Removing learner misconceptions and improving institutional teaching practices in one go.

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Abstract

Based on the Dochy model for the integration of learning, instruction and assessment (Dochy et. al, 1996), this paper proposes the use of that model (with a minor extension added) as the basis for the development of a software framework, for which tools designed to enhance learning might conform. The use of the extended model is inspired (by leaders in the field of educational research) having identified real dangers inherent in current education practices where frightening misconceptions arise in the learning of students who after assessment are graded in the high-achiever class. The extended model proposes to provide a dual benefit to educational institutions, namely, a student feedback methodology as well as an institutional education review tool which aims at capturing misconceptions and eliminating teaching practices which may support them.

Keywords

Institutional review, integration, instruction, assessment, feedback, software enhanced learning.

1. This stick is alive!

If fifty students take a course in first-aid, and after the course an instructor assesses their abilities and finds that forty of the fifty students – when taking a patients pulse – mistakenly use their thumb to press down on a patients radial-artery instead of their forefingers – an instructor is likely to realise:

a) Providing 'results' to some of these learners to inform them that they are, say, 80% 'qualified' might not result in a change in pulse-taking behaviour.
b) Providing feedback, while it might inform the learner of a 'misconception', may not result in a change in pulse-taking behaviour either; at least not one which has been validated.

This is the subject of this paper.

All students attend courses. All students sign-up to learn something. They all undergo assessment (of some form or another). All instructors assess and use a method to let the learner know how able they are. Most of the time this is where it ends. As David Perkins of Harvard put's it:
"*...learners often receive grades such as Xs or OKs, As, Bs or Cs with not enough indication of what is wrong or what could be done about it to guide effective revisions of conceptions or products*" (Perkins and Unger, 1999; p. 106).

The instructors assesses, the students get their 'result' and the next time the course runs – feedback from the first running of the course can inform the second running of the course to try to improve on past experience. This paper asks the following research question: are we missing out on an opportunity?

If forty of the fifty students, when assessed, mistakenly use their thumb to take a patients pulse and say twenty of these forty are virtually perfect in all other skills and receive an 80% 'grade' which identifies them as 'very good students': which one of these twenty would we choose to be first on the scene to an accident involving one of our loved-ones?

Is there a point of instruction that we are missing out on? The authors argue that there is. We argue that a 'misconception-mapping' can be created. On analysing the outcomes of instruction, an instructor can identify 'common misconceptions' – we argue that the forty students can be targeted for a special lesson to show that the thumb of a human can have it's own pulse, and that using ones thumb can result in stating "yes we have a pulse" instead of "defibrillator, now, quickly". We argue that special scenarios can be designed to show to students that, for example, a wooden stick can be examined to have a perceived pulse (i.e. "this stick is alive"), and we argue this in light of the work of highly-respected authors of cognitive and educational psychology (Hannifin, 1999; Perkins, 1999; Gardner, 1999).

2. The Trigger: Parallels from Highly Respected Authors in the Field of Cognitive (and Educational) Psychology

Howard Gardner, in his paper 'Multiple Approaches to Understanding' (Gardner, 1999) gives a startling account of the dangers of misconceptions arising in student learning:

"*Thanks to hundreds of studies carried out in the past few decades by cognitively oriented psychologists and educators, we now know one truth about understanding. Most of the students in most of our schools – indeed, many of the best students in the best schools – are not able to exhibit appreciable understandings*".

In a separate work, Perkins and Unger (1999; p. 95) state:
"*Unfortunately, a rich history of research during the past three decades has demonstrated over and over again that students often know far more than they understand about subjects that they have studied. Most students suffer from a number of misunderstandings about science concepts that persist in the face of conventional instruction, even instruction at the university level*".

And pivotal to this proposal – Hannifin, Land and Oliver (1999; p. 132) when prescribing their suggested methods of best practice for open learning environments (OLEs) state:
"*Known and widespread science misconceptions, for example, provide a powerful foundation for predicting likely conceptual difficulties and embedding support accordingly*".
These authors describe the embedded support as 'conceptual scaffolding' and recommended utilising this to guide learners "*regarding what to consider*". Further, these authors suggest that "*hints can guide the learner to available resources*" or that "*tool manipulations might be suggested where understanding is typically problematic*" and continue to show existing software systems which do just this.

More recently, Lia and Chen (2010) have produced a web-based software system called the "Dr. System" that attempts to identify individualized guidance using multi-media technology to help eliminate learner misconceptions.

3. Has this been done before?

In validating the novelty of this proposal the authors queried two research databases: a) the Educational Resources Information Centre (ERIC) and b) the British Education Index (BEI). The term 'misconception' was searched in each database with the top twenty results from each database being considered.

The work of Lai and Chen (2010), made the closest match where the authors use a web-based software system to diagnose 'individual remedial learning' needs for elementary school students learning electro-magnetics. Supportive to our work, their study shows learner performances being "*significantly better"* than students taking "*traditional remedial class"*. Their results align to the hopes of our proposal where they state that their study "*helps us understand learners' misconceptions"* as well as providing *"materials, which are necessary… to eliminate… individual misconceptions in the remedial learning process*."

Jessica Masters (Masters, 2010) studies the possibility of automatically catching misconceptions in the learning of geometry. Interestingly, and supportive to our proposal, her work showed validity in the possibility of automatically identifying misconceptions.

In a medical context, Dory et al., (2010) assess the certainty of student answers in an attempt to find what they call 'hazardous ignorance' from 'usable knowledge'. Their results find low but significant levels of hazardous ignorance co-existing with low levels of useful knowledge based on a multiple-choice questionnaire assessment.

Of the research found, we find that our proposal provides the following contributions:

a) The proposal for development of a framework - for which domain-specific tools might conform – appears to be unique
b) The 'dual' aspect of learner-guidance/institutional review appears to be unique (where Lia and Chen (2010) focus mostly on the former).
c) Application to the domain of Higher Education appears to be unique.

4. Removing Learner-Misconceptions - An Overview

Figure 1 visualizes how the framework proposed in this paper was conceived. Reference has already been made to several respected authors who highlighted the dangers of misconceptions. More current research provides support for the validity in catching misconceptions and attempting to remediate them (Lia and Chen, 2010; Masters, 2010, Dory et al., 2010).

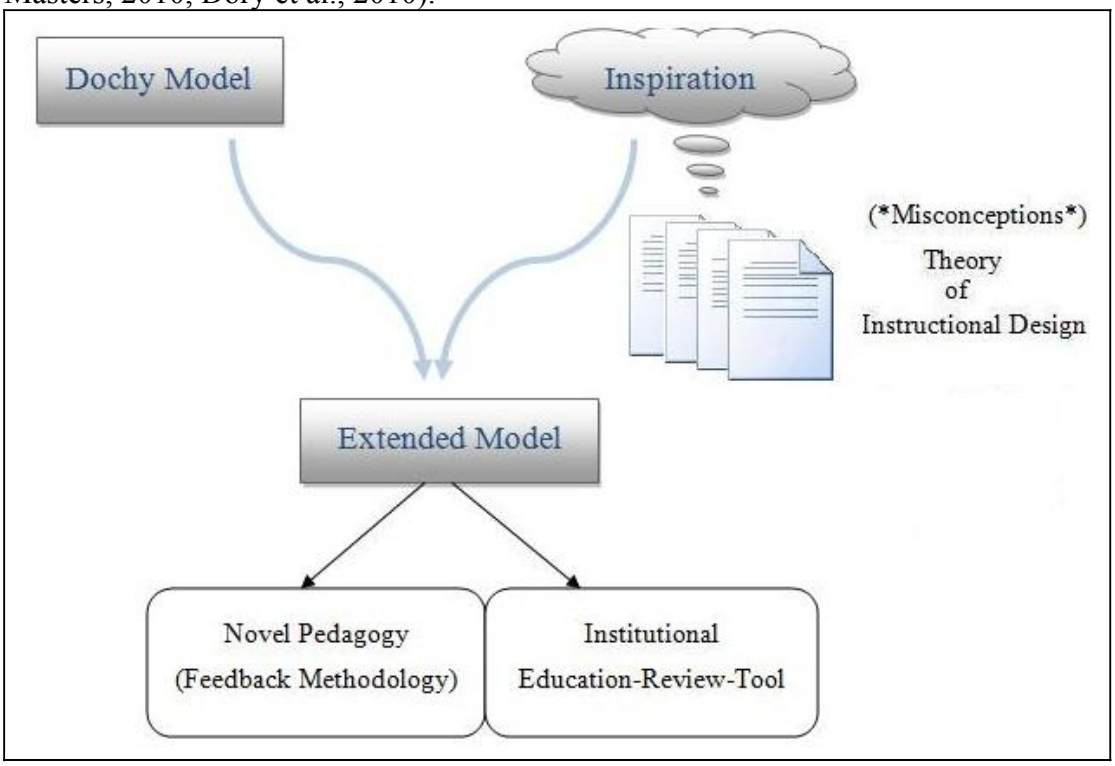

Figure 1: Overview diagram – shows the inspiration and inception of the extended model idea, and what it hopes to provide.

As the figure shows, the 'Dochy Model' (Dochy, 1992; Dochy et al., 1996) is identified as being readily adaptable for the development of a dual-purpose learner feedback and institutional review system.

The work of Dochy is cited in the awarding standards and assessment document of an Irish national governing body for higher education (HETAC, 2009), and when considered in the context of the future vision of the over-arching body for control of Irish higher education (HEA, 2010; pp. 7 - 9) it can be seen to be highly suited and readily adaptable for what is envisaged as 'open and flexible learning'.

5. The Dochy Model Extension

Figure 2 and Figure 3 show the proposed extension to the Dochy model (Dochy et al., 1996) as it was first conceived (Cleary et al., 2010). The original Dochy model describes a pedagogy centred on three principles labelled A, B, and C (see Figure 2). 'A' proposes that the learner would have input from the range of acceptable qualification goals[1] to develop a list of personal achievement goals. 'B' proposes that the prior knowledge of a learner be assessed pre-instruction to ascertain what aspects of a course (if any) may be skipped owing to an already satisfactory understanding being demonstrated; as such, the 'prior knowledge state' then determines the instructional activities. 'C' proposes that learning activities are followed by "progress tests" which determine readiness for subsequent learning activities and feedback from these progress tests guide the learner. What is described is effectively a self-regulated formative feedback system or pedagogy

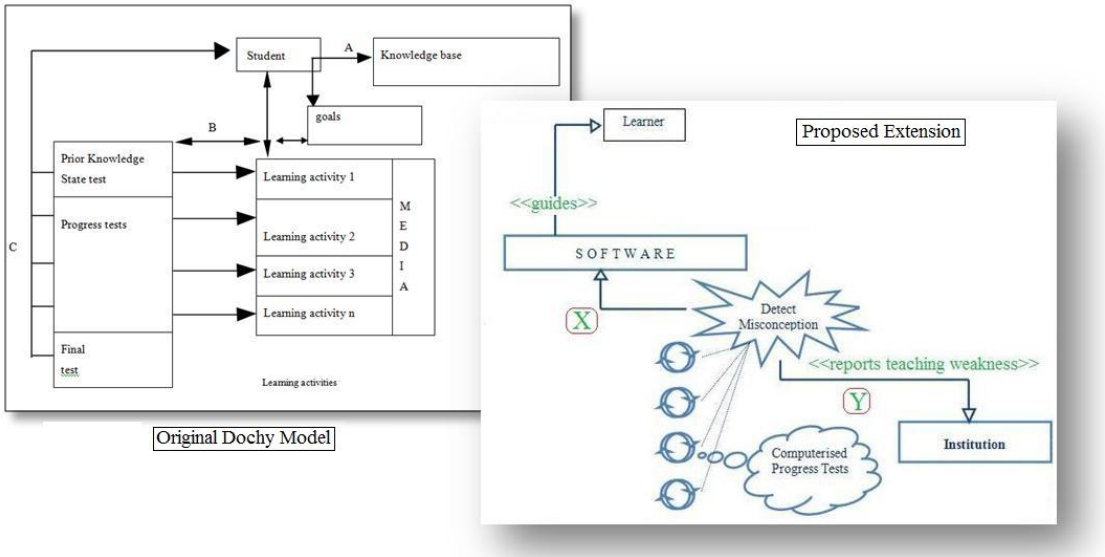

Figure 2: Shows proposed extension of the original 'Dochy model' (Dochy et al., 1996) where – path marked 'X' identifies use of 'caught' misconception as novel feedback methodology, and path marked 'Y' represents real-time institutional feedback.

The proposed extension (on the right side of Figure 2) gives a visual of the proposal in this paper. Essentially the proposal is to computerise the progress testing such that automatic detection of misconceptions can occur. These 'caught' or detected misconceptions are used internally in the computer system to generate an institutional report showing (for example), high frequencies of misconceptions occurring for a given Intended Learning Outcome (ILO). This information occurs in real-time providing the opportunity for the institution to *react* mid-semester (mid-course etc.) allowing for remedy of misconceptions that have been identified; similarly, a teaching improvement *need* can be flagged for this ILO.

As highlighted by Lia and Chen (2010) in the development of their domain-specific web-based tool, it is hoped that the advantage of software would outperform manual methods in terms of learner benefit. Also, current educational review typically only provides that this year's weaknesses can be addressed in the subsequent year; it is

[1]'Goals' here equate to Intended Learning Outcomes (or ILOs) in the context of European education (ECTS, 2009).

hoped that, with a software approach, this semester's weaknesses can be addressed this semester, with instant benefit to the learners.

Figure 3 (below) shows the complete extension proposed, as integrated with the original Dochy model. Annotations (in guillemots; i.e. '<<' symbols) are added to help facilitate understanding of the proposal. The model also factors for the future vision for open and flexible learning as envisaged in the Higher Education Authority (HEA) of Ireland's position paper (HEA, 2009); as this vision is highly integrated with the Bologna Process (Bologna, 2010) which governs higher education design in Europe it is intended that the proposed extension would be suitable in a European, as well as a national context. Similarly the extension can be seen to align with one of the Bologna Process ideals to put the learner at the centre of the Higher Education experience (ECTS, 2009).

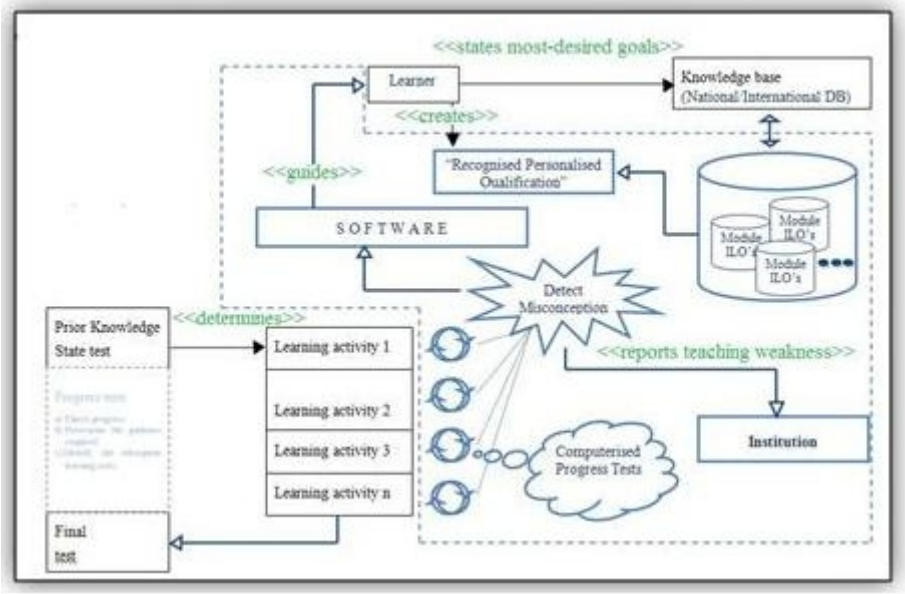

Figure 3: Complete extension of the 'Dochy model' (Dochy et al., 1996) which incorporates the Higher Education Authority (HEA) of Ireland's future vision for open and flexible learning in the potential for building 'recognised personalised qualifications' (HEA, 2009). The original Dochy model (seen in Figure 2 above required little alteration and readily lends itself to HEA ideal.

This paper proposes that there is a need to develop a software framework for which domain-specific tools (i.e. such as Lia and Chen (2010)) for handling learner misconceptions might conform. It is proposed that this would be a large undertaking and would be best developed collaboratively with inter institution/developer input, and would probably be best realised as an open-source software project. To date, the authors have refrained from starting a project as the responses to this paper may be critical in how to approach this. As such it is left open[2]. We do however suggest two requirements of such a framework:

a) an interface would be required to detail logging and reporting of newly found misconceptions,
b) an interface would be required to detail the getting of suggested guidance for the learner

[2] The authors can see no reason why competing frameworks can not be developed in parallel with a view to unification after some time.

6. Misconceptions, Misconception-Mapping and Frontal Tackling scenarios

While many authors provide examples of misconceptions in lieu of defining the term misconception – we provide the following simple (if course) definition:

A misconception is a wrong understanding of how something works or of an idea.

It should be added that our definition of the term 'misconception' should also allow for the development of a scenario or experiment which as Gardner (1999; p.76) puts it - provides for 'frontal tackling' of the obstacle to understanding; an activity which disproves the misconception and facilitates movement toward the correct concept.

Related to this, we find that Schank's pedagogy (Schank et al., 1999) of 'goal-based scenarios' seem to align naturally to the suggestions of Hannifin et al. (1999) in terms of their suggestions for developing software for open learning environments. As such, merging the two – we develop the term '**frontal tackling scenario**' to describe a learner-activity which has been designed with a will to remove an identified misconception.

We refer the interested reader to Gardner (1999) and Perkins and Unger (1999) for references to scientific research identifying the learner misconception problem for learners evaluated as high achievers. Also, Gardner devotes two chapters of his book "The Unschooled Mind" to examine previous research which identifies misconceptions occurring in multiple domains (physics, evolution, mathematics, social studies and humanities) which he identifies as internationally relevant (Gardner, 1993).

Misconception-Mapping

This paper, at the outset, introduced the term 'misconception-mapping' which was somewhat ill-explained. By this term, we intend that common misconceptions can be identified, per subject area – where all known misconceptions can be "mapped" or documented. It is hoped that each misconception can be further aligned to frontal tackling scenarios to try to remove the said misconceptions.

7. Area for Pilot Study - Sports Injury Assessment (HOPS)

As outlined in Cleary et al. (2010), the domain of sports injury assessment has been chosen as an area to conduct a pilot study to test the validity of the misconception 'catcher' concept. In this non-trivial domain-specific area – where we hope to develop a set of frontal tackling scenarios to remove misconceptions and use this domain-specific area as an example in which the proposed software framework can be realized. Learners being taught to assess sporting injuries are generally taught a procedure for carrying out a patient examination. The acronym HOPS (Prentice et al., 2008) can be used to describe the process:

- **(H) History**: The patient's history is first taken.
- **(O) Observation**: The patient's complaint is observed.
- **(P) Palpation** A physical examination is conducted.
- **(S)Specific Test**: After reducing the problem space, specific testing begins.

The authors have identified that learners frequently exhibit misconceptions in performing injury-assessment post-instruction or post-assessment or both. Owing to the serious consequences of misconceptions to injury assessment, the HOPS model is seen as an ideal test for this study.

We are currently developing a misconception 'catcher' for learners of sports injury assessment. This involves capturing the common misconceptions observed in learners post-instruction or post-assessment or both. To do this we rely on the observations of dedicated teaching staff to suggest the types and kind of misconception they have observed in learners performances after receiving instruction. We aim to build progress-tests to assess whether any identified misconceptions exist, and to develop assessment methods which decipher what misconception occurred and what guidance needs to be provided to cure that misconception. To be added to the group of contributors on this project please e-mail hopsguys@googlegroups.com.

8. Conclusions and Future Work

Although there are a wide range of future directions possible from our current point of research we have outlined the following two directions as most important:

1) Work on developing 'frontal tackling scenarios' for the removal of misconceptions – we propose to use the area of sports injury assessment as our test bed for this.
2) Further specification and development (hopefully through collaboration) of the proposed software framework such that our domain-specific area (sports injury assessment) can be used as a test for realisation of the framework.

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