Formative Assessment and Meaningful Learning Analytics

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Abstract—We introduce an independent open learner model for formative assessment and learning analytics based on developments in technology use in learning, also maintaining more traditional numerical and qualitative feedback options.

I. INTRODUCTION

With development of technologies there have been many changes in the ways that learning and assessment take place. Nevertheless, there is still room for approaches that can readily encompass the variety of new technologies, as well as accommodating more traditional formative assessment and feedback. Individual ‘learner models’ are inferred and dynamically updated during an interaction. These enable adaptive teaching systems to tailor the interaction to the individual [10]. Much as visualisation in learning analytics displays learning data to users (e.g. [8]), ‘open learner models’ externalise data from learner models [3], and so can be regarded as a specific application of visual learning analytics. Furthermore, as it is the learner model that is visualised, data typically relates directly to understanding, skills and competencies, etc. While this can be achieved for teachers using learning analytics data ([4]), learner models can very naturally make their inferences about learners available to students and teachers, since the learner model is an inherent and often core component of the adaptive system’s design.

Independent open learner models (IOLM) are not part of adaptive teaching systems: the independence of the OLM indicates that it is for use on its own. The aim is to focus on metacognitive skills that help in the learning process, allowing learners to assume greater control and responsibility for decisions in their learning [3]. An IOLM may be: part of a system that has tasks or questions ([2]); connected to an e-portfolio ([6]); or take data from a range of sources ([7]). We here focus on an IOLM to integrate data from a variety of sources (activities, applications, etc.), to help learners and teachers understand students’ learning; and to offer opportunities for formative assessment combined with learning analytics, as argued beneficial [1] – but with greater focus on learning or current competencies than performance. It also uses self and peer assessment as suggested, for example, in online learning [8]. That learners have to themselves use the visualised data, and identify what they need to do to improve their learning, is part of the learning process.

II. THE NEXT-TELL IOLM

Reports on the potential of (I)OLMs to be at the centre of contexts with learner data available from a range of sources, are increasing [5,6,7]). This means that starting points for reflection or formative assessment can take account of a fuller range of activities a student might undertake, that contribute to the learner model. The learner model in the Next-TELL IOLM is based on competency structures. Various activities, defined by the teacher, allow data to be collected as students interact: these may be online activities, using the IOLM API; or may be traditional feedback from self, peer or teacher assessments. Fig 1 shows four of the Next-TELL IOLM visualisations to illustrate how it can be used in formative assessment. Skill meters provide a clear, simple, indication of strength of competencies (and sub-competencies). Especially for small competency sets, these can easily show learners and teachers the extent of the various competencies measured by the various activities and/or technologies. Word clouds are useful when there is a large number of competencies. This is not ordered, but for quick viewing, it can help users identify strengths (left) and difficulties (right). It can be a useful way to identify where to focus effort or, if a student releases their model to others, for peers to quickly note who might be able to help with reference to a specific topic or competency. The competency network shows the competency structure, with shade and size of nodes indicating relative strength of competencies. This also allows users to easily see areas of the structure that are under-represented in their skill-set, as well as how their strengths are distributed. The radar plot enables comparison of data sources in the model, for example, comparing self-assessment to data perhaps perceived as more ‘expert’, such as teacher assessments or automated tools. Users can also view the influence of the learner model algorithm (Fig 2). This example shows evidence of contribution of different sources of data together with recent weighting from manual peer and teacher assessments, and automated data from an online tool (OLMlets [2]). The Next-TELL IOLM can support formative assessment in several ways. The first is by viewing the visualisations. As indicated above, these can be used for different purposes: quick identification of areas of strength or weakness; more detailed inspection of skills with reference to one or more competency frameworks used in the IOLM; comparison of learner model data from different sources. Each can serve as a prompt for learners to assess their needs and determine suitable follow-on activities (online activities, searches, reading, collaborating, asking the teacher, self-assessment, etc.).

Previously, a simple IOLM has been found to prompt spontaneous face-to-face discussion about the learner models, when they could be optionally released to peers [2]. This can also be the case with the Next-TELL IOLM, but following the earlier finding, it also includes a discussion component where students can comment on their learner models or request assistance, etc., when they are not in the same location. For example, Fig 3 shows an excerpt from discussion
prompted by the instructor, based on the learner models. This excerpt demonstrates that students can appropriately discuss their understanding, and clarify their understanding to themselves and each other. If considered useful, the instructor can ‘add evidence’ to the IOLM in the form of a numerical value, as well as additional text feedback as evidence. This can further focus students back to the discussion for elaboration, but can also be a way to acknowledge improved understanding in the IOLM itself, that could be a motivating factor. Students can perform self and peer assessments in a similar manner. Students and teachers can view this evidence by clicking the text icon (by the skill meters in Fig 1).

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**Instructor:** Cognitive style is one of the two topics still in the ‘very weak’ position for the group as a whole, according to the table OLM view. Are there specific difficulties that you are encountering here?

**Student 1:** Cognitive style is how information is processed and stored in memory, for example there are two types of styles of learning, the is the deep and surface approach of learning, the surface approach is trying to memory and reproduce of material, often without having much knowledge about the subject and how the memorised materials fit together. But in deep approach is the opposite because a student would have a deep understanding and a lot more knowledge about the subject and make sense of the materials instead of just memorising, and not knowing how the things you memorised work. That’s my understanding of cognitive learning style.

**Student 2:** Definitely the deep approach of learning style is where the learner tries to link his learning to what he/she already knows or believes in. They try to use the evidence to support their learning and fit it in their schema.

**Instructor:** But is there some confusion between cognitive and learning style?

**Student 2:** Learning style is the method/way you learn the information however cognitive style is the way you process the information in your brain. Am I ok with this as a basic understanding?

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If the IOLM is used throughout a course, there can be many formative assessment opportunities. Any activities that use the IOLM API can contribute to the model calculation, and appear in the visualisations. In this case students used another IOLM (OLMlets [2]), which provided data to their Next-TELL IOLM. This was combined with data from teacher assessments of individual and group texts; and self and peer assessments. In addition, written feedback was provided. Performing self-assessment and comparing against ‘expert’ teacher assessments can be useful to gauge the accuracy of one’s self-assessment. Peer assessments can also help the giver of feedback, in the process of appraising the work of others. Collecting this data across activities and technologies also allows continuing formative assessment to take a large proportion of a learner’s activities into account in prompting reflection through learner model visualisations.

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**III. USE OF THE NEXT-TELL IOLM**

Potential benefits of (I)OLMs have been previously described [3]. We here consider the extent of use of the IOLM as an indicator of perceived benefit for formative assessment.

Participants were 11 volunteers studying Computing Systems Engineering, from two courses: Personalisation and Adaptive Systems; and Adaptive Learning Environments. The learner models represented competencies and topics from the relevant course, but data from both groups is combined here. The IOLM was introduced in labs, but mostly used in students’ own time over 8 weeks. Use was encouraged as a means to obtain formative feedback, but no summative assessment was based on it. The discussion section began late in the 8 week period. User actions in the system are automatically logged. Questionnaires were administered at the end of the courses, using a 5 point scale (strongly agree (5) – strongly disagree (1)). A ‘not applicable’ option was also available. A few questionnaire responses for two of the students were removed, where those students had rated visualisations, but interaction logs showed no use of them. The questionnaires only asked about 6 of the 8 visualisations, but the logs were reviewed for all eight visualisations.

Looking at high-level learner actions within the IOLM (Table I), we see that all viewed their IOLM (any of the visualisations), inspected the modelling process, and viewed the evidence. The logs also revealed that 4 participants inspected the modelling process more than twice as much as any of the other learners. The majority of learners also viewed and participated in discussions. All participants completed at least one peer or self assessment, with most completing several.

Table II shows the most commonly completed part of an assessment as the numerical value. Around half also entered text describing strengths or possible improvements. Several instructor assessments by competency were also given (per student: $M=16.7, SD=7.7, Min=6, Max=31$). The questionnaire revealed general agreement with statements of usefulness, as in Table III. All stated at least one of the visualisations was useful for learning (strongly agree/agree), with most claiming several to be helpful. Responses were mixed for usefulness of assessments, but few negative responses.
Discussion: Over the 8 weeks, users accessed the visualisations (Fig 1) 64.2 times on average. The SD was high, indicating different use patterns: some may check frequently for updates, or switch between visualisations for different views on information; others checking less frequently. This is in line with the aim of a flexible tool as a focus for formative assessment, as suits the individual. Users viewed the modelling process (Fig 2) quite frequently given that it is in line with the need for immediate feedback (see [1]), with additional focus on current competencies; and allows inclusion of more traditional teacher feedback, as well as self and peer assessments that can themselves be useful formative assessment processes.

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