Chemical Handling – PLOTMaker for Training in Exposure Scenarios under REACH

Margrethe Winther-Nielsen and Ilaria De Rosa Carstensen
DHI, Agern Allé 5, DK-2970, Hoersholm, Denmark
mwn@dhigroup.com, idc@dhigroup.com

Persuasive design of e-learning is a relatively new area and not widely applied in training directed at industry and business. The Lifelong Learning project EuroPLOT has developed an e-learning resource on how to handle exposure scenarios for chemical mixtures according to the EU chemical legislation REACH. Eight sessions were developed applying persuasive principles. Each session consists of several persuasive learning objects. The course was uploaded on a Moodle website and offered to the industry as a stand-alone course. Sessions of the course were pre-tested in a focus group at DHI and a pilot-test was initiated in July 2013. Employees from industries, branch organisations and consultants were invited to the pilot-testing. The conclusion based on the first pilot-testing results was that training in a challenging topic such as the practical implementation of new chemical regulation by industries may be better understood through simplification by reduction, tunnelling, tailoring and application of animated interactive exercises. The possibility for learners to explore a topic at their own pace was found motivating. It was, however, obvious that some learners may benefit from a blended learning course or an online learning environment supporting discussions and contact with a teacher.

**Keywords:** Persuasive design of e-learning, formulating industry, exposure scenarios, case study

1 Introduction

In 2007 the European Union radically changed its chemical regulation with the introduction of REACH. The responsibility for management of the risk of substances was now placed on the industry, and this new strategy for the EU chemical policy introduced entirely new obligations for the industry. As a result, manufactures and importers must register and make a chemical safety assessment, depending on the tonnage of a chemical substance they are producing or importing. As part of the chemical safety assessment they may develop the so called exposure scenarios, which we are dealing with in our case.

Different roles are assigned to the industrial companies and the professional users of chemicals. The most important role for our case is the formulator, who is the downstream user of chemicals producing chemical mixtures, such as paints, cleaning agents and glues. The formulators must deliver information on the safe use of their products to their customers, applying the information in the exposure scenarios annexed to safety data sheets received from their suppliers of chemicals. Not only is it a challenge for the formulators to work with the huge amount of information embedded in exposure scenarios, but scenarios are often delivered in formats varying from supplier to supplier.

The main objective of our work was to create persuasive learning objects that addressed the health and safety specialists within the formulating industries or consultants working with these industries. Persuasion is of course not a new competence in teaching, but there have only been few attempts to combine persuasion with e-learning for education of the staff in business and industry applying the basic principles of persuasive technology defined by Fogg (1998 and 2003).
Fogg argued that a persuasive technology may function as a tool for making behavior easier, a medium for simulation or as a social actor. For each of these roles he designated a list of persuasive principles (Fogg 2003; Gram-Hansen 2012). While the principles of Fogg primarily are directed to persuasive technology, Oinas-Kukkonen and Harjumaa (2009) extended these principles to a description of 28 different persuasion techniques in their model of Persuasive System Design (PSD). Oinas-Kukkonen (2010) combined this model with analysis of the context of persuasion focusing on the designer and the usability of the user.

Persuasion is defined as the attempt to change attitudes or behaviours (Fogg 2003). By using persuasive design in an e-learning resource on exposure scenarios, related to the chemical legislation REACH, we attempted to engage and motivate the learner to actively apply the information on safe use of chemicals included in exposure scenarios delivered to him from his suppliers.

In this paper we present our work on developing the e-learning course, starting with course planning, continuing with design of learning sequences and persuasive learning objects and concluding with the first results of our pilot testing.

2 Materials and methods applied in the case study

Tools for developing persuasive learning objects
PLOTMaker was the main tool applied in the development of our learning objects. The tool was developed within the EuroPLOT project and based on the software tool GLOMaker developed by the Learning Technology Research Institute at London Metropolitan University (http://www.glomaker.org/index.html). Both the Freestyle and the EASA pedagogical patterns of the planner part of the software were used in the creation of our learning objects.

The PLOTMaker provides a teacher oriented authoring tool for creating persuasive learning objects. By incorporating new layouts and interactive components it has become a suitable tool for designing more engaging e-learning resources. Some of the components of the tool are in themselves interactive while other components allow importing of interactive flash animations and sounds created outside PLOTMaker. These resources are integrated into the Learning Object (LO) in its final shape.

We created several interactive learning objects in our sessions applying Microsoft PowerPoint in combination with iSpring Suite or Camtasia Studio. All sessions were assembled as a guided learning tour in how to handle exposure scenarios for chemical mixtures. The entire course was delivered in a Moodle website.

Persuasiveness in the design
We started designing learning objects applying the persuasive principles defined by Fogg (2003) and exploring how PLOTMaker could support interactive e-learning. Our primary goal was to design LOs, which motivated the learner to continue learning all the way to the end of the e-learning course. Furthermore, the learning content should inspire to further studying of the subject. It should provide employees from the formulating industry with a more comprehensive way to learn the basic principles of working with exposure scenarios for mixtures. The persuasive principles applied were: tunnelling, tailoring, reduction, simulation, self-assessment, suggestion, and to some extent social signals.

Testing by learners
A focus group at DHI tested selected sessions of the course in a pre-pilot test. Their experience of learning with the LOs was gathered in interviews directed by Herber (2012). Invitations to take part in pilot-testing of the whole course were sent to formulating industries,
branch organisations and consultants in Europe. When completed the online course each participant was asked to file in an online evaluation questionnaire anonymously. The questionnaire was developed by Erich Herber in 2013.

3 Results and discussion

Planning the course
Selection of target group, overall topic and learning outcome are of course essential parts of the planning of a course. These tasks should all be defined prior to the detailed planning and design of the course. For our specific case, a need expressed by industries was our basic for the selection of the particular topic and target group. The typical target of the learning is often one or two employees in each formulating company. We suggested that it would be beneficial to them to have access to an online course covering the whole topic.

A team of three teachers at DHI selected the course content and took part in the design of the course. The selection of content was based on our existing experience gained in several face-to-face courses and workshops within the area. Additionally, two other teachers were involved in evaluation and quality assurance of content and design.

The steps for the planning and design of the course were:

1. Selection of other software tools besides PLOTMaker which was preselected for our case in EuroPLOT and a suitable learning management system (LMS)
2. Selection of course content, number of sessions and topic for each session
3. Learning sequence, including pedagogical pattern within each session
4. Design and selection of materials for each LO
5. Internal evaluation and quality assurance of content and functionality of LOs

As already mentioned we chose to apply tools to supplement PLOTMaker in order to obtain a more varied and engaging learning. Knowing safety data sheets and classification rules for chemicals substances and mixtures were set up as a prerequisite for taking the course. However, the new terminology and methods introduced in the chemical legislation in 2007 were not assumed to be known in advance.

Before starting the design of LOs we decided on the sequences of learning activities for a session, applying the planner in PLOTMaker. We found both the EASA and Freestyle patterns in the new version of the software tool well suited for our purposes.

In total eight separate sessions were created, each consisting of a range of LOs. The content of the LOs was mostly developed from scratch and only few objects were reused or repurposed from LOs of others. Each session was packaged and uploaded on the Moodle website with a link to the GloWebPlayer.swf file. The uploaded course was discussed and evaluated systematically by the team and at least by one teacher outside the core team, and the course was adjusted before release for testing.
**Persuasive learning objects**

The front page of the course was inspired by the Learning Journeys (http://hermes.uwl.ac.uk/learnerjourney/), guiding the learner through the different sessions of the course (Figure 1), and providing an overview of the entire course. A learner without any prior knowledge of the subject may follow the suggested route from session one to eight while more experienced learners may jump to the sessions needed and thus plan a tailored learning tour.

![EXPOSURE SCENARIOS for MIXTURES TOUR](image)

Figure 1: The front page of the online course

The topic of exposure scenarios is in general considered quite complex learning content. The learning has so far been achieved through reading of technical guidances and face-to-face workshops and seminars. To our knowledge this is the first attempt to make an online course on this particular topic. When transferring the teaching to the PLOTMaker software we were able to reduce the big amount of guidance text to be read by presenting new terms and core knowledge in simplified illustrations and animations. One example is the LO in Session 2 of the course shown in Figure 2. By persuading learners to press the play button in this LO they will be presented with text and pictures related to a specific term or descriptor, e.g. the SU9. However, by linking to the original guidance in other LOs, the learners will still be able to study this in details.

According to Fogg (2003) we are likely to be persuaded by something which appears to be easy, and one important step towards making something easy is to make sure that everything seems familiar to the users (Gram-Hansen 2012). Selection of situations, illustrations, language, pictograms and other material that are known to the target group is a simple way to make a LO familiar to the learner.

The illustration at the front page of the learning resource (Figure 1) appeals to the target group, illustrating entities from their world. When entering the sessions you meet illustrations of situations where people are using chemical mixtures or products, such as professionals spray painting a car and technicians handling chemicals in a laboratory. Interviews of colleagues from other formulating companies who express their opinion on a topic is another way of making the LO familiar and the topic relevant to the learner. Besides including opinions of colleagues in LOs, social signals were introduced by using pictures of people in familiar situations.
Self-assessment and simulation take up large part of the learning sessions, allowing the learner to learn through interaction. The Multiply Choice Questions, Matching Quiz and Drag and Drop components of PLOTMaker have been used several times throughout the course to encourage learners to test their knowledge. Animations have been produced without programming, creating sequences of pictures in PowerPoint which were converted to flash files using the iSpring Suite. Use of animation in quizzes allowed inclusion of unexpected effects, like a simulated explosion when the learner chooses the wrong answer (Figure 3).

Simulation in our case means working with examples of exposure scenarios for chemical substances, going through exactly the same steps that health and safety specialists in the formulating industry have to perform when they receive real exposure scenarios from a chemical supplier. Before learners enter into a situation of simulation, they are offered the option to go through an example presented in a video. The simulations in the last part of the course (Sessions 7 and 8) allow learners to do a calculation using an interactive calculator (http://glomaker.wikifoundry.com/page/Links+to+free+resources?t=anon) and to type results directly into the LO. Having completed the steps needed for preparing an exposure scenario for a chemical mixture, learners in the end obtain the exposure scenario of the mixture.
Testing and interview of focus group
The focus group participating in the pre-testing was asked to think back on how they learned with the digital learning resources and how they benefited from them. The learners commented on individual LOs and gave suggestions for improvement. They used the feedback given in LOs repeatedly during the test to reflect on their individual learning success. However, the feedback was not in itself considered motivating for the learning.

The application of video-based interactive exercises was considered useful by learners and helped them to understand the exercise. Keeping simplicity in the LOs was recommended, although exercises should remain challenging and demanding. In some LOs, text and image were not synchronized and this caused irritation. The learner had to press a button for changing the text in the right part of the screen as the animation went on to the left. Unfortunately, automated synchronisation was not supported by PLOTMaker. The general lesson learned from this is perhaps that one should not try to push a system or tool beyond its capability, but keep it simple and functional.

The pilot testing of the course was still ongoing while this paper was prepared (August 2013). Examples of the first preliminary results from six questionnaires indicated that the majority (83%) enjoyed training with the online course, that the course helped them to better understanding the practical relevance of the subject (100% i.e. strongly agree / rather agree), that training with the online course can be useful for learning the subject (83%), that they could find effective ways to learn with the online course (83%), and that the online course motivated them to study the subject in more depth (67%). Furthermore, 67% of the testers disagreed on the question “I believe that I can better learn from teacher instruction than from online course”.

Four out of the six testers found that the online course was more motivating than other forms of teaching and training, as expressed by their answers and comments (Table 1). They appreciated the possibility to explore the topic at their own pace and without interference from other people. However, a drawback of online learning could be the lack of feedback and possibility to ask questions.

One of the testers pointed out that he or she experienced some technical problems during testing, because the connection slowed down during browsing in the online course. It was also annoying that a session started from the very beginning when he or she attempted to refresh the connection. Furthermore, comments on some of the soundtracks pointed out that it could be difficult to hear the content.

The pilot testing is anticipated to include at least 15 vocational learners from the industry. But we are still waiting for the remaining replies. However, from the answers presented above it is indisputable that learning through the online course motivated the majority more than face-to-face teaching. The first step in fulfilling our overall goal of the online course - “to engage and motivate the learner to actively apply the information on safe use for chemicals included in exposure scenarios…” - is achieved because testers so far has found that the course has helped them to a better understanding of the practical relevance of the subject.
Table 1: Answers and comments from six testers in the pilot testing of the online course

<table>
<thead>
<tr>
<th>Question to the testers:</th>
<th>Was training with the online course more motivating than other forms of teaching &amp; training (e.g. classroom teaching / face to face training)?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Answer</strong></td>
<td><strong>Number of testers</strong></td>
</tr>
<tr>
<td>Absolutely</td>
<td>1</td>
</tr>
<tr>
<td>Rather yes</td>
<td>3</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Rather no</td>
<td>0</td>
</tr>
<tr>
<td>Not at all</td>
<td>1</td>
</tr>
<tr>
<td>Indecisive</td>
<td>1</td>
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</tbody>
</table>

4 Conclusions

This paper demonstrates that the principles of persuasive design can be applied in e-learning directed at industry and business. We have shown that training in a challenging topic, such as the practical implementation of the new chemical legislation by industries, may be better understood through simplification by reduction, tunnelling and tailoring of the subject.

The application of video-based or animated interactive exercises support learners and keep them engaged in their learning. The possibility for learners to explore a topic at their own pace was found motivating. However, it was obvious that some learners may benefit from a blended learning course or an online learning environment supporting discussions and contact with a teacher.

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