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Citation for published version (APA):

Verpoorten, D. (2011). *Implications of the adoption of a concept-based approach to instructional design*.

Document status and date:

Published: 04/01/2011

Document Version:

Peer reviewed version

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
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Implications of the adoption of a concept-based approach to instructional design

Abstract. This article reports an attempt to import a traditional distance course in a tool conceived to support a concept mapping procedure intended to facilitate, in a second phase, the implementation of adaptive rules and personal learning paths. This article does not ascertain the value of this approach per se (for those interested, see some reflection on this topic in Appendix 1). It just aims at sketching the time needed for such a work and to document encountered difficulties. The article resolutely takes the viewpoint of an average instructor.

The course

It is called “Seks en de evolutie”. It is an OpenER course in Dutch. (Description “out-of-the-shelf” in Robert Schuwer’s report which might be enriched with John’s article). The course consists in 7 chapters composed of threshold content and of extra content (defined as elaborations and not as superfluous material). The course is illustrated with very finely selected static pictures. The course is intelligently crafted and represented X hours of work. It means that the added value of concept mapping and adaptivity must be quite high to compete with the initial version. The course has 105 pages. The course ends up with a MCQ test of 16 questions tapping both into threshold and extra content. The times given below include ONLY the reading – the instructional designer is NOT the content expert though he probably grew up to this status through the whole experimental process - and the mapping in Mindmeister. It does not include the extraction of concepts and the mapping of the test questions (which took in itself 1H10: making the test, getting the right answer, relating each question to a portion of content as offered by the mindmeister map). This whole process took 4 hours and often entailed back and forth moves from the Mindmeister map to the course.

	Number of pages	Time for the loosely Mindmeister concept mapping
Welkom	4	5’
Evolutie	18	1H50
Op het eerste gezicht	15	1H28
Bij nader inzien	15	1H40
Seksuele selectie	14	1H31
Pronken	13	1H43
Gezin	20	1H46
Tot slot	4	5’48’’

See Appendix 2 for a reflection about pedagogical return on invested time.

The Mindmeister map as a preliminary step

The observed teacher had received a training in the grapple tool and based on this experience he thought that a more flexible tool was needed to get a visual full picture of the course and its concepts. Mindmeister provided a visual of the course which reflects the actual structure of the course (it will not be the case with the mindmapping in the Grapple tool). It means that the Mindmeister map is a kind of visual and enriched table of content. Visual cues (colours) highlight threshold pages, extra content, important pages and test questions. This stage was judged as necessary by the observed teacher:

- to enhance its detailed mastery/ownership of the content domain (if the mindmeister map is a kind of visual table of content, it also encapsulates a summary of each content page);
- to have a maximum flexibility before becoming more powerful but also more rigid in the Grapple tool.
- to already get an idea of the relationships, of the repetitions, of the transversal or local concepts.

It must also be said that this approach was totally new (and awkward) to the observed instructor. Mindmeister, as a familiar, flexible and highly visual tool) allowed to get the grips on this approach and to steadily refine it.

The Grapple tool

Moving from the Mindmeister Map to the Grapple tool took 3H16. It lead the instructional designer to the following observations (some of which already perceptible at the Mindmeister stage).

- The practitioner firstly wonders what is the difference between the bottom up relationship (Belong to) and the top-down relationship “is composed by”. Should both always be indicated? Eventually, the practitioner decides to choose just one each time.
- At first sight, the offered relationships seem very limited to the practitioner (the drop-down menu offers only three options). It is only after some time that he noticed the possibility to label a relationship. The practitioner noticed also that the difficulty to specify the relationship sometimes comes from the content itself: the link can be established but needs explanations to rightly specify the connection. “The relationship forces to establish a rough link where I would expect nuance from the student”. The practitioner gets sometimes stuck with regard to accurate qualifications (“I cannot relate in a short way and fight the proper wording for the relationship of “polyginie” and “polyandrie” to “monogamie”).
- The practitioner regrets that once the concept is labelled, no change is possible anymore. An example: “signalen van reproductieve waarde” (plural) could not be modified to “signal van reproductieve waarde” (singular) which would be more logical when the relationship “is a” (singular) is established with instances of such signals. Indeed, the concept can be erased and reworked but when it is already connected to many other concepts, it turns to be a real hassle.
- Interestingly, the first move of the practitioner was to give a definition for each concept. It stopped because
 - o this is a huge work;
 - o because some terms that ought to be visible in the concept maps are not genuine concepts (“jongeren jongens”). Actually, we observed a dilemma between the choice of putting in the concept domain loosy terms which are not concepts on their own right or to “leave them to content”. “Jongeren jongens” for instance, was seen as an “intelligent confirmation” of the importance of the “reproductieve waarde”. Can such relationship be used? Eventually, the practitioner kept it in the domain map with a vague link “is a”;
 - o because more fundamentally he understood that the Grapple concept map is not intended to mirror content or to be a “visual glossary”, which was obviously its first belief and attempt. After the adoption of another logic, he eventually found the “description” field confusing and suggested to get rid of it! However, the practitioner also believed that the natural tendency is to have

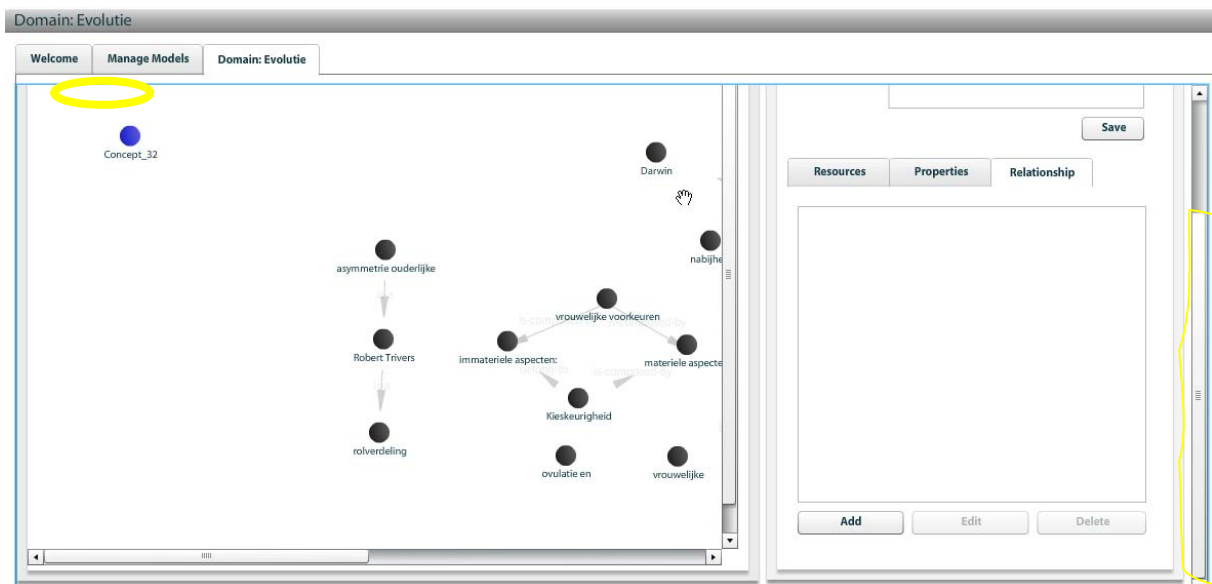
an “all in one” interface, that is displaying or giving access both to concepts and contents.

- The practitioner found the exercise interesting but thinks that he many times had to be compliant to the interface and not the contrary.
- The practitioner was first tempted to take the title of the course chapters as concepts but realized that it would not work and that it was not the intention underpinning the tool. It was one major change of mind. But this switch of logics brought uncomfortable uncertainties. What was initially separated for the sake of the learning rhythm and cognitive load had now to be linked. Interestingly, the practitioner fought against his feeling of being lost or of destructing something well-thought and homogeneous by using the “description” box to indicate the previous place of some concept in the initial structure of the course (“I link these two concepts but I know that the first one was first covered in chapter 2”).
- The practitioner bumped into difficulties with largely transversal or overarching concepts like “het verspreiden van genen” or “ultimaat en proximaat uitleg”. This type of concepts “which could be connected to almost everything” was usually left without any relationship in the concept domain. In a paradox, the most connected concepts are those which are left isolated! They connect to nothing because they could connect to everything. Nothing connect to them because it would not make sense (“the explanation to justify the link would call for too many elements”).
- The practitioner complained about “simplifications” to designate his tendency to eliminate any notion which cannot easily be summarized in one word (“prehistorie en pil”, “recent fenomeen van geboorte beperking...”. On the whole, the concern remains for the practitioner to be sure that the whole content is covered by the concept map.
- Several times, the practitioner was confronted to problems related to synonyms: “is it better to label this notion as “leeftijdsgat” or as “reproductieve curve”?”
- The nuances/explanations needed to specify a relationship made the practitioner ask for a possibility to link groups of concepts. For him, it made more sense to link such global entities than each of their components (for instance “nabijheid” supercedes “mannelijke voorkeuren” and “vrouwelijke voorkeuren” and it is not possible to visually represent this precedence with the two concepts altogether). Interestingly, he sometimes located related concepts close to appropriate “clusters of concepts”, using the proximity as a visual cue for a relationship, which is not intended by the tool. Example: link from “vrouwelijke voorkeuren, materiale/immateriale aspecten/kieskeurigheid” to “ovulatie”.
- The practitioner liked the transparent background when defining a relationship “because it allows to see which relationship is already worked out”. He liked also the endless space available for the concept domain.
- The drop-down menu of the available concepts is weird to use and it closes suddenly.
- The practitioner experienced problems with the interface (see screen captures).
- The practitioner considers that having an “alphabetical option” for concepts would be handy, especially with a growing number of concepts and considering the uneasy navigation in the drop-down menu.
- The practitioner says that there is no way to indicate concepts of a similar grain, level or importance or intensity (for instance “ouderlijke investering” and “seksuele selectie” which are key notions in the course). Again the practitioner tries to use the “topography” of the concept domain to create such equivalences (“I put them on the same line”).

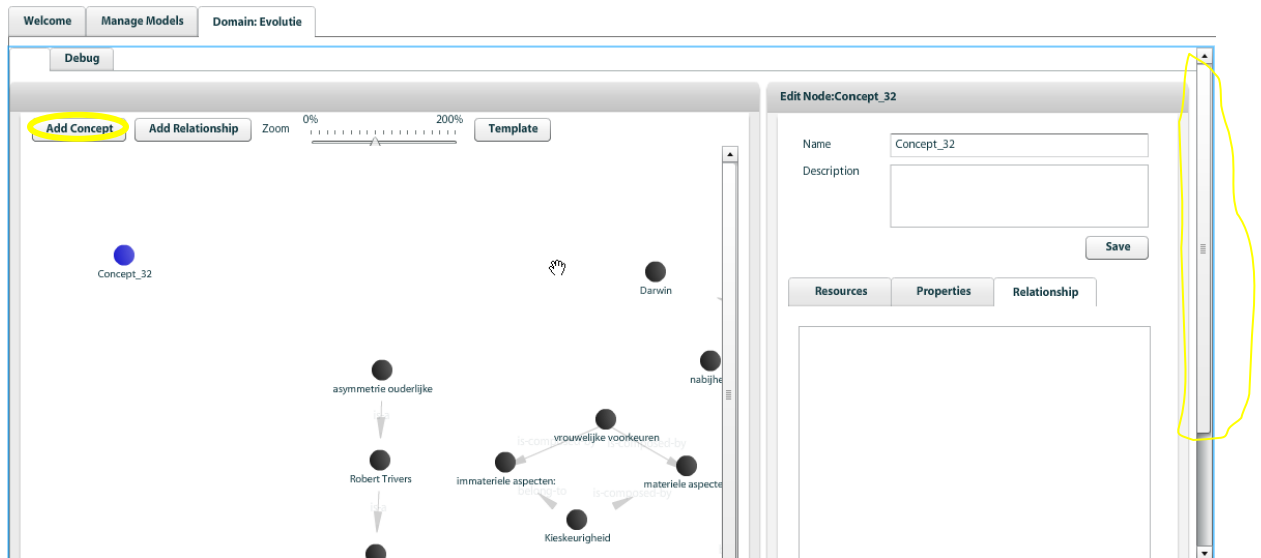
- The practitioner has problems with “Darwin” which is strongly related to two concepts. “But it is not the same Darwin”, he says. He hesitates to modify Darwin into two concepts referring to two different books but eventually drops the idea.
- The practitioner is a bit confused because the relationships (in the authoring interface) do not disappear instantaneously when a concept is deleted. He gets into trouble also when he re-opens his concept domain and do not see any link (“oh no, everything is lost”). But the systems seems to concentrate all the links in one point at the opening. Slightly moving this point expands all concepts again.
- The practitioner never used the button “add relationship” which is seen as an equivalent of the tab “relationship” in the authoring interface.
- When asked about the level of quality he thinks he achieved with the concept domain; the practitioner answered: “I am not fully satisfied but I stop now because I am a bit bored, because I am happy with this trial but not fully convinced by the approach (so, why invest more?), I do not even have clear cues about what I could do to raise the quality (more concepts? More relationships? More details in the qualification of the relationship?), because I think that “flaws” in my concept domain need the next step (the link to content) to emerge. For these reasons, I feel that this is enough at this stage”.
- As some sort of conclusion, the practitioner states that: “This concept domain that I created for my students is actually what I would prefer that my students create by themselves”. The practitioner also casts doubts on the benefits that can be brought by adaptive rules in a course which is very strong at helping students to steadily build relationships between its different parts. But this is an empirical question for the learning pilot!

Interface problems

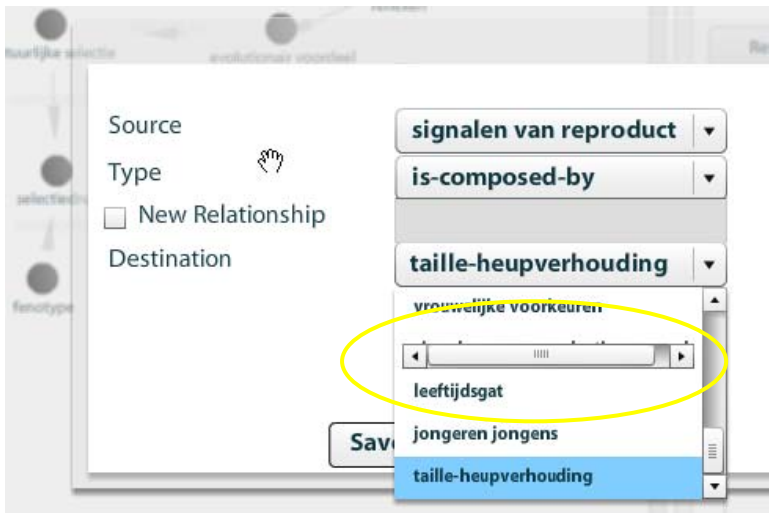
Practitioner: “the add concept button vanished”. Follows a sequence of action intended to get the button back.



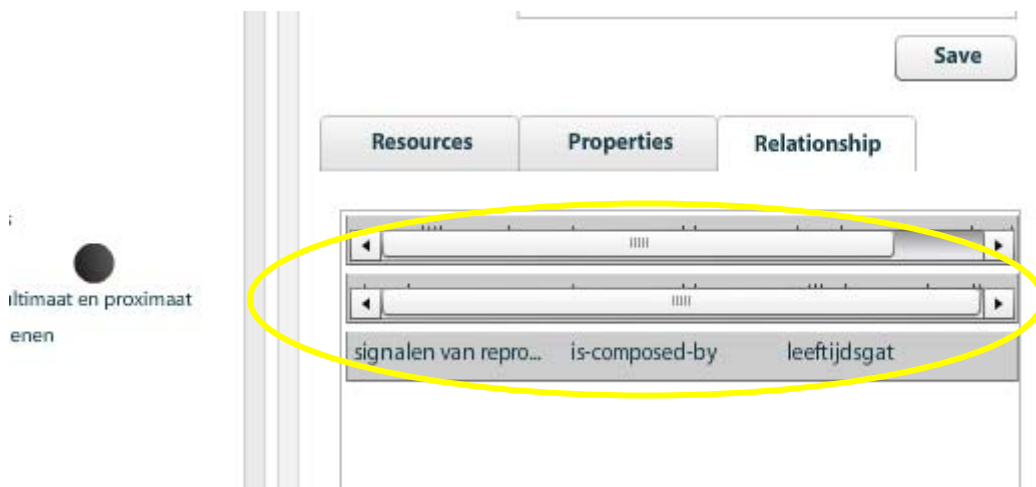
The problem comes from an interference between the navigation shaft of the authoring interface and the shaft provided for the concept domain.



Strange things I



Strange things II



APPENDIX 1 - The behaviourist tropism of adaptive systems

"Every piece of Education Software, Authoring Tool or Learning Management Services (LMS) implements a certain kind of learning theory. Every function of the software has underlying (tacit) pedagogical assumptions" (P. Baumgartner & Payr, 1999). Adaptive systems are no exception. Both in iClass and in ELEKTRA, the adaptive systems lay on domains knowledge representations, obtained thanks to Knowledge Space Theory (Doignon & Falmagne, 1999), KST, which strives to support the learner by scaffolding a domain of information towards level of knowledge and subsequent learning needs. This cognitive toolbox, namely a skills-based cognitive engineering, presents a solid and theoretical basis on which pedagogues must generate adaptive processes that are centred on mastery of competences. It involves a hierarchy of concepts (Razek, Frasson, & Kaltenbach, 2003) and, thus, the system will present ordered activities to the learner, making sure that he will always be clearly positioned in the knowledge space that has been defined in the User Model. This complex, mathematical and probabilistic way of positioning the learner into a knowledge space and, then, presenting adequate learning activities can be characterized as follows:

- KST is based on a teaching paradigm;
- KST has difficulty with ill-structured concept domains wherein knowledge and skills are fuzzier;
- KST is concerned about the adaptive capacities of the system while (constructivist) pedagogues will be more about developing pupil's ones (Gipps, 1994, p. 25; Smith, Ford, & Kozlowski, 1997, p. 90);
- When establishing rules and algorithms that supply the "Rules" component of the system, KST refers to behaviourist theories where learning is seen as a mechanic, adding associations to existing ones;
- KST requests yes/no answers regarding skills mastery where there are several proficiency levels;
- Once a test has been successfully passed over, there is no need anymore to come back to the activities having supported the acquisition. This is pedagogically disputable. Improvement is still possible when a test is successfully passed (need for overlearning, or risk of forgetting or of structural regression).

At first sight, KST is wonderful because it tells what to teach and in what order. It is partly true but another problem of this elegant version of programmed instruction is that it ignores totally the variety of methods of learning. It can talk about the "what" and, potentially, the "in what order" but it says nothing about the "how", or more exactly, the "how" is restricted to a standard problem resolution. According to the 8 Learning Events Model (Leclercq & Poumay, 2005), it means that only one major method of learning out of eight is trained. It is still difficult to see where it can be applied in case of more constructivist approaches in less structured domains than mathematics. KST and similar adaptive processes are relevant as long as the conception of learning it supports is made explicit and put into perspective with other views/approaches on the same phenomenon. After two projects based on this framework, the conditions for an adaptive system to support a non behaviouristic-like learning process remains for us an open question.

APPENDIX 2 - Pedagogical return on expensive adaptive developments

Ainsworth (2006, p. 132) notes:

Designers of intelligent tutoring systems hope that one day their systems will perform as well as expert human tutors, which, in itself, is very high goal. Bloom (1984) found that one-to-one tutoring by expert tutors, when compared to traditional whole class teaching, improves students learning by 2 sigma effect size. This was the only pedagogical technique which had such a marked effect. Currently, state-of-the-art in ITSs is around a 1 sigma effect with evaluations of ITSs revealing effect sizes of between .4 and 1.2 compared to classroom teaching (e.g., Graesser, Person, Harter & The Tutoring Research Group, 2001; Koedinger, Anderson, Hadley, & Mark, 1997). However, the time and expertise needed to produce such clever systems has meant that such ITSs have not yet achieved widespread application in schools, colleges or workplaces – creating an ITS is estimated to take between 300 and 1000 hours to produce an hour of instructional material (e.g., Murray, 1999).

As for the return on investment, namely an educational benefit resulting from personalization of learning obtained through adaptive systems, it is questioned. Studying the parameters selected by two adaptive systems (3DE, APeLS), Monthienvichienchai (2005, p. 3) concludes that in many personalized learning projects, critics and advocates for particular adaptation parameters have emerged with equal number of arguments for and against personalising to each parameters, with some even questioning the effectiveness of personalising learning in the first place (Marzano, 1998), while others have recommended personalisation with caution (for example,

(Ferguson, Schmoller, & Smith, 2004)). Commenting Hattie's meta-analysis, the Coffield report on Learning Styles (2004, p. 146) also casts doubts:

The benefits of individualized teaching are often greatly exaggerated, although many teachers will admit that it is extremely difficult to ensure that learners are benefiting from specially tailored approaches when there is a large class to manage. In a synthesis of 630 studies, Hattie (1992) found an average effect size of only 0.14 for individualized teaching in schools. This trivial result strongly suggests that in general, it is not a good use of teacher time to try to set up, monitor and support individual learning programmes where there are large groups to deal with. It should be noted that the potential of ICT to support individualised instruction has not been fully evaluated.

Hence, if the personalization impact factor is questioned in a context of regular teaching, caution is even more requested when it comes to "automatic customization" which adds its own assumptions and modelling filters (Dotan, 2006, p. 23). Matan & Aviram (2005, p. 8) note in addition that research in adaptive systems has still not yielded a scientifically corroborated set of methodologies to support personal learning and is flawed at an upper level by the lack of validated personalization theories. Better educational benefits measurements for adaptive systems are not necessarily right around the corner. As pointed by Verpoorten & Logan (2006), there are relatively few examples of adaptive educational systems in practical use. Furthermore, those personalized learning platforms based on adaptive philosophy are seldom tested, remaining small scale and mainly as experimental set-ups. It goes without saying that this relative poverty leads to a very modicum of empirical investigations (Weibelzahl, 2005) which would demonstrate that most effective learning is achieved or facilitated thanks to such systems (Ronen, 2006, p. 19).