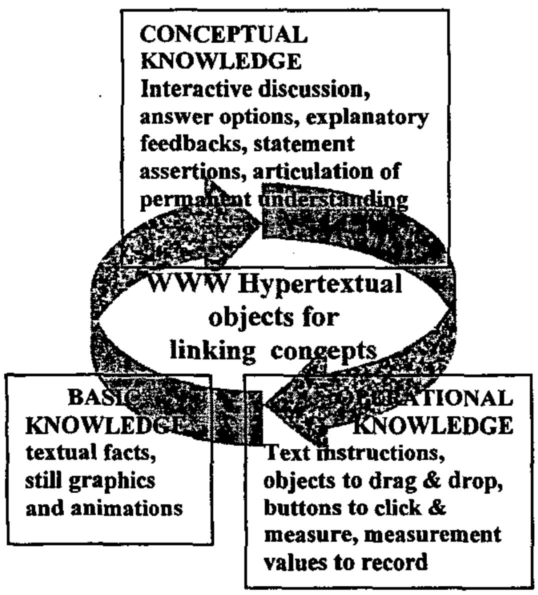
processes, is built upon the knowledge framework as a basis to design learners' interaction at the interface.

The knowledge realms invented in this research conceptually structurize the arbitrary gen of the world wide web akin to a 'learning space'. The coexisting 'basic', 'operational' and 'conceptual' knowledge realms in the 'www learning space' are assigned different learning interaction elements to support cognitive and meta-cognitive learning. The learner interactions in the knowledge realms of the www learning space are shown in figure 1.

Figure 1. Knowledge Framework for Learners' Interactions in www Learning Space



According to the concept-building model designed in this research, the students' activity shifts from simple to complex tasks, in tandem with the movement from low, medium to high cognition in building the true concepts. The content is sequenced to provoke and systematically direct the students to correct their misunderstandings about electric voltage and current. As a means to achieve reconceptualization, a learning approach, derived from the concept-building model, is adopted in this research. The learning approach (i)cognitive conflict, (ii)testing presented new knowledge, (iii)discriminating new and old knowledge, and, (iv) declaring and articulating new concepts, is adapted from the cognition hierarchy of the concept-building model. This learning approach is merged with the knowledge realms through learner interactions at the system interface as shown in figure 2.

Figure 2. Integrating the Learning Approach into Knowledge Realms through Learner Interactions

Knowledge	Interface Interaction Points	Learning Interactions	Learning Approach
Basic	Text to explain theory; Animated Graphics: Applying and removing voltage supply showing charge movements; Question buttons for learning-sequenced navigation; Graphical animations to introduce electric circuit;	reading information, looking at static diagrams or animations, observing effects on animated experiment, reacting to feedback, re-observing animations, referring to previous information, or advancing to next set of information.	**Low Cognition** Knowledge Recall Awareness of learning Predict and explain
Operational	interactive experiment: click to vary electric voltage with current to verify Ohm's Law; Animation demo of simple circuit connection; Instructions as guide for activity; Electric	refer to selected, or, specific previous information; observe demo for simulation; Enter text about prediction of bulb brightness; advance to experimental area; read	**Medium Cognition** Testing presented knowledge Cognitive conflict

	components in central area for circuit connection; Student input column for recording measurements;	instructions and figure out the activity;	
Conceptual	Objects provided for connection of open, closed, complete & incomplete circuits; Lighted and unlighted bulbs & meter readings for correctness; Button to discussion to discriminate ideas; Discussion form with asserting questions for discussions; Answer options buttons with explanatory feedback; Return button to review; continue button to declare & articulate conclusions; Conclusion form with assertion statements; Answer boxes to type opinions.	Drag and drop battery, bulb, ammeter and wires into experiment area to connect simple, series and parallel circuit; Record voltmeter readings; Click on answer options in discussion about activities; Return to re-do activities on voltmeter measurements; Enter text about own deductions from circuit activities.	**High Cognition** Discriminating new and old knowledge Declaring and articulating permanent understanding.

3.LEARNING INTERACTIONS

In this learning system, the learners construct several scenarios to analyze. They conduct on-screen drag and drop motion of objects into and out of a central area to construct the simple, series and parallel electric circuits of the closed and open configurations. A scenario, when correctly constructed, is acknowledged by a lit bulb or bulbs in the circuit, or the appearance of a reading at the current-measuring device, the ammeter.

Measuring voltage across several points in the different circuit configurations allow the learners to attest their predictions of voltage. The learners drag the voltage–measuring device, the voltmeter, and drop it at a position so the voltmeter wires precisely click at the points to be measured and the voltmeter reading appears. This voltage-measuring activity is repeatedly conducted across different points in the open and closed configurations. As a means to provoke cognitive conflict, a finite voltage reading appears across an open point even when a zero current reading is shown. The learners type in all the voltage readings to affirm old predicted knowledge of voltage magnitudes across points, as well as new conflicting knowledge of voltage magnitudes confronted at the open points; putting all in perspective for further review.

Interactive discussions take place when the learners click on answer options as their contentions for every question asserted. Feedback prompts pop up to appraise the learners' choice of answers. The conceptual focus of the assertions include, the constancy of the terminal voltage in all the circuit configurations, electric voltage being the primary concept, the dependency of electric current on the circuit elements, and, the perceptive analogy of current flow.

As a final measure to consolidate all the learners' transpired concepts as their permanent cognitive structures, learners are persuaded to articulate their old and new found concepts from the activities they conducted on-screen. To dispute, or, to concur the respective false and true assertions that may be deduced from the metacognitive and physical interface interactions, the learners type down their opinions, as their contentions, in text boxes provided for every assertion. These assertions are basically suggested reiterative conclusions about the hierarchy of electrical concepts, the function of the battery in an electric circuit and the influence of the resistive elements upon current. The learners' written deductions are their conceptual understanding of the electrical phenomena.

4. STUDY ON MALAYSIAN SUBJECTS

As part of the evaluation process of this prototype, experimental study on the learning was conducted to continually review the design of the learning interface. An investigation on 32 Malaysian university students was conducted to study their concepts from the web-based learning. The students' typed-in answers from the web-based tasks showed their understanding and hence also indicated any re-conceptualization which took place.

A multimedia designer and an instructional designer reviewed the prototype at three points in the development stage. The comments on the consecutive review checklists were concerns about insufficient navigation points, small font size, and poor colour contrast. These inadequacies were accounted by introducing more navigation points, increasing the font size, and changing the font and background colours for a better contrast. These corrective efforts improved the 'friendliness' and the visual clarity of the system as a whole. A positive review was given regarding the general layout of the interface, which showed activity instructions as the learners' guide, user input area for learners' to type in readings and check their observations, and a central experimental area to conduct simulations. The learning strategy of informing learning objectives, conducting simulation activities, reviewing by discussion and articulation conclusions also received positive reviews.

In investigating subjects' concepts, their answers submitted into the web folder of the system were sorted, grouped and coded according to descriptions of concepts which were compared to five correct scientific concepts about electric voltage and current. The following results were obtained:

1. There was an increase from 81.25% to 100% of subjects who understood that an electric circuit must be complete for current conduction, but not necessarily for voltage.
2. There was an increase from 43.75% to 81.25% of subjects who understood that the battery is an electric voltage generator; not current.

3. There was no change from 75% of subjects who understood that the terminal voltage is the battery voltage.
4. There was a small increase from 62.5% to 75% of subjects who understood that a change in the effective resistance will change circuit current.
5.There was an increase from 68.75% to 93.75% of subjects who understood that electric current is conserved and not consumed at any resistance within the circuit.

Based on the findings above, the web-based learning system is viewed to support some re-conceptualization among the Malaysian university students.

5. Implications to University Learning

Based on these facts, there appears a good rationale for implementing learning through the world wide web as a supplementary arm to extending knowledge to the Malaysian students. Knowledge which are usually formally verbalized and demonstrated to the students can be be made available over the World Wide Web as an alternative to address any schedule constraints in the formal instructional settings in a Malaysian university. The availability of the internet to be accessed at all hours can support conceptual learning in various aspects of the cognitive learning domain, namely, reviewing and reflecting knowledge, since it provides an environment where the learners can take charge of their learning at their own pace. Specific knowledge posted on the world wide web will enable students to return and review their learning materials out of their fully-occupied university schedules.

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