Multi-dimensional Approach for the Pedagogical Assessment in STEM Technology Enhanced Learning

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Abstract: The concept of the NEWTON project is based in an identification of the challenges and barriers in creating engagement and enthusiasm amongst STEM students and recognises the need to stimulate and embrace the type of change that innovative technologies can bring. Thus, NEWTON focuses on employing novel technologies to increase the quality of the learner experience, improve learning processes and increase learning outcomes. One of the major challenges of the project is to validate the platform impact and the effectiveness of the teaching scenarios in terms of learner satisfaction, improvement of the learning and teaching experience, and the evaluation of underlying technology through European-wide real-life pilots. In this paper, we describe briefly the criteria to be taken into account for technological learning systems evaluation from a pedagogical view point. After setting out the different dimensions of learning to be evaluated, we describe the iterative approach adopted to ensure that there is a continuous feedback loop created thereby ensuring that the results of all pilot activities are shared and are informing future iterations of the NEWTON solution. Finally, we provide a few details of the work plan designed to guide all stakeholders involved in the project pilots. This work is dedicated to teachers and teaching organizations willing to engage learners in STEM education.

Introduction

Technology enhanced learning is widely seen as the future of education, with personalised learning journeys created through adaptive software, taking into account the uniqueness of every student. These advances are not meant to replace the teacher in the classroom, but rather provide them with tools that will enable them to teach students at different levels, while keeping everyone engaged and up to speed. Technologies will change the role of the teacher – and this has to be part of our evaluation – but a change in role can be positive as part of a wider drive towards more dynamic, interactive and experiential forms of learning.

The concept of the NEWTON project is based in an identification of the challenges and barriers in creating engagement and enthusiasm amongst STEM students and recognises the need to stimulate and embrace the type of change that innovative technologies can bring. Although the rationale of bringing such novel technologies into the classroom is clear, we also recognise the need to:

- link the use of technologies with the application of new and existing pedagogies in a way that ensures effective learning and that goes beyond the mere 'novelty' of adding a new piece of technology to a learning process
- demonstrate how any new technology can adapt to the curricular demands of different learning institutions and support the delivery of learning content that builds required knowledge and skills
- understand better how the use of novel technologies impacts on the role of the teacher, on their preparation prior to learning, their interactivity with students during learning and the evaluation and assessment of students after learning
- identify and analyse the practical implications of implementing new novel technologies within a learning environment including an assessment of the impact on resources, time, cost and so on

The NEWTON project is unique in that the solution is an integrated, gamified system that utilises a number of novel technology components, such as game-based learning, gamification, Virtual and Augmented Reality, Personalisation and Adaptation, Mulsemedia, etc.

NEWTON[1] focuses on employing novel technologies to increase the quality of the learner experience, improve learning processes and increase learning outcomes. Furthermore, NEWTON aims to implement personalisation and adaptation for content, delivery and presentation. One of the major goals of the project is to validate the platform impact and the effectiveness of the teaching scenarios in terms of learner satisfaction, improvement of the learning and teaching experience, and the evaluation of underlying technology through European-wide real-life pilots. Special attention is be given to the evaluation of the pilot studies, as neither subjective nor objective methods alone are enough to assess all the properties of any given approach, including effectiveness, efficiency, satisfaction, etc. Thus, a framework that combines subjective and objective methods to evaluate the pilot studies, their learning effectiveness, learning efficiency, and learner satisfaction is proposed.

To support the evaluation, we offer a set of theoretical and practical recommendations for all the partners involved in piloting NEWTON proposed technologies and in pedagogical assessment of the impact of these technologies in school activities, both for typically developed students and for students with special educational needs. The objective of this theoretical framework complemented by a practical work plan has been to amalgamate different elements of the NEWTON project that relate to the effective evaluation of the project impact as a tool for teaching and learning.

Our methodology criteria

Specifically, we have identified important criteria to be taken into account for technological learning systems evaluation from a pedagogical view point. These criteria are described below:

- the nature, size and scale of all of the NEWTON pilots and the feasibility of assessment and evaluation within the context of each
- the interaction between the various NEWTON technologies, on the one hand, and the design of the content and experiments to be undertaken within the pilots on the other hand

[1] http://www.newtonproject.eu/

- the relationship between the NEWTON 'platform' (the learning management system we have developed) and the NEWTON 'components' (the various technologies that will be 'plugged into' the NEWTON platform)
- the nature of the data that will be generated through use of the NEWTON platform and how we will be able to use this data in order to inform our evaluation
- the way in which the evaluation and assessment tools that we develop may be useful or otherwise in addressing the impact of NEWTON on learners with special educational needs
- the requirement to address not only the value of the NEWTON approach in terms of promoting learning but also to explore the wider impact of using the NEWTON technology on learner motivation, affective state, teacher role and so on

Our methodology dimensions

In our theoretical framework and practical guidelines and work plan, we have set out the main dimensions to be evaluated: learning outcomes, learner satisfaction, affective state dimension, psychological profile development (an additional dimension that will be evaluated only for students with special educational needs; on this type of learners all the other dimensions mentioned above will be also assessed) and teacher role and satisfaction. For each of these dimensions we present definitions of metrics and methods (objective and subjective) to be used in assessment process and what the toolbox recommendations are. The impact on teacher role is a critical aspect of introducing any new technology into the classroom and in this context we have paid particular attention to the involvement of teachers in the evaluation process. For the evaluation made by teachers we have referred at the following aspects: level of enjoyment/frustration by the teacher in the use of the technology; degree to which the technology supports the teacher in their activity; degree to which the technology helps the teacher to achieve specified learning outcomes.

The work plan for pilot evaluation establishes that once usability and technical performance are addressed for the different learning scenarios of the project, the pedagogical assessment of pilots will be undertaken at three levels:

1. Project General Questions
2. Specific Research questions associated to each particular pilot (Pilot hypothesis), to be negotiated with each pilot.
3. Iterative Learning. We also consider a 3rd level related to the implementation of the pilots. It will be of utmost importance for subsequent pilots to learn from the experience gained in previous pilots. For instance, were the questionnaires understandable and of right size? Was the initial presentation to teacher relevant? Was the training to operate the technology sufficient? Was the information gathering processes efficient? Etc. This learning may be useful beyond the scope of the project, for future deployment of the NEWTON platform, technologies and pedagogical approaches.

Assessment objectives at the didactic level can be designed in the context of the educational process for verifying the quality of the training activity after three pedagogical indicators:

1. School progress – identify if the proposed technologies are implementable in the school infrastructure, if the institution is able to implement efficiently these technologies and how higher technical facilities contribute to improve school activity.
2. School effectiveness - Reporting the results to the general and specific objectives of the curriculum (in terms of competencies) and to the concrete objectives designed by the teacher (in this case we have the normative assessment). In NEWTON one of the objectives of pedagogical assessment is to verify how the use of modern pedagogical approaches and new technologies influences the development of competences in children.
3. School efficiency - reporting of school results to the existing resources in the educational process, (in this case, we have managerial assessment). In case of NEWTON pedagogical assessment, from this point of view, one of the main objectives is to highlight the benefits that NEWTON brings to school results by improving the resources that school has.

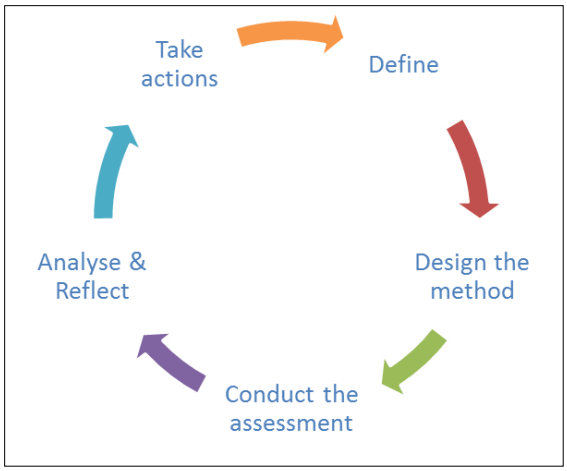

Figure 1: Action research process to be integrated in the evaluation process

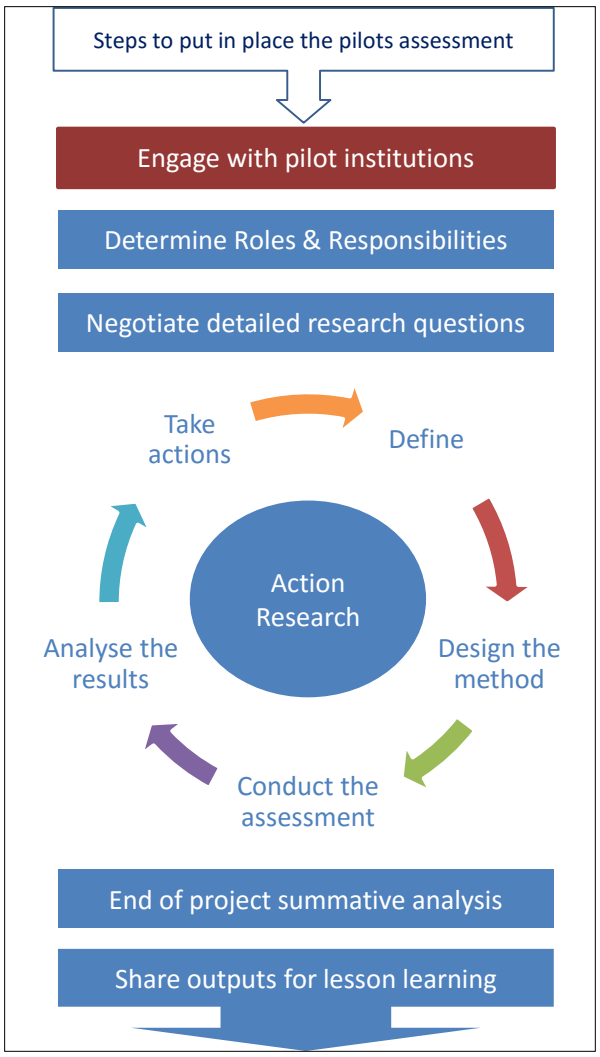

Figure 2: NEWTON Iterative Learning Process

The approach we are taking to assess is iterative and should ensure that there is a continuous feedback loop created thereby ensuring that the results of all pilot activities are shared and are informing future iterations of the NEWTON solution. We need to guarantee that there is a clear coherence between the type of pilot and the type of evaluation run. Although our aim is to create standardisation across the evaluation process, we must also recognise that we cannot run exactly the same evaluation for all pilots and that some aspects of the evaluation will be dependent on size, scale and context. Specifically, longer pilots will give us the opportunity to explore more deeply some aspects of learner progress whereas shorter pilots or 'one-offs' may be better focused on learner experience with the technology.

In order to ensure that our approach is iterative, we will broadly follow the model set out in Figure 1 above. It illustrates the iterative action research approach recommended in the evaluation process. In each iteration of the evaluation loop, the researcher will start by defining the evaluation goal, the research question, and the expected learnings of the evaluation. The researcher will design the methodology from the NEWTON evaluation toolbox based on the evaluation goal and research question(s). After conducting the assessment and analysing the results, the researcher (or the research team) will recommend and suggest actions to be taken. These outcomes will be shared within a communal online environment with other Pilot Leaders and other researchers working with pilots.

As shown in Figure 2, some of the steps to put in place the pilots' assessment have been defined and are planned. For example, initial engagement with pilot institutions, initial research questions, steps of the intervention.

We will also be able to generate similar data in relation to teachers – we will be able to evaluate how specific NEWTON elements fit with particular teachers from different backgrounds, contexts and situations. Not only will this data help us to continuously improve the NEWTON platform and components, but it will also provide us with a wealth of data that we can report back on, thereby ensuring that the NEWTON project makes a significant contribution to further an understanding of state of the art and, ultimately, to standardisation.

Concluding Remarks

The theoretical framework and complementary work plan represent a guide for all partners involved in piloting. We have included the main steps to be followed in order to gather relevant data from each and every pilot, regardless of the type, size or nature of the pilot. The work plan starts with clarifications on the terms we use (small-scale pilot, large scale-pilot, direct learning, indirect learning etc.) and with the presentation of the main objectives and methodology of pedagogical assessment. The main roles and responsibilities are established in order to ensure that all activities are coordinated and performed in alignment with the pedagogical assessment objectives. All participants in the pilots will be assigned a specific role and associated responsibilities. The work plan then presents the different phases and activities that will take place during the assessment and underlines the importance of a strong relationship with the partner institution that will host NEWTON pilots. Teachers are active partners in the pedagogical assessment and they will be involved in every step of this process.

Finally, the proposed methodology considers the support of a 'Pedagogical Assessment Committee', which is a group of NEWTON experts who will act as a guide, partner and critical friend to all NEWTON pilot leaders, ensuring that the assessments undertaken in each pilot study are in line with the overarching strategy set out in the methodology and that all results are collated, analysed and shared effectively across the project. All partners will be familiarised with the methodology and key elements of the work plan will be summarised and shared with participating institutions. The first pilots using the methodology have started in February 2018 in Ireland. They have taken on board the guidelines and have designed an assessment process aligned with the proposed approach. The NEWTON research community expect to able to share the first informal results by mid-June.

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