Simulations for meteorological training and assessment

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2. Simulations for meteorological training and assessment

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Abstract

Preparing forecasters to respond to extreme weather situations is a difficult task due to their limited occurrence. However, simulations offer a way to involve forecasters in practicing decision-making for even the most complex situations. This chapter describes the evolution of tools and processes for using simulators in forecaster training and assessment within an international collaborative community. This has resulted in tools that anyone can easily use to create weather forecasting simulations, as well as many different applications for their use. Results and feedback have shown that simulations greatly enhance the practical side of courses and allow increased work on developing skills

2.1 The need for simulators in meteorological training

Preparing forecasters of the Royal Netherlands Meteorological Institute (KNMI) to act in the best possible way during extreme weather situations is a particularly difficult task for trainers because extreme weather situations don't occur very often. The Royal Netherlands Meteorological Institute joint simulation training programme began in the 1980s with a group of new forecasters at the Dutch Storm Surge Warning Center who had never faced a serious storm surge but had to be able to forecast the extreme storm surges in the North Sea. Originally, simulation sessions were run in a role play setting with an ordinary clock and a pile of weather maps which the forecasters used to create their forecast. People from the Dutch Storm Surge and Warning Service and trainers in an adjacent office took the role of the outside partners during these simulation sessions. Over time, the pile of paper weather maps became a website, then a Flash-based simulator (Figure 2.1) and later a PHP/HTML-based simulator. Seeing the benefit of simulations, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the UK Met Office and the COMET programme developed their own simulation tools and uses of simulations for meteorological applications.

The use of the simulator has changed over the years. At first, KNMI used this tool primarily for training sessions, but after the Australian Bureau of Meteorology shared its competency assessment plan for Queensland, KNMI developed simulator sessions to assess aeronautical forecasters (Figure 2.2). Today simulators are used in many countries and in many different capacities. Simulations are not only used to prepare and assess forecasters, observers and their customers for extreme situations, but also in training sessions on the use of new data types and the application of new theories and techniques. Trainers also use simulations to provide learners with realistic events to work through and develop soft skills like communication with users and decision-making support.

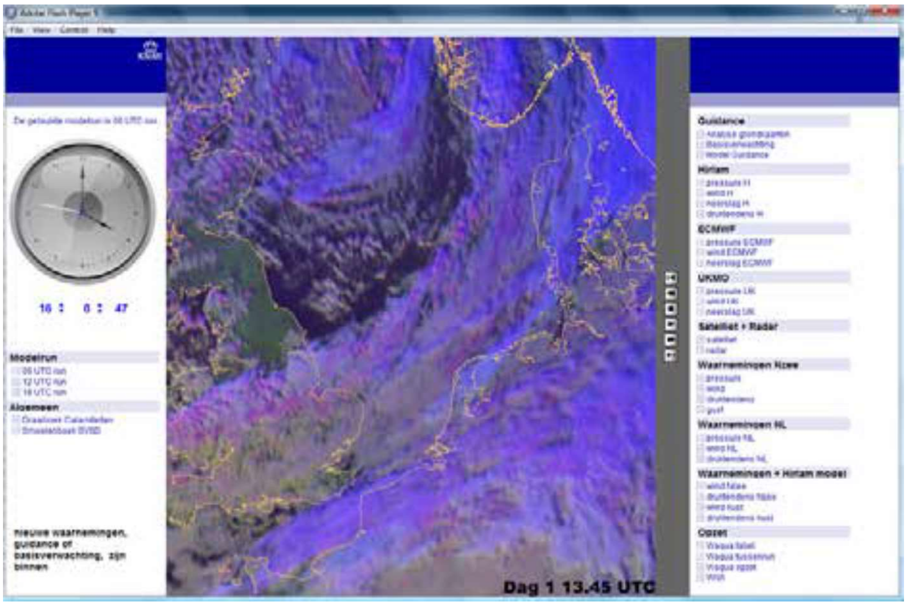

Figure 2.1. The first Flash simulator interface for an extreme high-tide event
Source: KNMI

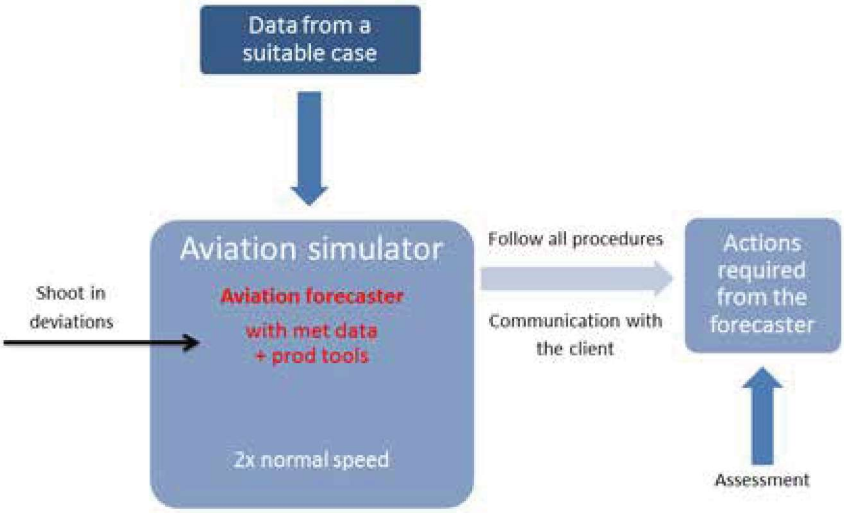

Figure 2.2. Schematic approach of a simulation exercise at KNMI
Source: KNMI

2.2 Learning with simulations

Daily life gives little opportunity to gain relevant experience in dealing with low-probability, high-risk events. This makes it difficult to anticipate risks and develop competencies that lead to an effective team.

Gaining experience is learning! When participating in simulation exercises you experience processes and gain insights into:

1. Using procedures and processes appropriately;

2. Collaborating and communicating with internal and external partners;

3. Making decisions in a team setting in highly stressful situations.

Learning must occur through both study and practice to prepare professionals to be fully competent to perform their job. During the study phase background knowledge is gained; during the practice phase the learner transfers knowledge into skills for the appropriate application of both theoretical knowledge and practical skills. During practice such as that provided by simulations, learners become aware of the risks inherent in the situations they will encounter by observing the consequences of their decisions and actions. They also become aware of the things they don't know and need to learn.

Simulations* can be used as a tool to support the study and practice phases of learning. Simulations are an excellent tool to:

1. Find the gaps in learners' performance and see where they get things wrong. Problems might be found in meteorological background knowledge, the way procedures are followed or how they communicate with customers;

2. Prepare learners for both normal and extreme situations. It is important to realize that in extreme situations people act differently than in normal situations. When a dramatic situation happens, for instance a child drowning in a pool, one or two people may jump into the pool but many more will be watching and not doing anything. That can happen in your Weather Service too, if people are not trained to perform under the stress of extreme situations;

3. Help assess whether your people are competent to perform their job.

With simulators, you can create a safe environment for your learners where they can gain experience, be trained and be assessed.

2.3 Uses of simulations

The weather forecasting training community has now used simulations in many new and innovative ways that the creator of the original KNMI simulator could never have dreamt of. We continue learning a lot from each other as new ones are made!

Simulators allow data products to be connected to real-life applications, so that the use of meteorological data is taught in the context of performing a task (Figures 2.3 and 2.4). This has been a welcome shift for training on satellite applications, for example, in which teaching the production and capabilities of data products was frequently abstracted from the use of the products. This shift makes the training much more effective for continuing professional development and performance improvement.

* We use the term simulation to refer to the learning activity. The term simulator refers to the tools that make simulations possible.

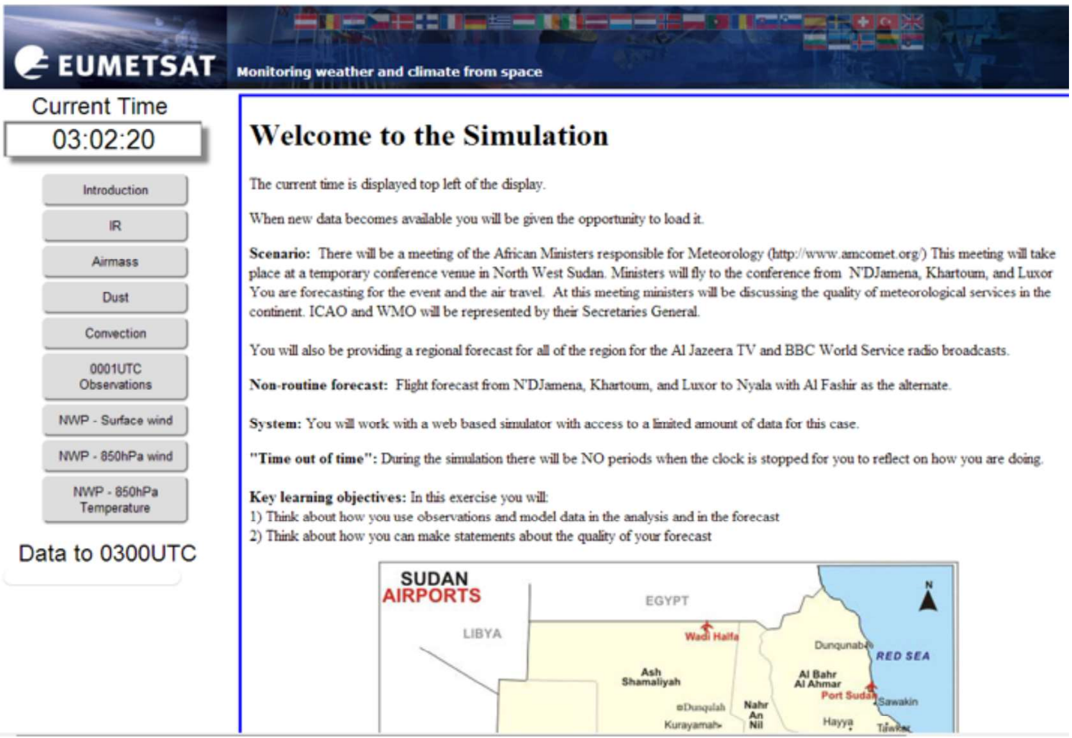

Figure 2.3. One of the first training simulators with a simulation on how to use satellite images for forecasting dust
Source: EUMETSAT

Figure 2.4. Trainees using a training simulator
Source: EUMETSAT

A simulation is also an excellent assessment tool for forecasters and observers working in aviation and other service areas because it allows trainers to create similar assessment circumstances for all individuals who are tested—which meets the need for fair and consistent assessment practices. By observing the participants in a simulation and evaluating the products they make, the trainer is able to collect evidence that the professionals are competent to do their job and ensure that all the required competences are assessed in an authentic context. This is different from the less authentic written test. The trainer is also able to see whether learners are competent to do their job under the circumstances that really matter—extreme weather situations.

A word of caution: when using recent cases for simulations, it is possible that some people will remember what actually happened during that case, and that will enable them to produce an excellent performance in the assessment. Yet in the community's experience so far it has never been a complicating factor in the assessment process.

Anecdotal evidence gathered during KNMI simulations has shown that if authentic assessments are implemented in the right environment and atmosphere, and participants have been given the time to adapt to the possible new circumstances, most people will be absorbed by the tasks in the work environment and will forget that they are engaged in a simulation.

Figure 2.5. Forecaster in action in a simulation session.
Source: KNMI

2.4 Collaborative evolution of meteorological simulators

Simulations used to be very costly and time-consuming to produce. The original simulation concept and simulator developed by KNMI was shared within the global meteorological education training community for free use, with the condition that new experiences and improvements of the tool should be shared within the same community. It turned out to be a great approach as it has resulted in a growing community using simulator tools for training. The European Organization for the Exploitation of Meteorological Satellites developed the tool for its own needs and created an easy-to-use JavaScript-driven simulator. Based on this version, a Moodle plug-in was developed in a joint effort by the UK Met Office, EUMETSAT and the South Africa Weather Service (SAWS) and was offered back to the community. Finally, the COMET Program, using its own HTML-based development system, created a branching simulation tool for training forecasters in online lessons.

The core innovation that made this evolution possible has been the use of simple simulators to support training and assessment for forecasters and observers (Figure 2.5). This approach avoids the problem of building a custom system on an institutional display that is powerful, but unusable outside of the National Meteorological and Hydrological Service (NMHS) that created it. Most of these simpler simulators are basically image viewers plus a built-in clock that can be set to run by the trainer at a desired speed to control when data products are available and when decisions must be made by users. Some simulators can ask learners to perform tasks while others are able to give personalized feedback based on the actions taken by the learners during the simulation session. Examples of simulators demonstrating the variety of implementations in our community are:

1. The UK Met Office, EUMETSAT and SAWS Moodle plug-in for creating custom simulations is currently available through info@eumetcal.eu. Many simulations made with this tool are available to the public at https://training.tools.eumetsat.int/sims/index.htm;

2. "Baltic+ 2019" course simulation using Google Forms: https://training.tools.eumetsat.int/sims/live/baltic+_2019fastloop/sim.html#;

3. The Argentinian National Meteorological Service (SMN) uses simulations to train and assess forecasters and observers. Some of the examples available at https://crf.smn.gob.ar/course/view.php?id=29 are simulations for training and assessing volcanic ash forecasters and for training on the Zonda (Foehn) conceptual model. The examples include a 3-D image of an observation site used for practice in meteorological observations;

4. The COMET Program's simulation on communicating risks: The impact-based forecast and warning service approach: https://www.meted.ucar.edu/wrn_sims/navmenu.php?tab=1&page=2-0-0&type=flash (account creation is required);

5. COMET's simulation that leverages social science to improve risk communication: https://www.meted.ucar.edu/social_science/ss_201/navmenu.php?tab=1&page=2-0-0&type=flash (account creation is required).

2.5 Challenges faced in implementing simulations

One challenge for the worldwide training community in implementing simulations was the fact that not all trainers have programming skills. The first simulator tool with a built-in clock used by KNMI was able to show data at specific times and was built in Flash, using the programming language ActionScript. ActionScript required a very steep learning curve for many institutions, and ten years later it became clear that Flash would disappear from use. The new EUMETSAT simulator tool was build using HTML and JAVA script, but even that turned out to be difficult to use for many.

As mentioned above, eventually the UK Met Office, with help from several partners, invested in a Moodle plug-in designed to build simulators using drag-and-drop techniques, which nearly anyone can master (Figures 2.6 and 2.7). However, having this Moodle plug-in available for the community did not mean that it could be implemented in every Moodle system. Because this plug-in was created by a private company and was not part of the official Moodle.org plug-in directory, other Moodle providers needed to determine whether they could install it on their systems at a reasonable cost. This procedure would have had to be repeated every time an update of the plug-in was created to make it compatible with updates to Moodle. To mitigate this limitation, both the UK Met Office and EUMETSAT have set up a Moodle server with the SIMS plug-in installed and have made it available to the community for creating a simulation (SIM). Once developed, the SIM can be exported to and used from another Moodle or internet site.

Figure 2.6. Moodle plug-in with drag-and-drop menu to create a SIM interface
Source: EUMETSAT

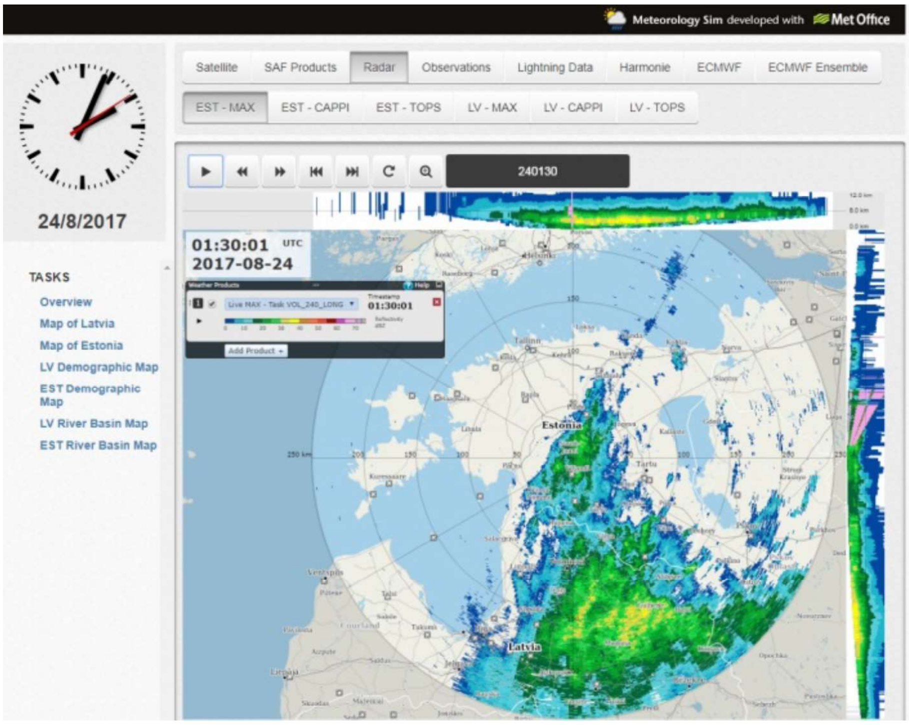

Figure 2.7. A simulator interface for a simulation over the Balkan region
Source: EUMETSAT

Another challenge related to the use of simulations is that it calls for pedagogical innovations. In recent years, we have noticed that too many trainers tend to focus on the technical requirements of building SIMs, while not enough time is devoted to defining the needs, goals and outcomes of the training. The result is that creating a simulation often takes more work than expected, and not all the simulation sessions are as effective as hoped. The training goals and needs determine the tools appropriate for the training, and not the other way around. In the past couple of years, in cooperation with EUMETSAT, some train-the-trainer events have been organized. The goals of these events were to help participants learn how a simulator can be used in training and assessment and how to use the simulator building tool in the optimal way. During training, participants inspire each other and begin collaborative projects. The participants go home with a training plan for a simulation training activity that includes a timed script for the training itself, and an early development of the simulation to be used for the training session.

Another challenge that KNMI has experienced is that at the start of each simulator session the differences between the working environment within the simulator tool and the normal forecast production tools can create some unease with learners. It is preferable to have either a simulator that is exactly the same as the tools used at work or a simulator tool that is completely different. If you allow time for the learners to adapt to a new simulator interface at the start of your simulation session, they will get used to it and use it well. Simulators that are similar to the normal forecast production tools but have subtle differences in the way they are operated, tend to irritate learners during the exercise because they have to behave differently from their normal conditions. This may adversely affect the learner's performance in the simulation.

2.6 Results

During training courses, participants have said that the simulations greatly enhance the practical side of the courses and allow them to develop their skills. An important element of simulation training is the debriefing after the simulation exercise. It enables participants to reflect on their meteorological and decision-making skills used during the simulation. In this context, standard meteorological competency frameworks such as those offered by the *Compendium of WMO Competency Frameworks* (WMO-No. 1209) are useful in designing simulation experiences for either training or assessment. For example, the regional satellite training course Baltic+ 2019 used Google forms as the place where students entered their answers to specific tasks during a simulation. This allowed the facilitators to gather data and follow the progress of more than 20 participants in real time. The data were used during the debriefing to show the choices that the students had made and provide feedback on the best approaches in communication with customers. Debriefing can be aimed at increasing a student's critical skills.

Another aspect that has been discovered is that learning times can be shortened when including simulations in training programmes. Each simulation session can cover many different aspects of the job and, last but not least, online simulations can be used day or night, regardless of the weather conditions outside the window! The Italian Civil Aviation provider (ENAV) has revised its training procedures for the initial training of meteorological technicians (MTs) and has included simulations at three different levels: basic, advanced and operational (Figure 2.8). The simulators used in all these simulations reproduced ENAV's operational suite (Figure 2.9) for MTs. Different weather conditions were designed to prepare the MTs to face every possible weather scenario. After the first course, results were well above expectations, not only because students were fully competent and ready to work under supervision in a short time (4 weeks), but also because all of them showed motivation and engagement during the entire course.

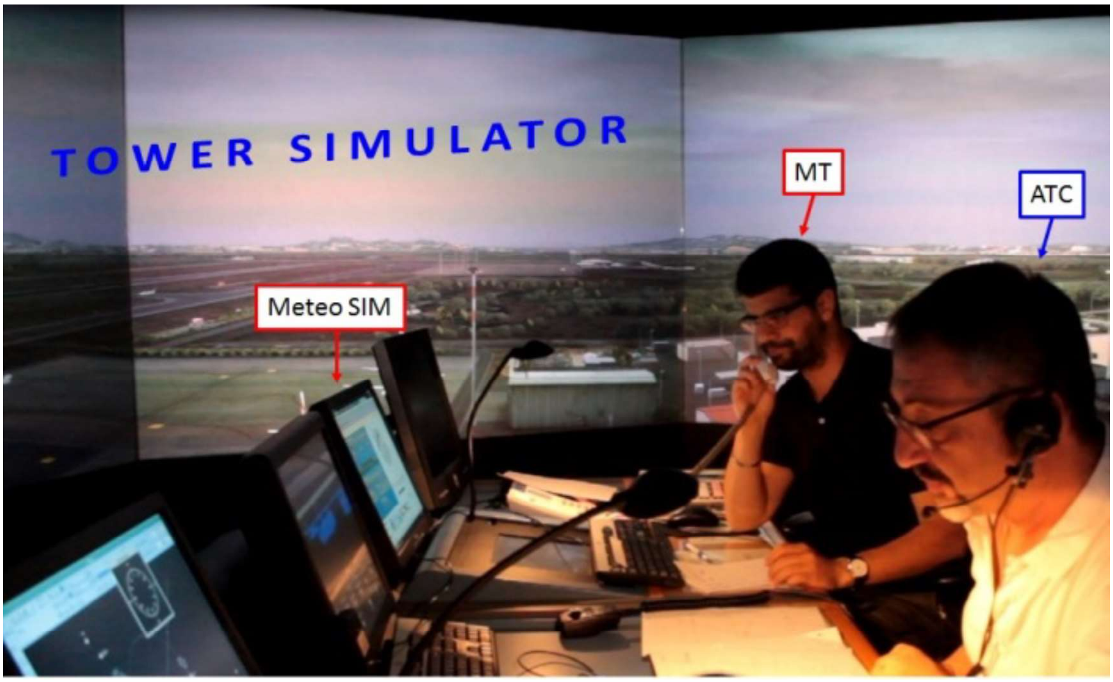

Figure 2.8. Integrated MT-ATC simulation for practice in an operational environment
Source: ENAV spa

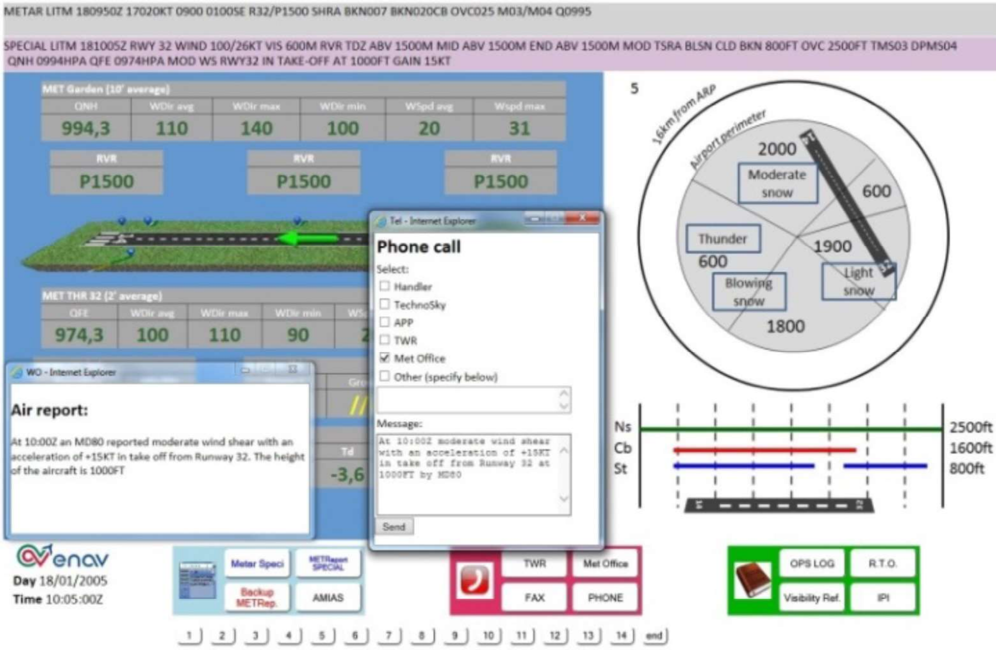

Figure 2.9. ENAV's SIM interface for practice on coding and coordination procedures using popups
Source: ENAV spa

When the Argentinian National Meteorological Service (SMN) started to use simulations in its training, it was found that they provided better learning experiences. The idea of developing a simulation is challenging and motivating, and building simulations requires teamwork. The major asset for SMN is that building these simulations encourages personnel from different departments to work together and to collaborate in the development of the training programme. Using simulators during training is catchy and gives a new perspective on training (for example, active learning, student centred, competency based) within institutions. Others wanted to try it and now it is spreading on its own. In addition, the use of simulations has given training a higher status within SMN.

2.7 Recommendations for further implementation

One area for future development of simulations is the inclusion in the simulation feedback of realistic consequences of learners' decisions . Realistic consequences may include an angry customer or even a serious accident or significant loss. With realistic consequences, learners will see the impact of their actions and will have to reflect on different strategies and approaches to use in the future. Learners can repeat simulations, they can experiment with different strategies until they find the one that works best. This engages the natural learning process of making mistakes, reflecting and trying something different that may be of use even in situations beyond those the learners worked on in the simulations.

Luckily there is still a lot to invent in the development of new simulations. Integrating virtual reality and 360 images generates a new feeling of being immersed in the simulations. This is SMN's challenge for the 2019 Meteorological Observations course (for WMO Regional Associations III and IV). The plan is to continue developing modules in collaboration with training partners to stimulate innovation and to increase the use and reach of simulations.

As more people get involved in developing simulations, there will be a wider variety of approaches, showing how people tackle problems in different ways. Many services are thinking of ways to engage trainees by creating new simulations. This can be done by encouraging learners to bring their own cases to training sessions on building simulations, thus co-creating the learning artefacts in cooperation with their trainers. The Argentinian National Meteorological Service is now considering running a simulator competition in which participants will work in teams to produce the best simulator for a specific training purpose in one week. The Royal Netherlands Meteorological Institute has good experience with a rotating team of assessors from the operational work floor who prepares and assesses the simulations.

Additional resources

A brief summary about creating simulations, prepared by Tsvet Ross-Lazarov, Bruce Muller and Patrick Parrish, is available at https://docs.google.com/document/d/1fWJsJdVPP-G7FtDhw8ebP_y17tEtREpj4xQTPfH2jUw/edit?usp=sharing.