Wong, L.-H. et al. (Eds.) (2013). Proceedings of the 21st International Conference on Computers in Education. Indonesia: Asia-Pacific Society for Computers in Education

Teacher Approaches to Adopting a Competency Based Open Learner Model

Matthew JOHNSON[a], Gabriele CIERNIAK[b], Cecilie HANSEN[c], Susan BULL[a*], Barbara WASSON[d], Carmen BIEL[b], Kolja DEBUS[e]
[a]*Electronic, Electrical and Computer Engineering, University of Birmingham, UK*
[b]*Knowledge Media Research Center, Tuebingen, Germany*
[c]*Uni Health, Uni Research AS, Bergen, Norway*
[d]*Information Science and Media Studies, University of Bergen, Norway*
[e]*MTO Psychologische Forschung und Beratung GmbH, Tuebingen, Germany*
*s.bull@bham.ac.uk

Abstract: This paper considers teacher adoption of an open learner model (OLM) constructed from automated and manual data. It shows OLM visualisations; how teachers, students and peers can provide data to an individual's model; and an overview of how such manually-provided information is combined with automated data. Teacher experiences reveal the potential for OLMs of this type in classrooms, as well as some of the barriers to achieving this.

Keywords: Open learner model, teachers, competency-based learning.

1. Introduction

Open learner models (OLM) – learner models that are visualised to the user in an understandable form – are increasingly used in Higher Education (e.g. Bull, Jackson and Lancaster (2010); Demmans Epp and McCalla (2011); Hsiao, Bakalov, Brusilovsky and Koenig-Ries (2011); Mitrovic and Martin (2007); Perez-Marin and Pascual-Nieto (2010)). The visualisations can take a variety of forms, e.g. skill meters (Bull, Jackson and Lancaster (2010), Mitrovic and Martin (2007)); concept maps (Mabbott and Bull (2006), Perez-Marin and Pascual-Nieto (2010)); hierarchical tree structures (Conejo, Trella, Cruces and Garcia (2011), Mabbott and Bull (2006)); treemap (Bakalov, Hsiao, Brusilovsky and Koenig-Ries (2011), Kump, Seifert, Beham, Lindstaedt and Ley, 2012). Aims of OLMs vary, but include promoting reflection by allowing learners to see representations of their knowledge or skills; facilitating planning; promoting collaboration; and helping teachers better understand student needs (Bull and Kay, 2007).

There is also increasing interest in competency frameworks in teaching, e.g. language (Council of Europe, n.d.); STEM literacy (Bybee, 2010); geography (Rempfler and Uphues, 2012). Changing teaching, or aligning theory and practice towards a competency focus, is not necessarily straightforward for teachers (de Bruijn (2012), for vocational education; Moonen, Stoutjesdijk, de Graaff and Corda, (2013), for language). We support teachers with a competency-based OLM to help them relate activities to competencies, and provide (automated & manual) feedback based around the competency approach. In addition to a competency focus, teachers need to (i) understand the purpose of OLMs, and (ii) be able to see how to adopt them in the classroom. This is not as easy as it sounds: teachers are used to the many ways in which data can be visualised, including learning analytics (e.g. dashboards: Verbert, Duval, Klerkx, Govaerts and Santos (2013)). Visualisation for teachers is often activity-focussed, e.g. what students have done (contribution to discussion, accessing information, test scores), rather than showing what *competencies* students are developing. Thus, there can be a preconception about what OLMs are.

This paper describes the approaches taken by four teachers to use competency frameworks in the Next-TELL OLM, indicating that while it may not always be an easy process, teachers are nevertheless able to find ways to incorporate the OLM into their existing or desired approaches to teaching.

2. The Next-TELL Open Learner Model

The Next-TELL OLM is a web cloud based tool. It functions in all major browsers, and can be used on desktop computers and iPads. This section presents technical points, and how teachers set up the OLM.

Technical Information: At the front end, the OLM serves up .jsp pages, many of which contain AJAX functionality, allowing real time interaction. The .jsp pages harness the power of JQuery functions, amongst other open source JavaScript libraries. An API lets other tools communicate with, and contribute data to the learner model. The back end logic is programmed in Java, and served up by an Apache Tomcat server. The database is Apache Derby based, accessed through a JDBC connection.

The learner model may be opened at different levels of abstraction and for different scopes of information, e.g. a specific student's participation in an activity, or a specific competency for a student group. As a result, much of the learner modelling algorithm is executed at the time of the information request. A cache of small grain size exists to specify the learner model for each evidence source for each competency for each activity for each student. All other information is combined from this cache by the modelling algorithm at the time of the information request. When a new piece of evidence is added to the database the cache item is recalculated that matches the specific *student, competency, activity,* and *evidence source* associated with the piece of evidence. All pieces of evidence that match are retrieved. Starting with the oldest, the following algorithm is applied on each item:

new_value = old_value (1 - depreciation_factor) + evidence_value (depreciation_factor). This gives the newest piece of evidence slightly more influence than the second newest, which in turn has slightly more influence than the third newest, and so on, to reflect *current* competencies. The model is built from multiple pieces of information to increase the accuracy of this prediction. Variation of the value for depreciation_factor allows the level of influence of information to be changed (e.g. if the value is set towards 1.0, the last piece of evidence contributes most to the model, with older evidence not used).

The cache contains learner model values for each combination of a specific *student, competency, activity,* and *evidence source.* Cache items are combined to give the model values for queries of coarser grain sizes. Three parameters are used to determine the level of influence cache items have when they are combined: *competency influence*, *activity influence,* and *unit influence* (i.e. *competency influence* is only used when combining competencies, and so on). Each has a value between 0.0 and 10.0. For example, when combining several competencies to give the modelled value for an activity:

$OLM\_value = \sum competency_n \ x \ competency\_influence_n$, each competency is combined with a relative influence. The default value is 5.0, but the teacher may change this value as required. The same method is used for combining activities and units. When students are combined, this is with equal weighting: no one student is more important than another within a group. When evidence is combined for different sources for the same grain (competency, activity, student are specified), this is done proportionally according to the volume of information associated with each source. The OLM draws evidence from a variety of sources: the 'usual' automated learner model data: an instance of OLMlets (Bull, Jackson and Lancaster, 2010) provides inferred data in some of the cases described in this paper; and manual input from teachers, students (self-assessments), and peers (peer assessments). Thus, the OLM is flexible in the data it comprises, and also in its use.

Setting Up the OLM: There are two ways in which a teacher can give assessment/feedback/evidence: (i) Google spreadsheet; (ii) web form (Figure 1). Cells for number values in spreadsheets, and stars in the web form, provide numerical data for modelling, while text feedback may be given as additional explanation to help students understand the information in their learner model. Students provide self and peer-assessments using a similar web form; and an additional rubrics interface is being developed. Automated data can directly enter the learner model through the OLM API.

Figure 2 shows examples of how the OLM is visualised to teachers. Top left shows the treemap visualisation, allowing drill-down to sub (and sub-sub) competencies. Top right shows the word cloud (upper blue component – the larger the text, the stronger the competency; lower red

component shows weaker competencies – the larger the red text, the less evidence there is for the competency). The bottom of Figure 1 shows the skill meters (clicking on 'e' shows the evidence list). Thus we have combined more traditional OLM presentation methods (skill meters) with more recent treemap and word cloud approaches, to align with visualisations that are often used in other settings. The first columns (shown for the skill meters) give the selected group and students in that group; the middle columns, the competencies; and the final columns show the extent of contribution of each activity to the competencies. Thus, in this example, the teacher is viewing several (demo) students at the same time. Information can also be displayed relating to a specific individual, competency or activity; and individual students can view their own OLM (or that of others, if permission was given).

To enable the OLM to receive student, activity, and competency data, teachers need to set up the OLM for their course. Existing competency frameworks may be used (e.g. Common European Framework of Reference for Languages (Council of Europe, n.d.); Next-TELL-created frameworks such as for facilitating meetings (Reimann, Bull and Ganesan, 2012)); or teachers may develop (or share) their own competency frameworks. Setting up a framework is achieved as illustrated in Figure 3, showing how nested competencies can be added. Students, groups and activities are added in a similar way, and these components are then linked to each other. As can be seen, while leading to a potentially useful tool, the setup does require some effort from the teacher, especially if they are designing their own competency framework. This is a further barrier to overcoming possible teacher reticence to using a flexible OLM tool. In this paper we introduce ways in which four teachers have approached OLM introduction, to demonstrate a range of methods that may be adopted to suit teacher requirements.

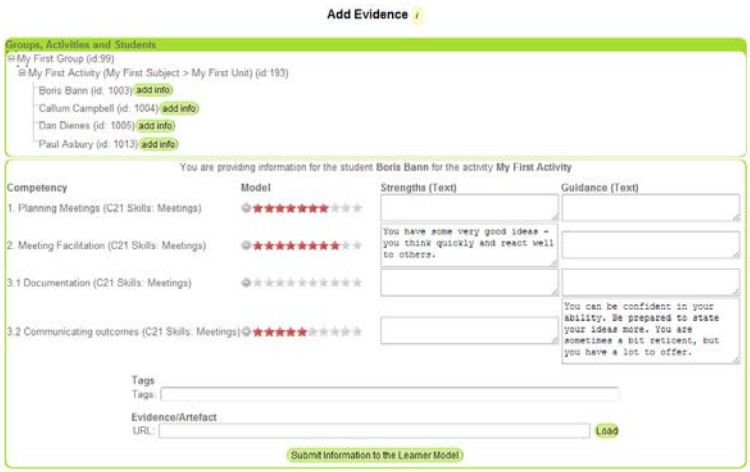

Figure 1. Providing Learner Model Data and Feedback (Teacher)

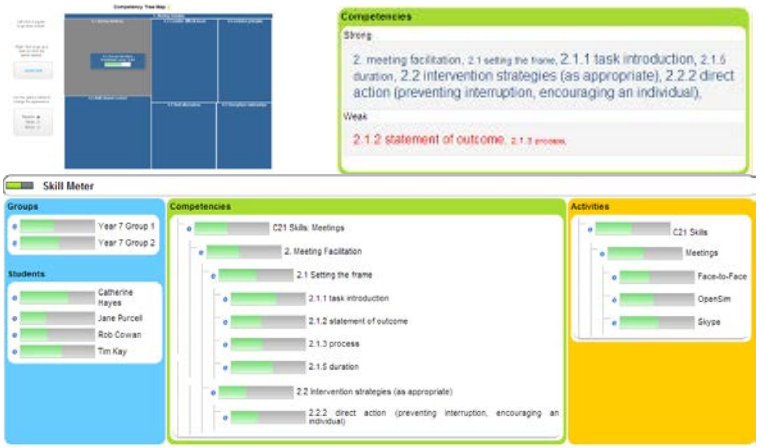

Figure 2. The Next-TELL Open Learner Model Visualisations

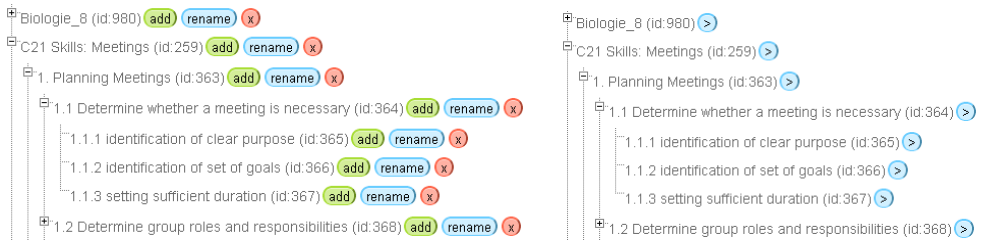

Figure 3. Configuring for the Next-TELL Open Learner Model

3. Teacher Use of the Next-TELL OLM

This section describes examples of how 4 teachers approached introducing the OLM into classrooms.

Teacher 1: A teacher of history and economics to 16-18 year-olds in Germany was introduced to competencies and the OLM with a demonstration. While requesting guidance on using the OLM, he wished to retain independence concerning set-up. However, he did state that access to pre-formulated examples could be beneficial - especially from colleagues. For his first use in an economics course, he divided the OLM into four broad clusters of competencies: (i) Kommunikationskompetenz (communicative competence); (ii) Sachwissen (expertise/knowledge of the field); (iii) Interpretation/Deutung und Reflexion (interpretation and reflection); (iv) Methodenkompetenz (methodological competence). The teacher's primary interest in the OLM is to provide students with a platform to peer-review and comment on their own work and results. He would also like to offer course content and tasks directly to students, to highlight the link between their work and associated competencies. The teacher was also keen on using OLMlets to provide automated data to the OLM. In line with the point above, he stated that he would like to link the OLM with additional materials and instructions as already used in the classroom. For example, add a source on analysis in economy or history courses, to relate to the competencies defined. This suggests a perception of achievable integration into his existing teaching. The teacher is now inputting competencies for use in two classes each having 20 students.

Teacher 2: A teacher of geography and history to 16-18 year olds in Germany was given a demonstration of the OLM in an introductory session, for a bilingual programme taught in English. About a month after OLM introduction, the teacher stated that he wished to streamline his classroom teaching, assessment and feedback procedures in both subjects towards a greater focus on the competence scheme used in the final examination - with the intention of supporting his students in improving these competencies. He considered the OLM an opportunity to help him in achieve this goal because of the competency-related feedback structure. He was keen for students to become aware of the competencies and competency levels with reference to the course and the related grades as early as possible in their preparation for the exams. During introduction to the OLM, he liked the functionalities of self and peer-assessment (he already offered paper-based self-assessment), but not peer model viewing. Over the month he built an increasingly specific picture of how he wanted to use the OLM. However, determining competencies and sub-competencies was a challenge, as he had to define each precisely. He formulated a sentence for each, to explain the meaning of the competency name to his students. However, initially the students did not understand the teacher's formulations. He subsequently produced 2 posters (Figure 4), one for geography and one for history, which he taped to a board in the classroom so that they remained visible at all times. The sub-competencies were formulated as questions, to help clarify to students, the information they need to provide (e.g. for geography – What spatial structures can be identified? What criteria can be used to assess the problem?; for history – What motives, conclusions and structure does the source have? What is the historical value?) Each subject-based overall competency was divided into three sub-competencies: identification, analysis, and assessment. The teacher then put "competence-answers" to the questions on the posters, in the manner of "I can..." statements, to form sub-competencies in the OLM (e.g. I can indicate and explain the spatial structures and developments; I can assess the spatial structures, developments and/or problems by applying self-chosen criteria). Figure 5 gives an excerpt from the competency structure configured in the OLM (geography). Following this, the teacher input his data for 19 students, covering the three sub-competencies in 'Identification of Region and Problem', relating to four activities. There were 68 instances of numerical teacher input to the model. The

following day the students performed 49 self-assessments, providing data for the learner model (plus 4 text comments).

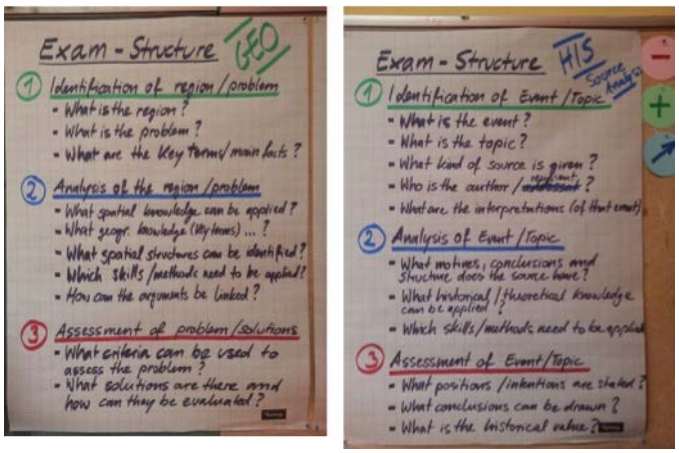

Figure 4. Teacher's Posters for Students (introducing the idea of competencies)

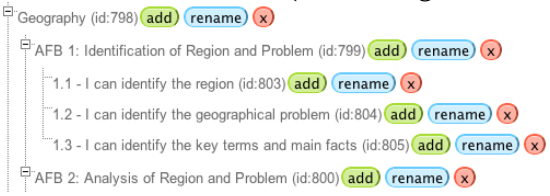

Figure 5. Excerpt from Teacher's Competency Structure

Teachers 3 & 4: The OLM was introduced during a one-day workshop to two teachers of 15-18 year olds in an Upper Secondary School in Norway. The teachers were jointly teaching *Natural Science* for first year students in the General Study Programme, a programme for students aiming for higher education. The unit to be taught was on *Energy for the Future*. The unit addresses six competence goals defined in the national science curriculum: (i) carry out experiments with solar cells and suntraps and explain the main principles for how these function; (ii) explain how heat pumps function, and in which contexts heat pumps are used; (iii) explain what redox reactions are, carry out experiments with combustion, galvanic elements and electrolysis, and elaborate on the results; (iv) describe the principles and areas of use of some common rechargeable and non-rechargeable batteries and fuel cells; (v) elaborate on different uses of biomass as an energy source; (vi) elaborate on hydrogen as an energy carrier. The workshop was to help teachers set up the OLM for this unit, in particular: adding competencies; defining activities to generate evidence; and tying relevant competences to the defined activities. (Previously we had worked with the teachers to identify activities to generate evidence for the OLM. These included: OLMlets; teacher and peer evaluation of a presentation of a group project on solar cells; and self-evaluation.) Looking at the national curriculum competence goals, the teachers were confused about how to use them with the OLM, because the competencies were formulated as combinations of *knowledge* and *skills*, rather than *knowledge*, *skills* and *attitudes* (e.g. EU, 2007). In the Norwegian national curriculum, the competence goals, while including knowledge and skills, express these as, for example, "Carry out experiments with solar cells and sun traps, and explain the main principles for how these function". Thus, the teachers were unsure whether these should be defined as an activity, competence goal, or both. Discussion resulted in each of the competence goals being divided into subgoals; and a set of activities for the unit: 5 experiments, self evaluation, peer evaluation, OLMlets.

17 of the 29 students submitted 80 numerical self-assessments; and 13 submitted 20 numerical peer assessments to the OLM. 20 received automated data from their use of OLMlets (484 items). There were 18 text comments in self-assessments, and 22 in peer assessments. (Teachers were not assessing.)

4. Summary and Conclusions

This paper has introduced potential benefits of OLMs, including consideration from a competency perspective. It has also considered difficulties in encouraging more widespread OLM use in schools. We have introduced how four teachers took up the Next-TELL OLM as examples of how this can be flexibly achieved in practice: i.e. an OLM that has no tightly prescribed use can be integrated into the classroom. This was the case even when teachers had to define their own competency structures and relate these to activities, which required them to think about their courses in new ways.

With reference to learning about how to configure information for the OLM, teachers had different levels of support. Two teachers took part in a workshop introducing the OLM, which fitted their school's approach of discussing teaching of specific subjects amongst the teachers teaching those subjects. The other two teachers developed, or are developing, more independent approaches.

Some teachers may initially use manual-only learner model input. This is sufficient for the OLM to be usable and, indeed, it provides a way for current information about competencies to be presented to students and teachers following the OLM concept (rather than performance results, or data on activities completed). Teachers may decide to later include automated data, or may decide to retain this learner-model inspired approach that is closer to their current methods of providing (and enabling) feedback. One of the teachers in Germany was keen to use OLMlets in the future to incorporate automated input alongside teacher and student assessments, and the Norwegian teachers integrated OLMlets into their classroom activities – this then contributing a major part of the Next-TELL OLM information.

The teachers took different approaches to building competency structures. The first, in the early stage of considering competencies, produced a small set of broad descriptors. The others defined sub-competencies within competency structures, building their own structure or extending from the national curriculum. One produced posters to introduce the OLM to students, suggesting OLM can have an impact on the whole assessment and feedback culture in class by increasing the transparency of a teacher's assessment scheme. Two teachers used self, peer and automated data, but not teacher input, having a student-centred focus; while one input student assessments in advance of students providing self-assessments. The remaining teacher plans to initially use self-assessments and OLMlets. Two teachers focused on a specific unit of teaching, while two are using, or planning to use the OLM more widely across courses. Thus, while it may not be straightforward to think in terms of competencies and understand the OLM concept, our teachers were motivated to use the Next-TELL OLM (and OLMlets), and identified ways of incorporating it into their teaching. Therefore, the growing use of OLMs in higher education may also extend to schools – perhaps in some cases as part of a broader feedback tool.

Acknowledgements

This project is supported by the European Commission (EC) under the Information Society Technology priority of the 7th Framework Programme for R&D under contract no 258114 NEXT-TELL. This document does not represent the opinion of the EC and the EC is not responsible for any use that might be made of its content.

References

Bakalov, F., Hsiao, I-H., Brusilovsky, P. & Koenig-Ries B. (2011). Visualizing Student Models for Social Learning with Parallel Introspective Views, *Workshop Visual Interfaces to the Social Semantic Web*, IUI11.

Bull, S. Jackson, T. & Lancaster, M. (2010). Students' Interest in their Misconceptions in First Year Electrical Circuits and Mathematics Courses, *Int. Journal of Electrical Engineering Education* 47(3), 307-318.

Bull, S. & Kay, J. (2007). Student Models that Invite the Learner In: The SMILI Open Learner Modelling Framework, *Int. Journal of Artificial Intelligence in Education* 17(2), 89-120.

Bybee, R.W. (2010). Advancing STEM Education A 2020 Vision, *Technol. & Engineering Teacher* 70(1), 30-35.

Conejo, R., Trella, M., Cruces, I. & Garcia, R. (2011). INGRID: A Web Service Tool for Hierarchical Open Learner Model Visualisation, *UMAP11 Adjunct Poster Proc.* www.umap2011.org/proceedings/posters.

Council of Europe (not dated). The *Common European Framework of Reference for Languages*, http://www.coe.int/t/dg4/linguistic/Source/Framework_EN.pdf. Accessed 1 June 2012.

De Bruijn, E. (2012). Teaching in Innovative Vocational Education in the Netherlands, *Teachers and Teaching: Theory and Practice* 18(6), 637-653.

Demmans Epp, C., McCalla, G. (2011). ProTutor: Historic Open Learner Models for Pronunciation Tutoring, in G. Biswas et al. (eds), *Artificial Intelligence in Education*, Springer-Verlag, Berlin Heidelberg, 441-443.

EU (2007). *Key Competencies for Life Long Learning: European Reference Framework.* http://ec.europa.eu/dgs/education_culture/publ/pdf/ll-learning/keycomp_en.pdf

Hsiao, I-H, Bakalov, F., Brusilovsky, P., Koenig-Ries, B. (2011). Open Social Student Modeling: Visualizing Student Models with Parallel Introspective Views, in J.A. Konstan et al. (eds), *UMAP11*, Springer, 171-182.

Kump, B., Seifert, C., Beham, G., Lindstaedt, S.N. & Ley, T. (2012). Seeing What the System Thinks You Know - Visualizing Evidence in an Open Learner Model, *Proceedings of LAK 2012*, ACM.

Mabbott, A. & Bull, S. (2007). Student Preferences for Editing, Persuading and Negotiating the Open Learner Model, in M. Ikeda et al. (eds), *Intelligent Tutoring Systems*, Springer-Verlag, Berlin Heidelberg, 481-490.

Mitrovic, A., Martin, B. (2007). Evaluating the Effect of Open Student Models on Self-Assessment. *Int. Journal of Artificial Intelligence in Education* 17(2), 121-144.

Moonen, M., Stoutjesdijk, E., de Graaff, R. & Corda, A. (2013). Implementing CEFR in Secondary Education: Impact on FL Teachers' Educational and Assessment Practice, *Int. J. of Applied Linguistics* 23 (2), 226-246.

Perez-Marin, D., Pascual-Nieto, I. (2010). Showing Automatically Generated Students' Conceptual Models to Students and Teachers, *Int. Journal of Artificial Intelligence in Education* 20(1), 47-72.

Reimann, P., Bull, S. & Ganesan, P. (2012). Supporting the Development of 21st Century Skills: Student Facilitation of Meetings and Data for Teachers, R. Vatrapu et al. (eds), *TAPTA* (ECTEL12), ceur-ws.org/Vol-894.

Rempfler, & Uphues, R. (2012). System Competence in Geography Education Development of Competence Models, Diagnosing Pupils' Achievement, *European Journal of Geography* 3(1), 6-22.

Verbert, K., Duval, E., Klerkx, J., Govaerts, S., Santos, J.L. (2013). Learning Analytics Dashboard Applications, *American Behavioral Scientist*, online first version Feb 28, DOI: 10.1177/0002764213479363.