An Inquiry Approach In Learning Science
With Engaging Web-Based Multimedia Interactive Resources

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Abstract:
Recently, there are some science educators (who are more comfortable with the new media and the internet) starting to employ many of the freely available Web-Based Multimedia Interactive Resources to help students learn science. Web-Based Multimedia Interactive Resources (WMIRs) like interactive learning objects (LOs), videos and animations have taken the internet world by storm and have become more pervasive in recent years. But it is still not a popular means of learning science in many countries due to various reasons like accessibility and low comfort level of teachers. The youths are particularly enamored with these Web-Based Multimedia Interactive Resources because they are engaging. The easy access to these Web-Based Multimedia Interactive Resources has attracted educators to examine its affordances for learning science with an inquiry approach. Some learner-centered and engaging Web-Based Multimedia Interactive Resources like Interactive Resources (IRs) and Digital Resources (DRs) which are designed and developed by Ministry of
Education of Singapore (MOE) are being used by many schools in Singapore for educational purposes. Also there are plenty of videos (from web portals like YouTube) which can be used for learning science. This presentation describes an inquiry-based approach in the teaching-learning of science with engaging Web-Based Multimedia Interactive Resources. The five essential features of science inquiry (question, evidence, explanation, connections and communication) based on the new 2008 MOE primary science syllabus will be highlighted in this web-based multimedia inquiry approach. This paper also discusses some learning outcomes, and gives suggestions for future implementations.

Introduction:

Web-based multimedia learning objects (LOs) or resources for teaching and learning purposes are here to stay whether educators like it or not. For those who do not already know, a learning object is usually a digital, self-contained and re-usable unit of multimedia for learning (consisting usually of elements like simulation, animation, graphics, video, sound or text) for the user/learner to listen, view, interact or receive feedback. When a few learning objects are used (in combination underpinned by pedagogically sound instructional design) to form learning activities or tutorials; they offer a potentially powerful learning opportunity and enhance the learning process. In order to facilitate learners of the current digital Net Generation (Oblinger & Oblinger, 2006) with a suitable learning environment that promotes self-study and improves learning outcomes, it is essential that a learning environment not only has sound pedagogical basis but also incorporates appropriate technology affordances that facilitate learning. In other
words, learning objects must participate in a principled partnership with instructional design theory if they are to succeed in facilitating learning (Wiley, 2000). What would be an appropriate underpinning instructional design theory or learning approach that is in tandem with these Web-Based Multimedia Interactive Resources (WMIRs) to facilitate learning? The authors are positing adopting an inquiry approach as the pedagogical framework to anchor learning with Web-Based Multimedia Interactive Resources as supporting LOs. In essence, this use of LOs could potentially promote and support inquiry-based learning (Orrill, 2000). Hence, it will be natural for science educators to leverage on the great learning potential of such web-based multimedia learning objects. However, the challenge faced by many science teachers is either lack of awareness of the existence of such LOs or not knowing how to go about using these web-based LOs (many are free for use in the internet) or the low comfort level in using these WMIRs even if they (the teachers) knew where to access them.

This paper adds to the wealth of knowledge by giving an account on a proposed implementation of how this innovative use of Web-Based Multimedia Interactive Resources can support inquiry-based learning. This paper will also strive to discuss some learning possibilities or suggestions for others who are considering exploiting this technology.

**Pedagogical Framework:**

One of the most effective and exciting models of science instruction for teaching-learning and assessment purposes is the BSCS 5E Learning Cycle (Bybee, 2002). Widely acclaimed as one of the most powerful inquiry-based instructional strategies underpinned by the theory of constructivism, the 5E Learning Cycle (Engagement, Exploration, Explanation, Elaboration or Extension, and Evaluation) has all the 5 essential features of science inquiry (Question, Evidence, Explanation, Connection and Communication) embedded in it. It can also be used
flexibly as a lesson planner containing an excellent mix of both teacher-centered instruction and student-centered instruction. This framework is used as the pedagogical underpinning for this proposed implementation.

**Figure 1: 5E Learning Cycle**

![5E Learning Cycle Diagram]

In the Engagement (1st E) phase, traditionally the teacher sets the stage for learning by introducing the topic of the lesson and fires the students’ innate sense of curiosity and imagination by means of attention-grabbing demonstrations, discrepant events, scientifically-oriented questions, ideas or natural phenomena, interesting problems to solve, relevant current events or local issues to discuss etc. Based on the students’ responses to these triggers, the teacher (in the original 5-E learning cycle) is able to assess the students’ incoming prior knowledge and note their naive conceptions or misconceptions of science. But for this inquiry-based learning approach supported by Web-Based Multimedia Interactive Resources which is coined as WMIR-Inquiry-based learning model, the learner engages with the Web-Based Multimedia Interactive Resource.

Under the Exploration (2nd E) phase, engaged learning through hands-on activities (or similar activities) occurs with the students’ use of the inquiry cycle of generating question(s),
formulating hypothesis, designing and carrying out a plan, collecting evidence/data to draw conclusions and communicating their results. In this stage, the teacher (in the original 5-E learning cycle) serves as a leader and facilitator of the inquiry process and as an assessor to determine how the students are progressing in their knowledge construction or concept development. However, in this WMIR-Inquiry-based learning model, the learner explores and learns the concepts through interacting with the Web-Based Multimedia Interactive Resource.

In the teacher-facilitated Explanation (3rd E) phase of the original 5-E learning cycle, the students will be guided to check their explanations against the scientific explanations offered by the teacher or reliable sources of knowledge. Besides promoting a common language for the whole class to articulate their thinking and describing their results in scientific terms, the use of scientific explanations seek to address the naïve conceptions and remediate the misconceptions detected in the engagement and exploration phases. On the other hand, the WMIR-Inquiry-based learning model, the student receives explanations from the Web-Based Multimedia Interactive Resource as he/she interacts with the Web-Based Multimedia Interactive Resource and then check his or her understanding against that offered by the Web-Based Multimedia Interactive Resource.

At the Elaboration/Extension (4th E) phase, the teacher (in the original 5-E learning cycle) helps the students to reinforce their scientific concepts either by providing opportunities for students to apply and transfer their understanding to new contexts or showing them how these concepts are applied in real-world situations. In this way, besides mastering science content and process skills, students’ appreciation of science as relevant to their lives will help them grow towards greater scientific literacy to become scientifically literate citizens in the world and for the world. Using the WMIR-Inquiry-based learning model, the student is helped by the Web-
WMIR-Inquiry-based learning model

Based Multimedia Interactive Resource to apply his knowledge through a process of testing his/her concepts through different simulated scenarios.

Finally, in the Evaluation (5th E) phase, the teacher (in the original 5-E learning cycle) brings the lesson to a meaningful closure by summarizing the big ideas in point form/concept map, administering a formal assessment (e.g. test or presentation) or an informal assessment (e.g. journal or portfolio) to ascertain the level of achievement of the learning outcomes. Having said this, for effective teaching and meaningful learning to take place, continuous evaluation in the form of observation and participation in class (other modes of informal assessment) are strongly advocated and encouraged even in the first four stages of engagement, exploration, explanation & elaboration/extension. In the WMIR-Inquiry-based learning model, the Web-Based Multimedia Interactive Resource provides embedded interactive exercise/testing with feedback acting as evaluation/assessment to enhance learning.

The in-built feature that allows for non-linear quick jump to any part of the WMIR anytime when the learner (becoming a “veteran”) chooses to deviate from the usual prescribed sequencing of stages of learning (of the 5E learning cycle) also facilitates iterative or repeated (revisiting) learning. This affordance of iterations for learning is key in enhancing the 5E learning cycle into an adapted 5-E learning cycle with supporting Web-Based Multimedia Interactive Resource known as WMIR-Inquiry-based learning model shown in Figure 2 (with the double arrow lines to indicate the iterative learning affordance of the WMIR).
This adapted learning model is also capitalizing on the “scaffolding” potential that was indirectly proposed by Vygotsky (1978)—the zone of proximal development (ZPD) of a learner can be extended to achieve new learning or task, not possible in the past, unless guided by someone (or something) more knowledgeable or more capable than the learner. The underpinning learning approach of the WMIR is that it should provide learners with the opportunities to receive and process information (in small chunks); to be guided (through just-in-time scaffolding); to practise (in solving problems) and to be assessed (through questions with appropriate and helpful feedback). This learning model is adopted from the phases of instruction mentioned by Alessi & Trollip (2001) in the hope of that the learner is able to select and transform information, construct hypotheses, and make decisions (Bruner, 1973) in order for the learner to go beyond just information-reception to knowledge building and possibly learning through inquiry-based approach.

Another major strength of the WMIR is the embedded interactivity with appropriate feedback which affords scaffolding (to guide the learner to facilitate his/her process of learning).
Essentially, the interactivity allows the learner to explore, manipulate, postulate, test out ideas, construct his/her own mental models and reflect in a safe but viable visually rich learning environment. Also, interactivity embedded in the multimedia environment, is able to potentially engage learners in meaningful activities (Alessi & Trollip, 2001). The other major strength of the WMIR is the affordances of multiple representations through visualization (such as models, graphs, equations, diagrams, pictures, animations and simulations exhibited in verbal, mathematical, visual and actional-operational modes) to make difficult scientific concepts more intelligible to students by increasing the likelihood of progressing towards more sophisticated conceptual learning (Treagust, 2008). Ainsworth (1999) reinforced this further by positing that “a common justification for using more than one representation is that it is more likely to capture a learner’s interest and, in so doing, play an important role in promoting conditions for effective learning.” Treagust (2008) put forward the evidences to support the suggestion that “different representations have shown to help learners understand the target concept in terms of the underlying features of the concept at a deeper level and help make connections between concepts that were otherwise not easily comprehended.” Hence, multiple representations, visualization and embedded interactivity serve to provide learners with the learning opportunities to extrapolate and construct knowledge to achieve positive learning outcomes.

**Description and Features of Web-based Interactive Resources (WMIRs):**

According to the underpinning learning approach of the WMIR mentioned earlier, the resulting design of the features of the WMIR coincidentally have similar elements to the interactive mathematics learning environment according to Holm (2007) who pointed out the following key features that are desirable in a learning environment that promote self-study through providing enriching learning experience coupled with improved learning outcomes:
WMIR-Inquiry-based learning model

- It must have a clear pedagogical concept as its backbone
- It must recommend a learning sequence that guides the learner through the content
- It must provide a variety of learning objects suitable to various learning styles
- It must provide a rich palette of interactive features in order to actively engage the learner
- It must have built-in mechanisms that provide instant and valuable feedback
- It must provide ample opportunities to the learners to learn, to explore, to practice, to reflect, and to self-check

An overview of a WMIR (based on an example downloaded from MOE eduMall website which can only be accessed by MOE teachers with login passwords through this website: http://www.edumall.sg) is shown:

Table 1: Recommended Sequences for Web-based Interactive Resource Learning Environment

<table>
<thead>
<tr>
<th>Stages of Learning</th>
<th>WMIR Learning Activities (e.g. WMIR on Levers)</th>
<th>Screen Dumps (Figures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage</td>
<td>Show an interactive animation of applying effort to the lever to lift a load</td>
<td>Figure 3</td>
</tr>
<tr>
<td>Explore</td>
<td>Explore the balancing of the lever through investigative simulation and providing immediate feedback to “scaffold” learning</td>
<td>Figure 4 and 5</td>
</tr>
<tr>
<td>Explain (with scaffolding)</td>
<td>Ask learners to try an activity that tests their hypothesis</td>
<td>Figure 6 and Figure 7</td>
</tr>
<tr>
<td>Extend</td>
<td>Linking learned knowledge to real-life examples of levers (simple machines)</td>
<td>Figure 8</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Provide interactive exercise/testing with just-in-time immediate feedback on learner’s response</td>
<td>Figure 9 and 10</td>
</tr>
<tr>
<td>Enhance (iterative or repeated reinforced learning)</td>
<td>Provide opportunities for repeating the learning, closing the learning gap (as a form of reinforcement of learning) and for generalizing learning.</td>
<td>Any figure</td>
</tr>
</tbody>
</table>
Figure 3: Introduction Page

Figure 4: Investigation Page

Figure 5: Feedback to help to scaffold (simulated scenario)

Figure 6: Exercise page to test hypothesis

Figure 7: Feedback on exercise

Figure 8: Real-life examples (application)

Figure 9: Evaluation (Feedback to correct)

Figure 10: Evaluation (Feedback to affirm)
Learning Outcomes:

A survey was conducted after the implementation of this WMIR (Levers) in 1 class of mostly 11 year-olds (35 students) within the context of an hour Science lesson in a computer lab. The data gathered suggested that the WMIR was engaging or fun to learn with. In fact, most of the students (about 90%) wanted to learn Science with this WMIR in the near future. Also about 83% of the students were happy with what they have learnt from the WMIR. Interestingly, 89% of the students commented that the WMIR aided them in learning the particular Science topic. This could be the result of the combination of good instructional design coupled (aligned with the 5E learning cycle) with good interactivity (with appropriate immediate feedback) embedded within the WMIR. In terms of ease of learning with this WMIR, 71 % of the students affirmatively agree. Figure 11 shows a screen dump of the results of the survey.

Figure 11: Survey Results
Conclusions:

One sticking learning issue that stood out which suggests that learning science concepts was still not easy was shown by the survey. This was evidenced by the fact that only 71% agreed that learning process was made easy with WMIR even though 89% of the respondents agreed that the WMIR has helped them in learning outcome. The survey seems to suggest there are some limitations of the learning potential of WMIR (used in an inquiry approach) even though WMIR had aided learning outcome. It could also mean that the process of learning Science entails some form of difficulty—there is no easy short cut even though the WMIR has enhanced the learning outcome.

Because of these nagging unanswered questions of a possible learning gap (however small) due to learning science (in an inquiry approach) with WMIR, this prompted the authors to want to further uncover more insights. Perhaps, a more effective way of learning science can come from a form that combines interacting with WMIR coupled with the teacher consolidating learning at an appropriate end (as a form of clarification and summary) or the students (while interacting with the WMIR) could be engaging in peer collaborative learning (knowledge building). Hence these questions could spin off potential future research projects.

Suggestions for Future Implementations:

With the successful implementations, there could be possibly be future projects which can exploit the affordances of web-based multimedia interactive resources for learning by investigating whether (and evaluate how) WMIRs that have been designed for self-study may be integrated into learning environments that are more supportive of social interactions (teacher-students or peer-to-peer) and dialogic teaching (e.g. Mercer et al., 2009) and thereby possibly further enhancing or improving the learning of science concepts.
References:


