Analysis of interactivity and autonomy of existing digital educational resources: the case of Life and Earth Sciences in Morocco

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ABSTRACT

The educational policy in Morocco is aimed at promoting the wide use of Information and Communication Technologies in Education and the adoption of interactive and autonomous digital resources for distance teaching and self-learning. The objective of this research is to evaluate the suitability of the existing digital educational resources for distance learning purposes by analysing their interactivity and autonomy. The study of the contents of 190 existing products for teaching and learning Life and Earth Sciences in high schools has revealed the existence of weaknesses related to interactivity and autonomy. The results have been used to set down guidelines for designers of future interactive and autonomous digital educational resources for distance learning use.

Introduction

The integration of Technologies of Information and Communication in Education has a priority for the official texts of the Moroccan Ministry of National Education (MNE 2008a, 2008b). Indeed, the National Charter of Education and Training, adopted in 1999, insisted on the use of Digital Educational Resources (DER) as a means of improving the quality of teaching (Special Commission for Education and Training [SCET], 1999). The use of digital tools in teaching was also reinforced by many government programmes such as the GENIE programme in 2006–2011 and the Emergency Plan of 2009–2013 (MNE, 2008a). The government’s efforts have led to the investment of 53 million dirhams to purchase DERs that foster classroom learning, the creation of the National Laboratory of Digital Resources (NLDR) as well as some official platforms for promoting and disseminating information relating to education (NLDR, 2012). In the same context, the programme for validation and labelling of DERs [VAREN] was launched in 2013 by the Ministry of Education, with the collaboration of Microsoft. The main objectives of VAREN were certifying and encouraging the use of DERs produced by teachers or local cells experienced in the engineering of digital tools. Ministerial documents evoked the growing demand on interactive resources. The most desired resources
were questionnaire-generators, multimedia courses, tutorials, exercises, animations and simulations (MNE, 2008b).

The Economic, Social and Environmental Council (ESEC, 2014) recommended supporting the use of new technologies for teaching experimental sciences. This recommendation was further justified by the increasing number of Internet subscribers in Morocco and the diversified and increasingly widespread use of connectable digital tools (smart-phones, tablets, computers …) by youngsters. The targeted population is living in a world increasingly dependent on digital tools and is willing to interact with new educational technologies (e.g. MOOCs, flipped classrooms and Learning Management System platforms).

The growing interest in e-learning is a result of the technological development in various disciplines and the dynamic growth of the information technology market in Morocco. The second reason is the need to connect isolated areas of the country and serve people with disabilities (ESEC, 2014; SCET, 1999). But at the present time, the implementation of e-learning is inevitable for educational institutions in order to provide good quality training to mass populations and to reduce costs and time constraints.

The Moroccan educational reform has been based on the adoption of the competency-based approach, which focuses on active learning and is based on the learner motivation, giving thus greater importance to varied learning activities and respecting learner diversity (Bosman, Gérard, & Roegiers, 2000; Le Boterf, 1994; Tardif, 1998). The use of appropriate digital equipment is aimed at facilitating learning and generating learner interest. Practically and according to the adopted approach in Morocco, the learning sequence consists of a succession of three main steps: (1) establishing a learning situation that sets the context and significance of learning, (2) the dynamic learning activity targeting skill construction and (3) the learning evaluation. Skills relating to specific competencies targeted in each level of high school are defined and listed in pedagogical guidelines and curricula, such as the case for Life and Earth Sciences (LES; MNE, 2007). Meirieu (1996) related the effectiveness of the learning situation to the degree of guidance in a learning sequence conceived to achieve one or more learning objectives, whose levels are classified by Bloom, Engelhart, Furst, Hill, and Krathwohl (1956) and modified by Anderson et al. (2001) (as cited in Krathwohl, 2002). These considerations constitute a challenge facing the use of DERs which must have specific characteristics to meet techno-pedagogical requirements. The hurdle is higher for distance learning. Indeed, a DER has a first component ‘content’ relating to the transmitted information, and a second component ‘process’ relating to the ability of the resource to respond to the learners’ initiatives (Baron & Dané, 2007; Bibeau, 1992). Active distance learning requires the use of DERs to help the learner to be autonomous, motivated, aware of the process of learning and able to build up competencies.

Expectations of various reform programmes (MNE, 2008a) and those of protagonists of education in Morocco, notably the SCET (1999), the NLDR (2012) and the opinion of the ESEC (2014) are all in agreement with the results of discussions about e-learning in Morocco, held by teachers and teacher trainers at meetings and symposiums (Ettazarini & El Jakani, 2015). Consequently, DER as defined by Bibeau (2005) must meet certain requirements to be adequate for interactivity and autonomy in distance learning. The main requirements are as follows:

- To be consistent with the skills list for each level of the school curriculum;
- To provide diversification of intellectual operations for the learner through varied interactivity;
To ensure the learner’s autonomy through well-organised content, fairly comprehensive and focused on the targeted competency;

To offer assistance to the learner during the main stages of the learning event.

The necessity to meet these requirements for an effective distance learning is not only specific to the educational system of Morocco. Indeed, a lot of countries are adopting the same educational approaches and use similar digital materials available in various languages. Therefore, the challenge is the same for all countries, just as solutions for problems relating to distance learning are the same.

Starting points and hypothetical situation

One should take into consideration the earlier efforts of the government to provide DERs, 90% of which are applicable to the classroom (MNE, 2008b), as well as the majority of DERs produced by innovative teachers, which are also classroom-acceptable (Ahaji, El Hajjami, El Mokri, Ajana, & Chikhaoui, 2008). In addition, Morocco has joined different international projects on the integration of new technologies that promote the rapid development of distance learning. Here, a big question emerges: ‘If the existing DERs are suitable for class teaching, would they be also suitable for distance learning?’

Using LES as an example, the existing situation corresponds to the view of a large part of stakeholders and practitioners in the field of education. This reality is a consequence of discussions about e-learning and existing digital materials. Thus, the hypothesis statement is:

Despite the existing DERs conforming with high school curricula and classroom use, they do not offer the desired autonomy and interactivity to serve efficiently in Distance Learning. And due to the scarcity of DERs specifically designed for e-learning, it is important to have a vision for future DERs based on criteria enabling the resources to meet the previously mentioned requirements.

Study objectives

In order to contribute to the improvement of the techno-pedagogical content of future DERs, adapting it to distance learning stipulations in LES, two main objectives were set:

• Conducting an expert evaluation of DERs, based on criteria relating to interactivity in terms of learner actions, and autonomy expressed in the degree of guidance and accompaniment provided to the learner, as well as the potentially targeted skills (Table 1(a)). The evaluation combines a checklist and statistical methods to assess DER suitability for distance learning and to reveal meaningful inferences;

• Making suggestions and proposals for guiding future designing and production of DERs serving for distance learning of LES.

Description of the sample studied

The sample consists of 190 DERs frequently used by high school LES teachers. The evaluated sample, although appearing large, is assumed to be representative of the diversity of available materials. Nearly 360 DERs are provided by the GENIE programme and are proposed for use in the classroom; about 26% of them were evaluated. Other DER sources frequently
used by teachers in Morocco were considered in this study. The study sample is thus composed of:

- Resources from the GENIE programme retrievable at eduMedia-sciences website (93 products);
- Resources from the eduMedia-Share website (27 products);
- Resources from the website of the Academy of Rouen (19 products) and
- Resources from other educational websites (51 products)

These sampled DERs take different forms: simulations, illustrations, animated flash images, flash video sequences and educational games. Some DERs are a compilation of more than one type of these. DERs were presented in different languages: French (61 products), English (35) and Arabic (93). They covered life sciences (82 products), earth sciences (67) and environment sciences (41). 163 DERs were delivered with a copyright licence, while 27 were open to the public under Creative Commons licence conditions. The resources from the GENIE programme were available on DVD support. Those from eduMedia-Share were downloaded from the corresponding website, while DERs belonging to Rouen Academy and other educational websites were evaluated directly online between May and August 2014.

**Methodological approach**

The methods and criteria used to evaluate a DER are varied (Britain & Liber, 2004; De Vries, 2001; El Mhouti, Nasseh, & Erradi, 2013). The method adopted in this study consists of a
checklist and a statistical analysis using SPSS software. DER interactivity and autonomy are seen as key elements in distinguishing between DERs adequate for classroom learning and those suitable for distance learning. These criteria focusing on the techno-pedagogical content are also adapted to the competency-based approach.

Interactivity corresponds to dynamism in a learning system where the learner engages with material that is responsive to his/her actions (Thomas, 2001). In the DER-based e-learning, it concerns learner–content interaction that refers to any interactive activities between the learner and instructional content in an online teaching environment (Moore, 2016). When a multimedia-based e-learning environment offers more learner–content interaction, learning performance and learner satisfaction can be improved (Zhang, 2005). Practically, the DER offers some onscreen elements by which the learner can interact with the content. The interaction between the learner and the content through the DER is thus possible by simple and advanced learner actions as defined in Table 1(a) and considered as indicators of the DER interactivity.

According to Goulão and Menedez (2015), greater autonomy implies a greater maturity, greater motivation and greater self-discipline because more freedom implies greater responsibility for the learner. Holec (1981) defined autonomy as being the ability to take charge of one’s own learning. But in a formal educational setting, context-dependent and instructions-guided autonomy is beneficial for the learner. This is because supervised autonomy helps avoid the use of inadequate material causing irreparable misconceptions. This kind of autonomy provides better educational experience of an active learner. Indeed, a relevant learning experience places the learning in a real context for the learner and offers the possibility to get information, process it and make decisions. The instructions set up tasks and goals to be achieved by the learner (Raynal & Rieunier, 1997). This guidance is provided by the DER to the learner to help him/her become aware of the learning process. The presence of a learning context and instructions remains among the major indicators of quality in terms of autonomy, particularly for DERs designed for distance teaching and self-learning. The coverage of the main stages of the learning sequence was inspected as a second indicator of the autonomy of a DER. Targeted skills are the ultimate goal of the learning sequence and are conveyed through pertinent interaction of the learner with the content. The diversity of potential targeted skills in a DER constitutes the third indicator of autonomy (Table 1(b)). For each case, potentially targeted skills are defined in accordance with the skills and competencies defined in the official documents for high school levels and the LES branch. This step helped us to distinguish the most targeted skills within DER from those most neglected.

**Database building and processing**

Sampled DERs are run and their techno-pedagogical content is carefully analysed. In an excel database, an ID from 1 to 190 is assigned to each DER. Information relating to the learning domain, form of DER, language, source, licence is entered as nominal variables. The descriptions referring to the use of instructions, learner actions and potential targeted skill as well as the coverage of the learning sequence stages are entered as numeric variables by attributing value 1 to the presence and 0 to the absence of each. Every learner action (there are 15 actions) is checked separately. The same approach is adopted for the stages covered in the learning sequence (there are 3 stages) and targeted skills (there are 18 skills). The generated database concerning all the sampled DERs is used to calculate the values of the
interactivity and autonomy indicators and the total score for each DER as shown in Table 1(b). The DERs are thereafter arranged into five classes covering the variability range of the final scores. The database is then transferred into a SPSS environment to perform advanced statistical analyses and provide additional information by using descriptive and inferential statistical methods. Indeed, one of the important functions of SPSS software is the Multiple Correspondence Analysis (MCA) that corresponds to a generalisation of Principal Component Analysis, useful to study the pattern of relationships of several nominal variables. Another function used in this research is the Analysis of Variance [ANOVA] that can be defined as a statistical technique for determining the degree of difference or similarity between two or more groups of data. It is based on the comparison of the average value of a common variable. The Scheffe Post-Hoc test, as a complementary possibility offered by the SPSS software was also used to illustrate the ANOVA results graphically, to determine the status of officially recommended resources compared with other existing products and to reveal the learning domains in which interactive and autonomous DERs are mostly in demand.

After developing the evaluation instrument, it was presented with preliminary results and discussed by experts in digital-based teaching during the International Symposium on e-learning in Casablanca 2015. The encouraging remarks and suggestions relating to the presented method enabled the current research.

Results

Learners’ actions

The inventory of learner’s actions found in the analysed DERs showed 15 used actions. Briefly, these actions are expressed in terms of simple and advanced action verbs.

Figure 1(a) illustrates the number of DERs using each of the seven simple learner’s actions. It shows that the actions ‘click’ and ‘watch’ are the most frequent and are used in 170 and 158 DERs, respectively, they are followed by the actions ‘read’ and ‘check/select’, which are used less frequently. The actions ‘zoom’ and ‘navigate’ are underrepresented in the studied sample, while ‘listen’ remains the least common action since it is used in 5 DERs only.

Figure 1(b) shows that advanced learners’ actions are less frequent when compared with simple actions. The mostly used action is ‘drag and drop’. But it was found in 7.9% of DERs only. The actions ‘type/insert’ and ‘print’ are used in a few products. Other advanced actions, such as ‘link’, ‘draw’, ‘build’, ‘calculate’ and ‘save’ are very rare; each of these actions was used by one resource only. These remarks concerning DER interactivity align with earlier researches. Indeed, Boucheix and Rouet (2007) have already raised the issue of the inefficiency of multimedia interactive animations for learning. Their study reveals that this type of DER, supposed to be dynamic, is far from guaranteeing a systematic advantage over static illustrations. Difficulties can be observed in the weak interaction, the lack of guidance and the inadequacy in the process of information delivery.

Instructions statements and learning sequence coverage

Thirty-five DERs provided instructions that direct the learning activity. They were fewer than those without instructions (n = 155). Guidance is thus missing in the majority of the analysed DERs.
In addition, products whose contents form a fairly complete learning sequence, including the three main steps, constituted only 6.32% of the entire analysed DERs. The remaining products showed incomplete and truncated sequences. About 77% of the resources concerned the learning step only and neglected both the learning situation and evaluation steps.

**Targeted skills**

Figure 1(c) shows the number of DERs potentially targeting everyone of the skills listed in Table 1(a). The skills mostly targeted by more than 93% of the resources are: ‘get informed’ and ‘observe’. The DERs targeting the skills ‘simulate’, ‘restore’ and ‘compare’ represent, respectively, 81, 67.9 and 59.47% of the analysed resources. ‘Identify’ and ‘explore’ are two skills respectively targeted in 37.9 and 36.3% of products. The skills targeted at an average rate are ‘orient’, ‘classify’, ‘evaluate’ and ‘experiment’. The remaining skills, notably ‘exchange/communicate’, ‘present’, ‘measure’, ‘sample’, ‘express’, ‘detect’ and ‘argue’ are rarely addressed. These results confirm that a large number of targeted skills, listed in the governmental guide are not integrated in the majority of the DERs studied. To overcome these problems, future DERs...
must target more skills through the integration of various learning activities requiring content manipulation by diversified learners’ actions.

Global assessment and score distribution

The DERs were assessed as shown in Table 1(b) and ranked into five classes relating to their suitability to distance use (Table 2). The higher the score is, the more important the interactivity and autonomy ensured by the resource. The classification revealed that among the 190 DERs analysed, none is ranked in the first category. Only two products are in the second category and offer good conditions of interactivity and autonomy (Table 2). They are efficiently used for distance learning on pedagogical websites. The third category is grouping DERs that provide acceptable conditions; it concerns 6.84% of the analysed sample. The majority of DERs, forming 71.05%, is classified into category 4 and offers just a few opportunities for interactivity and autonomy; fewer chances exist for category 5 which includes 21.05% of all resources. Therefore, the interactivity and autonomy of the DERs studied are generally medium to low. The observed averages of partial scores relating to simple actions, advanced actions and targeted skills are calculated for 190 resources, and following up the learning areas as shown in Figure 1(d). The environment domain recorded the highest averages, while advanced learners’ actions were the less common for all learning domains.

MCA and inferential statistics

The MCA method was used to produce a more reliable view of the internal consistency of the sample. In Figure 2, DERs are plotted in Dimension1-Dimension2 diagram and labelled by ID numbers. The two first MCA dimensions explain 40% of the total information. Cronbach’s alpha (Cronbach, 1951) values for the two main dimensions are 0.90 and 0.80 and are assessed as excellent and good, respectively (Georges & Mallery, 2003). MCA results are therefore accepted. Graphically, the grouping of DERs, with a few elements out of the group, confirms a low discrimination among the analysed material, homogenous following the autonomy and interactivity criteria.

To check the influence of the DER source on the score for all analysed products, one-way ANOVA analysis was conducted, by considering the score as a dependent variable and the source variable as a factor. The $F$-test (Levene) value of 25.82 was found significant, with an error probability ($p$-value) of 1%. It indicated the existence of at least one significant difference between the average values of the four predefined sources. In this case, the use of the Scheffe Post-Hoc test is pertinent to assess the significance of differences between groups of unequal size. Indeed, Figure 3(a) graphically shows significant differences between the score averages of compared source groups. It demonstrates that discrimination can be made

<table>
<thead>
<tr>
<th>Class (Category)</th>
<th>Score</th>
<th>Interactivity and autonomy</th>
<th>DERs ranged in class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>30–37</td>
<td>Excellent conditions</td>
<td>0</td>
</tr>
<tr>
<td>2nd</td>
<td>23–29</td>
<td>Good conditions</td>
<td>2</td>
</tr>
<tr>
<td>3rd</td>
<td>16–22</td>
<td>Acceptable conditions</td>
<td>13</td>
</tr>
<tr>
<td>4th</td>
<td>08–15</td>
<td>Weak conditions</td>
<td>135</td>
</tr>
<tr>
<td>5th</td>
<td>01–07</td>
<td>Unfavourable conditions</td>
<td>40</td>
</tr>
</tbody>
</table>
between a group Gr1 of resources from Rouen Academy and other educational websites and another group Gr2 with lower scores, including GENIE resources and those of eduMedia-Share initially conceived for class use.

To assess the impact of the learning domain on the score, the 190 studied resources were divided into three learning areas: Biology, geology and environment. One-way ANOVA analysis was performed by considering the score as dependent on the learning domain. The $F$-test (Levene) 7.31 value was significant, with an error probability of 1%. It revealed a significant difference between the mean score values of predefined groups. The Post-Hoc test graphically (Figure 3(b)) shows a ranking of the three areas, with a significant advance for the field of environment compared with the other learning areas. This confirms the results of global assessment shown in Figure 1(d).

Considering only the DERs officially recommended by the GENIE programme, the impact of the learning domain on the score was searched after selecting the 93 corresponding products from the whole sample. One-way ANOVA analysis and Post-Hoc test revealed a value of $F$-test (Levene) equal to 1.1, but with an error probability of 33%. So, the differences

Figure 2. Distribution of DERs in Dimension 1–Dimension 2 diagram resulting from the Multiple Correspondence Analysis.

Figure 3. Additional information from Post-Hoc tests. (a) graphic illustration showing the impact of the DER source on the final score, (b) the impact of learning domain for the whole sample and (c) the impact of learning domain for products proposed by the GENIE programme.
in the score averages between the three groups are negligible despite a non-significant ranking that puts geology resources in a retracted position (Figure 3(c)).

**Implications for practice and transferable practice**

The global assessment showed that only 15 DERs representing 8% of analysed products, used for teaching LES in high schools, offer acceptable to good conditions for autonomy and interactivity (Table 2). The first DER showing good conditions refers to flash animation, with a score of 27, offering a mix of media forms (e.g. text, animated image, graph builder, mobile onscreen elements and responsive buttons) that allow the learner to get information, process it, make decisions and communicate his/her findings. In the evaluation phase, the learner is able to express and show his/her current level of understanding of what he/she has learned. The content is presented in a context reflecting the way the learning can be employed in real life. The remainder, 92% of the products, provides weak to unfavourable opportunities. Besides the weak exploitation of new technologies by Moroccan teachers suggested by previous researches (El Ouidadi, Lakdim, Essafi, Sendide, & Depiereux, 2013), the use of unsuitable DER may have negative impacts on transferable practices. DERs’ weakness can be overcome by the teacher’s intervention in the classroom, but distance teaching and self-learning require adequate strategies.

**Impact of learning actions**:
The DER interactivity based on a few learner’s actions, including ‘click’, ‘watch’, ‘read’ and ‘check’ often target a small number of skills, such as information seeking, ‘get informed’, watching the animation of a natural phenomenon, ‘observe’, and exploration of a natural environment, ‘explore’. Skills related to experimentation, argumentation, communication, expression of opinion, and others cannot be transferred without the integration of advanced and diversified learners’ actions in DER (e.g. drag and drop, insert text or value, draw, build a graph, print, save …). Neglecting some actions, such as listening to an audio clip and saving the learner’s production, eliminates a large number of learners whose learning is better with auditory and kinaesthetic styles (Fleming, 2010; Fleming & Baume, 2006; Robertson, Smellie, Wilson, & Cox, 2011; Schulz, 1993). Thus, it is argued that there exists a close relationship between skills and learners’ actions leading to skill acquisition. And as suggested by previous works (Mayer & Chandler, 2001; Schwan & Riempp, 2004), future DER should give the learner more opportunities for interaction.

The use of non-interactive resources is equally risky for seatwork practice if they are not used carefully by highly qualified teachers. Novice teachers risk falling into the trap of traditional teaching and the resource becomes a copy of the static document as information vector but without an added value in terms of interactivity. That partially explains the difficulties limiting an effective use of available DERs as evoked by previous works (Betrancourt, 2005; Betrancourt & Tversky, 2000; Tversky, Morrison, & Betrancourt, 2002).

**Impact of instructions and learning sequence coverage**:
The presented arguments show that if a resource does not present a situation mapping the learning context, it will be lacking in engagement and unable to help learners at high school level to be aware of the dimensions (e.g. knowledge, practice and attitudes) of their learning and their later usefulness. This is the case for the majority of the resources studied. Giving instructions and providing the necessary autonomy are valuable means for understanding the learning process and supporting the learner. Resources that are well structured technically and pedagogically can
help teachers make their teaching session successful, but otherwise, the use of unfavourable DERs accentuates problems encountered by some teachers, related to the learning management associated with the competency-based approach. For distance education, the scarcity of digital resources providing clear content and effective assistance makes the acquisition of specific skills in LES very difficult to achieve.

Implications for the DER design orientation: For the DER developers, the low discrimination between studied products proven by statistical analysis means that the issue related to the autonomy and interactivity criteria applies to the majority of existing DERs in LES; the problem is relatively significant for the fields of geology and biology if compared to the environmental learning domain. Designers of future DERs are invited to consider the integration of the learners’ actions targeting variable skills and attracting different categories of learners.

Suggestion of principles and guidelines for future DERs development

The evaluated DERs, notably those from edumedia-science and edumedia-share, are available in various languages. They can therefore be used in Morocco and elsewhere. The resources in the Arabic language can also be used in other Arab countries. This means that the weakness of DERs in terms of interactivity and autonomy is a general problem everywhere they are used. Other particular disciplines, such as languages, may show different characteristics, the results of a similar analysis might not be identical to the ones discussed above. To insure that DERs meet the autonomy and interactivity criteria for distance education and possibly seatwork, principles and guidelines for designing future DERs are proposed for Morocco and similar settings in the following section:

Principles

- Pedagogy and technology are unified for better DER production and designing.
- Dynamism with assisted autonomy and interactivity, as well as targeted skills constitute the main keys for the student-centred and competency-based approaches, as conceived in Morocco.
- Distance training platforms continuously progressing constitute the principal vector for knowledge transfer in the future.

Guidelines

Content

- The DER content is aligned to targeted competencies and skills listed in governmental guides for secondary levels, especially high school.
- Highly qualified teachers in biology, geology and environment domains contribute to DER designing and implementation. Their participation is necessary in order to provide techno-pedagogical content for DERs useful for distance teaching and self-learning.
- Qualified committee including developers, teachers and supervisors reviews and endorses DERs obtained from vendors and developers.
**Pedagogy**

- DERs are planned to be integrated into pedagogical scenarios helpful for mobilising the learners' cognitive knowledge, practice and attitudes. This will be possible if (i) learning scenarios are based on active teaching and learner-centred, and (ii) are also adaptable for distance learning management.
- Accurate and pertinent instructions are provided in DER. The instruction must be presented in a context that helps the learner to be aware of the learning process. The statement must thus contain the necessary information and use monosemic terms that can have a single meaning only (De Vecchi, 2000).
- DERs are covering the learning sequence stages: learning situation, learning activity and learning evaluation. To insure this condition (i) practitioner teachers and educationalists are inspired by scientific and educational researches for developing real learning situations adapted to the objectives and skill building, (ii) teacher can use a complete DER or a compilation of many resources in a distance learning sequence and (iii) learning reinvestment is targeted by additive resources that help the learner discover the applicability of acquired skills and competencies in variable situations.

**Technology**

- DER Designing offers varied options that help the learner to intervene in wide-ranging ways: (i) the designer takes into consideration the variability of learning styles and offers to the learner the possibility to use simple and advanced actions in DER, (ii) the designer overcomes compatibility-based issues and dysfunction of some DER options (e.g., reading data from external files, data saving, direct opening of executable files etc …) and (iii) the designer offers the learner the possibility to stop his apprenticeship at any time and continue later without losing the record of prior activities.
- DER designers prioritise the learning domains where demand on interactive and autonomous DERs is revealed to be higher (geology > biology > environment).
- Training platforms are the main strategic tools for wide use of DERs for distance learning purposes. They develop and meet the evolving requirements of e-learning.

**Leadership and governance**

- Qualified institutions and teachers participate in production, review and endorsement of DERs.
- DER vendors provide evidence that products are suitable for distance teaching–learning.
- DERs which are proved efficient are exposed to a wide use.
- DERs are regularly evaluated and assessment results are published. That includes observational monitoring by all partners (teacher, learner, supervisor, researcher). In the same context, findings are communicated to DER design groups and help quality improvement.
- Governmental promotion supports the effective contribution to distance learning improvement.
Conclusion

Based on the interactivity and autonomy criteria, the examination of 190 digital educational resources for teaching LES showed that the majority of existing products offers medium to weak conditions for distance learning. Thus, the hypothesis that ‘the content of existing DERs is insufficient and incomplete to obtain the desired learner’s autonomy and resource interactivity for distance learning’ is retained. This suggests that distance learning and self-training would face enormous obstacles that have to be addressed in the future. Indeed, despite their certified compliance to Moroccan high school programmes and suitability for class teaching, DERs are mostly incomplete in terms of interactivity and autonomy and inadequate for effective use in self-learning and distance teaching. The DERs do not provide the learner with diverse possibilities to interact with onscreen elements. The interactivity is thus limited to the use of a few learner actions. The missing instructions in the majority of examined DERs and the neglecting of both learning context and learning evaluation stages are obstacles facing the construction of real and pertinent learning experiences according to the competency approach as conceived in Morocco. The number of potentially targeted skills in the studied DERs sample is very limited, compared with the targeted skills listed in official educational guides.

The inferential analysis also showed that a higher demand for interactive and autonomous resources is notable in the geology and biology domains if compared to environment.

The current situation may influence negatively the practice and transferable practice for both face-to-face and distance teaching. The low scores highlight the issue of poor autonomy and interactivity of existing DERs that are used for LES learning in Morocco and elsewhere. This problem can be overcome in future products designed for e-learning by considering the proposed guidelines. Indeed, the contribution of both technology and pedagogy should lead to a new conception of DER designing. Highly qualified teachers are asked to produce pedagogical learning scenarios, which are learner-centred and pertinent for interactive and autonomous DER use. They are thus considered partners in DER design and production. Technology should provide the possibility to programme various actions that help learners acquire targeted skills specific to LES for high school levels. The governmental promotion of interactive and autonomous DERs is suitable as a strong element to support the effective contribution to the improvement of learning conditions and distance learning particularly.

Acknowledgement

The author wishes to thank Pr. Abdelaaziz Ouargui for proof-reading the manuscript and making necessary revisions to the English presentation.

Disclosure statement

No potential conflict of interest was reported by the author.

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