Issues, Initiatives and Prospects of ICT Use in Chemistry Teaching

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Abstract
*In 2013, the AWT [1] conducted a large survey to make an assessment of ICT equipment and use in compulsory education in Wallonia. It came to the conclusion that there is a lack of computer material and teacher training. Yet, ICT are part of our society and of students' environment. Moreover, ICT have many assets to help every student succeed. These observations should lead the stakeholders of education to consider a well-thought integration of ICT in education. To make chemistry learning more efficient, the investigative approach is unavoidable in secondary education. ICT specifically integrated in this approach should make it possible to overcome certain obstacles that are typical of this complex and abstract discipline. Indeed, without replacing real experimentations, ICT can support the investigative approach at different moments of the process in order to make the transition from the macroscopic to the microscopic level and to symbolic writing easier. This article will outline a pedagogical scenario designed for this purpose. This type of pedagogical scenario is one current concern pointed out in the survey by the AWT. In this respect, a project "*École numérique*" (literally: "digital school") has been initiated by the Fédération Wallonie-Bruxelles (French-speaking Community of Belgium) to fund innovative projects that integrate ICT. One of those initiatives in chemistry, conducted in a pedagogical section of a college, will be described. Finally, the article will outline other important axes such as future issues concerning emerging technologies and (future) teachers' professional development.*

1. ICT equipment in Wallonia
According to the results of the AWT survey on "Equipment and Use of ICT 2013 in Schools in Wallonia", the availability rate of ICT equipment in schools barely reaches half of the European average [1]. The comparison could be made thanks to the recent study "Survey of Schools: ICT in Education" conducted by European Schoolnet for the European Commission [2].
Indeed, the current situation of ICT equipment in Walloon schools can be summed up in four points:
1) At the secondary level, there is one computer per seven students and at the primary level, a bit less than one computer per twelve students.
2) Laptops and digital tablets are only 8% of the whole.
3) There are interactive whiteboards (IWB) in 27% of schools, mainly secondary.
4) 55% of schools have WiFi [1].

2. Well-thought use of ICT
Thanks to the digital tools used in class, it is possible to diversify pedagogical practices, motivate students exploiting the resources of the digital world they use every day and individualise work by increasing students' involvement and attention [1].
Despite these assets and the importance of ICT at the socio-professional and educational level, in Wallonia, Canada and elsewhere in the world, the use of ICT in a school context remains a huge challenge [1, 2 and 3]. It is necessary to search which uses of technologies by teachers and students need to be implemented to support a larger educational success [1, 2 and 3]. The article "*Les plus-values des TICE au service de la réussite*" ("The Benefits of ICT at the service of success") analyses in this sense the uses of ICT and the related benefits for students and teachers in different subjects. These benefits related to chemistry are

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mentioned: the student is an actor of their own learning, motivation and valorisation, easier learning, pedagogical continuity and immediate knowledge of the results [4].
Nevertheless, the use of ICT must be well-thought out. Digital tools must make existing teaching practices richer and livelier but not replace them! Indeed, in sciences, observation and experimentation of the real world must prevail over the virtual world [1, 5 and 6].

3. Integrating ICT in an investigative approach

The action research "*faire des sciences entre 10 et 14 ans, c'est mener une démarche d'investigation*" ("Doing sciences between 10 and 14 years old is conducting an investigative approach") reminds the place of experiment in the classroom in a more general pattern of investigative approach. It emphasises the necessity to approach reality through different means (experiments, observations…) and above all to be aware that this activity must come along with a more global intellectual approach in order to fully reach the learning objectives. This research attempts to provide answers to make science learning more efficient, at the level of knowledge and approaches likewise. The researchers concluded that "doing sciences" means conducting a real investigative approach, which is the didactic transposition of a science research in the same way as a scientific researcher does it [7].
The contribution of the article "*Du questionnement à la connaissance en passant par l'expérience*" ("From questioning to knowledge through experiment") [5] is particularly interesting to consider the transposition of this approach to older students. Indeed, in Belgium chemistry lessons begin in the second cycle of secondary schools, thus is with 13-14 year old students. Whatever the age of the learners, the two sources agree on the principles of unity and diversity of an investigative approach. Indeed, there is a common thread with the unavoidable steps: the students' questioning on the real world (starting point), a students' investigation guided by the teacher that leads to final structuring (finish) [5 and 7]. Diversity is characterised by the "path" followed by the students. Between questioning and structuration, depending on the subject, various investigative methods can be used (direct experimentation, research in documents…). Moreover, toings and froings between those moments are desirable. Nevertheless, each identified step is crucial for a well-thought investigation by students. Obviously, experimentation and direct action by students on reality must be favoured [4 and 5].
Those sources support the first conclusions of the "Chemistry is All Around Network" project [8] that points out the necessity to establish meaningful learning activities fostering experimentation in order to increase students' motivation. Moreover, a proven obstacle to chemistry learning is the transition to abstraction, that is from the macroscopic to the microscopic level [8]. With a mean to turn students into actors of their own learning while making this transition to abstraction easier, ICT seem unavoidable [4 and 8]. Indeed, those tools integrated at certain key steps of the pedagogical scenario are an undeniable benefit for learning in chemistry [4].
Therefore, it is necessary to build pedagogical scenarios integrating ICT resources in a specific way (videos, animations, IWB…) in order to support the investigative approach with a view to a gradation of abstraction levels. With those scenarios, it would be possible to develop many scientific, technical and transversal skills [4 and 6].
Integrating the contributions of those various articles, I could build a diagram (fig.1) with the key moments (unity principle) of the investigative approach and the many possible links between these (diversity principle). Depending on the subject addressed, ICT can be used at different moments of the process.

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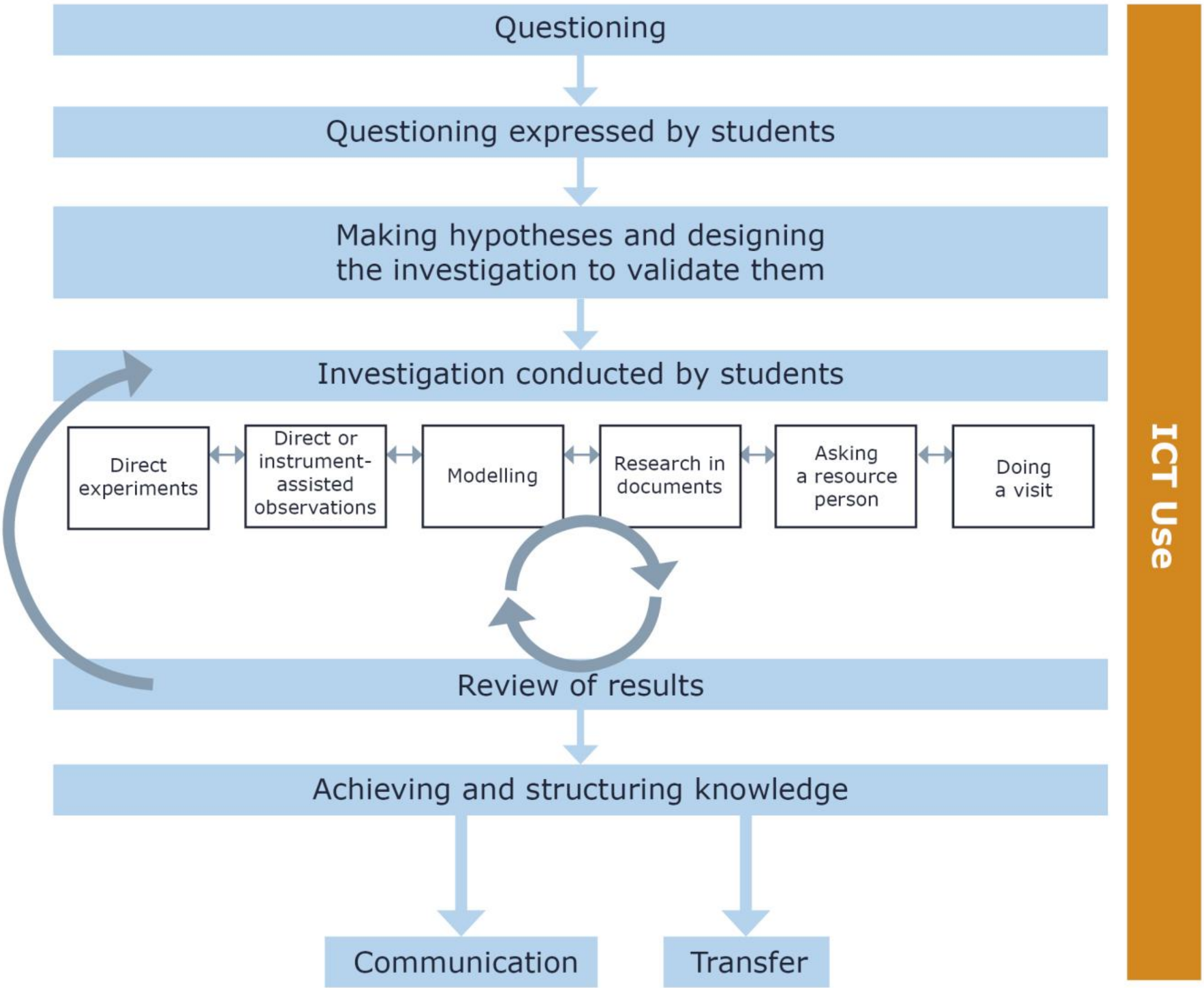

Fig. 1. Diagram showing the integration of ICT in the investigative approach

3.1. How can ICT support the investigative approach?

In order to experiment a pedagogical scenario based on those theoretical contributions, I built a pedagogical scenario on interactive whiteboard (IWB). The theme developed was the discovery of the chemical reaction for students of the second cycle (14 years old) of secondary school [9]. This scenario was tested partly with 1st year university students (future science teachers) and partly with 3rd year secondary school students. Thanks to those first targeted experiments, it will be possible, through a reflexive analysis, to identify and analyse the strengths and weaknesses of the activities at different moments of the process.

In this scenario, the ICT resources integrated in the IWB are mainly used during the questioning, students' hypotheses, investigation, results analysis and communication phases. The IWB is a medium with many advantages regarding communicational as well as didactical quality to support the investigative approach. cf. complete analysis [9].

To support the phases of experience observation, dynamic phenomena modelling and transition to symbolic writing of chemical equations, the learning sequence integrates the use of videos and screen captures, traditional modelling and modelling supported by flash animations [3] and existing ICT resources [11]. It is a "conceptualisation" type modelling that simplifies phenomena at best to bring out the concepts more easily (conceptual models) in order to help students build a mental representation of them. It is unavoidable in

chemistry to help students overcome their understanding problems [10]. In this regard, animations are considered relevant to illustrate the dynamics of a phenomenon but they must not disturb the investigative approach (questioning and investigation phases). Moreover, one must make sure that students are able to put things into perspective when facing modelling. Indeed, a model can simulate one specific aspect of a phenomenon but it can generate wrong representations due to its simplifying feature [5].
Generally speaking, the teacher must always use ICT resources appropriately and at the right moment of the learning to avoid the misuse that would be an exclusive use of computer tools [12].

4. Current and future issues of ICT for teaching and learning

The conclusions of the AWT survey emphasise the necessity to develop a systemic approach of ICT dissemination putting (back) the teacher at the core of the process. To do so, six priority axes of recommendation are expressed. Beside ICT equipment in schools, they mainly concern teacher training and supervision for the pedagogical use of ICT, the creation of digital resources, expertise sharing and a narrower cooperation between the stakeholders in the development of the digital school. [1]

4.1. Digital school

All the recommendations and initiatives show the scale of the construction of the "digital school". "*École numérique*" is an initiative of the Fédération Wallonie-Bruxelles (FWB) to fund innovative educational ICT-based projects. One priority for this school year is the "pedagogical sections in *hautes écoles*" [13] (*Hautes écoles* are non-university colleges that train, among other, lower secondary school teachers.)
Our *Haute école*, HELMo, was chosen to carry out various projects including the one I initiated: the working group called "TIChimiE". The main objective of this working group is to build together open pedagogical scenarios in triangular cooperation "2nd year university science students – internship supervisors – HELMo science teachers". Those scenarios have to favour the investigative approach while specifically integrating ICT. The cooperation with Inforef provides technical support. The project emphasises some of the priority axes of the AWT [1] and of the project "*École numérique*" [13]:

- teacher and student training before and during the project (technical and didactical continuing training provided in cooperation with Inforef);
- initial training of future teachers to implement ICT in their pedagogical approach and to create pedagogical contents and resources;
- possibility to assess the relevance of the use, in the education context, of a large range of technological equipment (IWB, tablets, cameras...) and digital resources;
- experimentation of new ICT-supported pedagogical uses in the context of skills-based education, as it is carried out in the FWB;
- use of new projection and tabular presentation devices, multimedia equipment, online sharing and production devices, online communication tools...
- organisation and structuration of the sharing of tools and of pedagogical scenarios integrating ICT (dissemination through a platform such as MOODLE ...).

This dissemination through a platform would lead to a larger experimentation and interesting feedbacks for a reflexive practice.

4.2. Teacher training and future prospects

Training teachers to pedagogical and digital uses, a priority in many countries [1, 3, 10 and 13], would increase teachers' confidence in their own competence. However, beyond training, continuing attention is indispensable to identify ever-evolving digital tools. Moreover, a process that is crucial to professional development also needs to be integrated: reflexive practice. ICT can support this practice. Kaserti and Collin's article [3] highlights ideas to be explored such as virtual communities of practice, the electronic portfolio or video analysis of practice in the context of online self-training.
This article also considers emerging technologies and what they mean for education. Digital learning

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environments (integrated learning platforms, mobile learning, distance education or hybrid devices that include on-site and distance education) are interesting to develop in order to make learning individual, foster autonomy and increase interactions [3].

Indeed, a platform could be considered as a real space for interactive learning activities aiming to develop skills based on delineated pedagogical scenarios. This interactive meeting place would help increase students-students and teachers-students interactions, implement different forms of differentiation [14], create remediation tools ... The digital platform would also make it possible to test the “flipped classroom” strategy [15] and new innovative online evaluation practices such as the post-evaluative strategy with individualised feedback.

All these aspects show that future issues are opportunities to improve chemistry learning and teaching.

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