REMIE
Multidisciplinary Journal
of Educational Research

Hipatia Press
www.hipatiapress.com

Instructions for authors, subscriptions and further details:

http://remie.hipatiapress.com

Mini-Cases of Professional-Inspired Activities in E-Learning Platforms: An Experience for the Formative Assessment

Luis Antonio Tortajada-Genaro[1]

1) Universitat Politècnica de València

Date of publication: December 21st, 2021
Edition period: February 2022 – June 2022

To cite this article: Tortajada-Genaro, L.A., (2022). Mini-Cases of Professional-Inspired Activities in E-Learning Platforms: An Experience for the Formative Assessment. *Multidisciplinary Journal of Educational Research*, *12*(1), 38-59. http://dx.doi.org/10.447/remie.6070

To link this article: http://dx.doi.org/10.447/remie.6070

REMIE – Multidisciplinary Journal of Educational Research Vol. 12 No. 1 February 2022

Mini-Cases of Professional-Inspired Activities in E-Learning Platforms: An Experience for the Formative Assessment

Luis Antonio Tortajada-Genaro
Universitat Politècnica de València

(Received: 30th June 2020; Accepted:16th December 2021; Published: 21st December 2021)

Abstract

The formative assessment is a strategy that allows students to be aware of the state of their learning and to establish ways to correct the identified deficiencies; at the same time, it provides information to the instructor about those issues where misunderstandings occur. In the present study, we study its application to the solving of problems in university subject of scientific field. The activity involved short extension cases, coming from professional situations combined to self-learning tasks and supported on e-learning platform (Sakai software). The methodology was designed to achieve deep learning and a continuous evaluation of the process, not only the final product. The evidences collected (student's documents, interviews and smartphone-based surveys) informed about the impact of the presented approach. The participants positively valued the initiative against the more traditional methodologies. In conclusion, the study demonstrates that students can actively participate in the learning-oriented assessment, maintaining the guarantees of the educational process, mainly suitable for large classes, limited schedule or on-line classes.

Keywords: assessment for learning, authentic assessment, chemistry-based cases, active learning

ISSN: 2014-2862
DOI: 10.4471/remie.6070

Hipatia Press
www.hipatiapress.com

REMIE – Multidisciplinary Journal of Educational Research Vol. 12 No. 1 Febrero 2022

Mini-Casos de Actividades de Inspiración Profesional en Plataformas de E-Learning: una Experiencia para la Evaluación Formativa

Luis Antonio Tortajada-Genaro
Universitat Politècnica de València

(*Recibido: 30 Junio 2020; Aceptado: 16 Diciembre 2021; Publicado: 21 Diciembre 2021)*

Resumen

La evaluación formativa es una estrategia que permite a los estudiantes conocer el estado de su aprendizaje y establecer formas de corregir las deficiencias identificadas; al mismo tiempo, proporciona información al profesor sobre aquellos aspectos que generan más errores. En el presente estudio, se estudia su aplicación a la resolución de problemas en una asignatura universitaria del área científica. La actividad incluyó casos de extensión cortos, provenientes de situaciones profesionales combinadas con tareas de autoaprendizaje y con soporte en la plataforma de e-learning (software Sakai). La metodología fue diseñada para lograr un aprendizaje profundo y una evaluación continua del proceso, no solo del producto final. Las evidencias recopiladas incluyeron documentos de los estudiantes, entrevistas y encuestas basadas en teléfonos móviles e informaron sobre el impacto del enfoque presentado. Los participantes valoraron positivamente la iniciativa frente a las metodologías más tradicionales. En conclusión, el estudio demuestra que los estudiantes pueden participar activamente en la evaluación orientada al aprendizaje, manteniendo las garantías del proceso educativo, principalmente adecuado para clases numerosas, con horarios limitados o telemáticas.

Palabras clave: evaluación para el aprendizaje, evaluación auténtica, casos basados en la química, aprendizaje activo

ISSN: 2014-2862
DOI: 10.4471/remie.6070

Hipatia Press
www.hipatiapress.com

The current teaching-learning process in numerous university studies is featured by a competency-based approach (González & Wagenaar, 2003). In this context, assessment has acquired a new dimension derived from placing the student at the centre of the learning process (Schuwirth & Van der Vleuten, 2011; Bernholt & Parchmann, 2011). The design of all the structural elements, as well as their teaching tools and evaluation methods, has been revised (Hughes & Barrie, 2010).

The assessment should be adapted on the basis of some principles (López-Pastor & Sicilia-Camacho, 2017): (1) giving more importance and dedicating more time and effort to the continuous and formative assessment than to the final and summative one; (2) carrying out an evaluation aimed to improve learning and teaching-learning processes and not only as a final control of assumed processes; (3) evaluating all types of learning and competencies, using different approaches; (4) evaluating also the learning process itself, not only the final product. In short, all activities should enhance deep versus superficial learning; thus, the student must incorporate the critical analysis of new ideas, the ability to integrate them with prior knowledge about the subject (Biggs, 1999). Consequently, the long-term understanding will be favored enabling the solving of new problems in different contexts.

The participation of the student in the assessment is one of the key aspects to achieve these goals (Dochy et al., 1999, Bailey & Garner2010, Gikandi et al., 2011). The advantages of this approach are a direct improvement in their learning and skills, a higher involvement in their own training process and the development of skills associated to decision making. Opposed to the simple qualification made by the teacher, a shared assessment is sought, where the evaluation processes are part of their tasks. In addition to achieve the learning objectives, the goal is to develop enough autonomy to manage the own process (Nicol & Macfarlane-Dick, 2006). In this paradigm of university education, the assessment combines the conventional certification of success or failure and a strategy to improve learning.

An important approach is the formative assessment based on tools to improve their skills and understanding (Taras, 2005). The teaching-learning processes are oriented to the student to learn more, and to the teacher to improve his/her teaching practice. Therefore, the methodology of this alternative assessment involves techniques intended to move away from

approaches with the only or main purpose of qualifying, such as multiple-choice tests, fill in blanks or true-false There are different variants depending on the way to put it into practice, but the assessment for learning corresponds to several actions clearly oriented to the student's learning, differentiating them from those to control the student and qualify him (López-Pastor, 2008). This learning-oriented assessment includes processes for the development of self-regulatory capacities in learning, as well as learning throughout life (Carless, 2007, Carless, 2015). In addition, these techniques generally lead to a high participation of students.

At a more advanced learning level, the so-called authentic assessment stands out as a strategy in which students are asked to perform real-world tasks that demonstrate a significant application of essential knowledge and skills (Darling-Hammond & Snyder., 2000). This approach is appropriate and coherent with the current educational system, since performing the tasks requires mastering the specific skills of their professional area (Wiggins, 1998, Mueller, 2005). In particular, it is especially interesting to achieve learning outcomes that require skills with a higher order thinking (Vaino et al., 2012). Authentic assessment involves the application of what the students have learned to a new situation, and that one requiring judgment to determine what information and skills are relevant and how they should be used. As they involve real-world tasks, they are also likely to be more attractive to students and, therefore, more motivating. Another identified advantage is the fact that students do not perform preparatory activities aimed to pass a test, but they are prepared to perform structured actions in order to solve problems of their future professional life (Villarroel et al. 2018). Finally, this type of assessment generates direct evidence because the performance of the task itself demonstrates that they possess knowledge and have understood it in an integrated and contextualized mode. Therefore, it is considered that more specific and clear information is provided about what students have truly learned.

Effective assessment involves a high participation of students, contains self-regulated tasks supported by a clear decision-making strategy, and includes activities based on replication or simulations of professional contexts. However, they are generally aimed to solve complex situations in a specific discipline, involving important resources and more teacher effort

(Bennett, 2011). Therefore, innovative methodologies are demanded, particularly for large classes and limited schedules. The aim of the present study was the design and the application of formative assessment focused on solving short-extension cases, and supported by a e-learning platform. The main principles from the cited literature that helped build this novel methodology were:

- Tasks should be designed to stimulate sound learning practices amongst students.
- Assessment should involve students actively in engaging with criteria, quality, their own and/or peers' performance.
- Feedback should be timely and forward-looking so as to support current and future student learning.
- Assessments sample the actual knowledge, skills, and dispositions desired of teachers as they are used in teaching and learning contexts, rather than relying on more remote proxies.

Methodology

Participants

The proposed action was applied in Spanish public university to a subject of Analytical Chemistry field (second year subject) through three academic courses. The students who participated in the activity were 83, 77 and 68, corresponding with 93.3%, 95.1% and 93.2% of the total students, respectively. The main learning goal of the designed activity and methodology was that the student used chemometric tools for the treatment and interpretation of data obtained with techniques applied to food analysis. Nevertheless, the study is described from a more generalist approach to facilitate teaching innovation to be implemented in other subjects.

Materials & Tools

The e-learning platform based on the LMS (Learning Management System) open source Sakai (https://sakaiproject.org/) was used. The educational software platform is aimed to help teaching, research and collaboration, designed to be scalable, reliable, interoperable and extensible. The software includes typical features applied to course management systems, including

document distribution, a gradebook, discussion, live chat, assignment uploads, and online testing. Each student accesses the platform with its personalized password to download the files for the development of the activities, upload the reports and send comments to other reports. In our experience, five mini-cases for the module called "Treatment of data generated by chemical methods" were prepared. An example of the mini-case, entitled "Milk packing", is shown as Supplementary Material.

Students analyzed the cases using the statistical tool Statgraphics Centurion XVI (www.statgraphics.net). The Surveymonkey application, a free and customizable on-line survey cloud-based software, was used to assess the experience (http://www.surveymonkey.com/).

Activity

The designed activity was based on mini-cases following several principles. First, tasks simulated relevant problems faced by professionals in the field (in our experience, Food Quality/Safety Control, e.g. identification of food allergens, detection of frauds). Second, the cases were clearly focused to deepen into specialized topics of the subject (i.e. applications of Analytical Chemistry techniques in Food Science). Thirdly, the activity had a small extension, but keeping the essential step of this methodology. Thus, students should analyze professional situations presented by the teacher, in order to perform an experiential conceptualization and to conduct a search for effective solutions (e.g. parallelized experiments, comparison of new and reference methods). The learned concepts and methodologies were directly applied to situations, activities and real learning contents, and clearly related to professional competences. In short, the selected strategy opposed the traditional approach of proposing artificial situations away from real practice.

Regarding the development, students performed the activity individually using activity materials available in the e-learning platform (Figure 1).

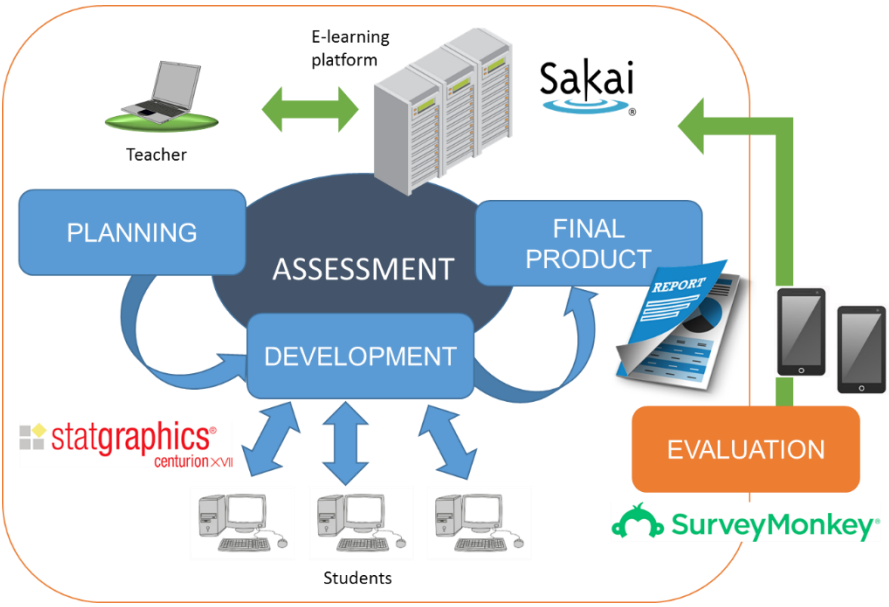

Figure. 1. Connectivity scheme, including devices and computer programs used in the activity.

The material consisted of: (1) introductory document of the activity where the learning objectives and the main associated concepts are listed, (2) file with the data of the scenarios to be studied, (3) guide document for the development of the activity autonomously and (4) report template.

In the first part of the activity, the general aspects to be treated were introduced, the methodology to be followed was detailed and the general questions were resolved (10 min). Then, the class season was used to solve five cases (15 min/case). Students sought, analyzed and processed relevant information from the field under study for each case. The progress of these activities was monitored by the teacher. The output was a report of results that each student uploaded to the e-learning platform in a shared space area, so that the student and teacher could access it. Only one submission per student was allowed ("one-shoot assessment"). The last part of the class

season was dedicated to share the experience and highlight the most critical aspects of the activity and the working process (5 min).

Data Analysis

Different evidences were generated during the activities such as partial results (e.g. graphs or tables), and notes of face-to-face tutoring. The interviews were conducted in an organized fashion (random sampling, short open-ended questions). The specific focus was to ask the students if the cases helped them learn or if the tools were an improvement over traditional. To assess the impact of experience on student's opinion, a specific survey of two closed-ended questions was prepared. The first question was "The cases studied in the seminar are close to your professional future. 0: strongly disagree, 1: disagree, 2: neutral, 3: agree, 4: strongly agree". The second question was "You would recommend this activity for the next course because it helps to evaluate my learning. 0: strongly disagree, 1: disagree, 2: neutral, 3: agree, 4: strongly agree". The students accessed the website from different electronic devices (laptops and mobile phones) to complete it one week after performing the activity (thoughtful opinions). From the point of view of the teaching research, the analysis of the results (documents and surveys) and the improvement proposals were carried out. The statistical analysis of answers was also performed with the Statgraphics Centurion XVI tool at a confidence level of 95%.

Results and Discussion

Activity Design

As the methodology of mini-case study was proposed for the first time, several features were considered for a successful application. The identified key elements are described in Table 1. The first part was the general description of the activity, including the learning goal, targeted skills and professional context. The second was focused on the case description, data and a model report to be prepared. Also, additional information was provided such as, a general guideline, optional tasks and relevant references. The activity was supported by an e-learning platform to facilitate the access to everything the students needed in one place. Thus, a webspace for

educational content and resources was created supporting both traditional and remote education approaches.

Table 1.
Components of mini-case activity.

Element	Function
Learning goal	Brief statements that describe what students will be expected to learn by the end of mini-case.
Targeted skills	List of abilities, work habits and set of knowledge on which the activity is focused.
Professional context	Brief description of workplace problem and their circumstances in terms of which the mini-case can be fully understood.
Case description	Problems and challenges based on real life situations and addressed to make decisions based on the evidence given.
Data	Information about software to be used and the access to the downloadable files with the results to be analysed.
Report	Document to be filled by the student compiling the results of the activity.
Guideline	Recommendations to carry out the activity and complete the report, showing how the real working problem should be solved according to the learned skills.
At-home activities	Optional tasks to deepen in the professional field raised.
References	Related citations of sources of information such as books, scientific papers or webpages.

The specific tasks of the studied innovative learning-assessment were chosen according to the following criteria.

(1) The **professional-inspired activities** were created considering that their solving would imply a decision-making strategy and the development of analytical and critical thinking skills.

(2) **Short duration cases** (mini-cases) were designed to ensure that it could be done with the time constraints of a face-to-face class and the limitations of a tight schedule.
(3) **Clear objectives** were established for each case, as well as guidelines to achieve them. It is vital importance that students are clear about what they are going to be asked to do before taking part in the process.
(4) **Evidence** were identified that would allow monitoring both the process and the final result. Ideally, this type of case-study based methodologies should be applied with an important degree of feedback on the product (iterative process).
(5) **One-shot activities** were defined and teacher participation was focused to support the development, but once the product was presented, no corrections were allowed. In this study for large classes, we opted for promoting feedback only during the process and avoiding recurrent revision tasks.

According to the educational approach sought, the innovation was accompanied by a specific way of conceiving the learning process. The teaching was intended to achieve deep learning by promoting that students used high levels of cognitive skills such as "analysis" (compare, contrast) and "synthesis" (integrate knowledge into a new dimension). Thus, the tasks were focused on the development of these skills.

Regarding the evaluation system, this multi-case methodology is compatible with several options (Stiggins, 1987, Carless, 2015). Following a conventional approach, the assessment could be limited to determine if the process was successful or not, measuring in the final product of each case if the students acquired the knowledge and the expected skills. However, this problem-based learning provides continuous and useful information to self-diagnose the individual skills and knowledge of each student (Figure 2).

In the context of a case study, the objective is the application of certain knowledge, providing a framework to develop the designed activities. Formative assessment enables teachers to monitor students' progress and activates students to self-regulate their learning. Designing an appropriate case is a challenge for instructors because the assessment structure must be

well aligned with the intended learning outcomes. Nevertheless, a clear alignment between their current role as students and their future role as professionals, is achieved. For that, our approach replicated or adapted the tasks and performance standards typically found in the world of work. The motivation is also crucial because students need satisfaction of autonomy, competence and relatedness. Thus, a continuous feedback student-instructor is important to identify the advances and the limitations of the process.

In the proposed approach, a formative assessment is planned including control points so that the student could recognize by himself the state of his learning. Students have a way to estimate the partial success or failure of the project and/or the need of additional inputs from the instructor. For example, tables or figures were requested to be generated in the middle of the process, allowing the student to monitor the progress (self-regulated learning).

In addition, the assignments were designed to reproduce real-world challenges and to ask students to perform meaningful actions to face them. For this, specific outputs were required (result, graph, figure), as well as an associated justification that allowed reflection on the possible solutions to the problems arisen. Consequently, they serve on their own to establish whether students are capable of doing them or not, beyond a score.

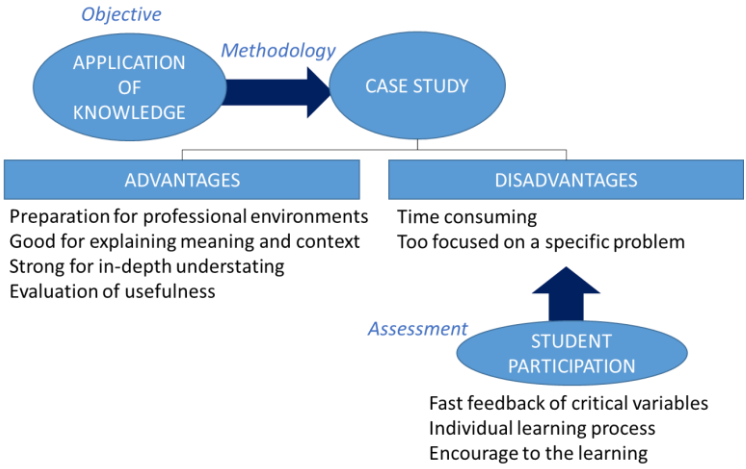

Figure. 2. Scheme of activity design for assessment of mini-cases.

Formative Assessment

Due to the principles of the presented methodology, there are potential benefits compared to other approaches. A study, elaborated by Mueller, 2005, collects some recommendations for creating authentic tasks and standards for measuring and improving student learning. The intended purpose of this section is a deeper analysis following these criteria.

(a) **Final product**. In traditional assessments, students are usually given several options and asked to select the correct answer. On the contrary, this type of assessment asks students to demonstrate the acquisition and understanding of knowledge by performing a more complex task that generally represents a more significant application. Another option for achieving a realistic teaching proposal consists of developing complex tasks with multiple pathways of solving but limiting to a single correct answer. This favors that the student is a priori aware of what is expected and facilitates the qualification.

(b) **Linking with real life**. Many types of evaluation are disconnected from real-world contexts and constraints to meet the intrinsic demands of a saturated university system, their advantage being the capability to isolate particular knowledge or skills of the corresponding discipline. However, it is not very common in professional life to request to select among four alternatives to indicate mastery of a specific issue. In the real working life, a demonstration of competence by doing something is usually asked. The mini-cases offer this artificial academic environment to be able to be carried out in the context of a university class (e.g. short period of time) but without renouncing to the student demonstrating his competence.

(c) **Brain action and type of learning.** Well-designed traditional assessments allow to determine effectively whether or not students have acquired some knowledge. But generally, a revocation and recognition activity are used, according to the revised bloom taxonomy (Krathwohl, 2002). Mini-cases provide a higher level

because they demand actions such as construction or application of facts, ideas and propositions, creating a new meaning in the process. They are integrated challenges in which a variety of skills and knowledge should be used in coordination. The consequence is a deeper learning.

(d) **Structuring and plagiarism**. In the traditional approach, the student will focus basically on what is required in the test that the teacher has carefully organized. Although the final product may be similar, with mini-cases, flexibility is higher because it can lead to several itineraries depending on each student. This also complicates the teacher's work, because it requires considering the different possible scenarios. Also, due to the nature of the technique, plagiarism is more limited because it is easily identifiable when a student does not make his or her own contribution. In short, ways are sought for students to use particular knowledge or skills but considering different forms or contexts.

(e) **Evidence**. Many of the traditional tests, and especially the multi-choice tests, give indirect evidence, since it is very difficult to fully guarantee achievement of the learning objectives. On the contrary, our authentic assessment variant offers more direct evidence of the application and construction of knowledge. In addition, the inclusion of open-ended questions allows one to open avenues to establish the status of his/her learning individually and immediately. In short, the correction against a template is not the only evaluative criterion.

Comparison with Other Methodologies

In the last years, important progresses have been achieved in the field of learning-oriented assessment (Zeng et al., 2018), especially in the field of formative learning (Panadero et al. 2018, Broadbent et al. 2021). The proposed methodology is based on the same principles and, consequently, the main features are similar. During the tasks, learners set goals and then systematically carry out cognitive practices and procedures that move them closer to those goals. Also, the proposed methodology information about

their progress, which is then used to enable adjustments and updates to both teaching and learning, resulting in improvements. All compared methodologies are designed for achieving a positive impact on student autonomy, and self-regulation; abilities highly related to employability. Nevertheless, our assessment technique based on mini-cases shows several differences respect to the most of techniques that have to keep an important place in university courses, particularly respect to the traditional assessment (Wigging, 1983).

(1) **Test**. Even for well-designed and executed questions, the evidences are indirect. Mini-case provide a direct information of the student's ability to apply the acquired knowledge and skills. Also, our approach provides a way to clear guide for students and a self-evaluation of their learning process.

(2) **Projects or portfolios**. They are often inspired on professional context and can support a deeper self-regulated learning. Project demands several tasks and to obtain a concrete final product. Also, the issuance mode of a judgment by the teacher coming from the data presented by each student is similar. But, these techniques are generally recommended for collecting evidences of longer learning processes.

(3) **Problems**. Problem-based learning/assessment involves the solving of a numerical/text question of short extension. In essence, the objectives and procedures can be similar to our proposal, particularly if active methodologies are applied (Hughes & Barrie, 2010, Gikandi et al., 2011, Tortajada-Genaro, 2014). Nevertheless, the case is a more complete educational approach. Table 2 shows identified differences between mini-cases with respect to the problem-based methodology, demonstrating that it is an alternative, especially suitable to approach professional scenarios.

Table 2.
Comparison between the solving of problems and cases.

	Problem	**Case**
Problem	Abstract or ideal situation	Real situation
Action	Select an answer as a result of applying a solving algorithm	Design, perform and analyze a set of tasks
Student participation	Medium	High
Brain action	Recovery / Recognition	Construction / Application
Motivation	Low-medium	High
Possibility of plagiarism or copying	High	Limited
Structuration	Predefined by the teacher	Adapted to the student
Evidence of learning	Indirect	Direct
Learning style	Superficial	Deep

Both traditional teaching and remote education processes have gradually grown their interest in implementing online formative assessment activities (Yilmaz et al. 2020). The outbreak of the COVID-19 epidemic has accelerated this process. As students must engage in more on-line learning than off-line study, assessment tools have been revised (Chen et al. 2021). In this context, the improvement of existing methods and the development of novel assessment techniques are demanded. In the boom of online learning, the proposed methodology fulfils these requirements according to new application scenarios, obtaining similar performances than other published approaches (Dhawan, 2020).

Evaluation of the Experience

The class-based research included some actions to confirm that the student truly reached a specific set of contents and skills. The study provided data on student performances, enabling the comparison with those obtained in other courses without the case studies. Statistical tests indicated that global rates (drop-out rates and global pass rates) were comparable (t-test, p-value < 0.05). This observation agreed with the expectations because the innovative

action involved a small contribution, considering the entire subject (low number of hours). Nevertheless, a significant difference was reported for the pass rates of the specific teaching unit where the activity was included (t-test, p-value > 0.05). The number of passing students was slightly higher in the courses with case studies (improvement 5-10%).

Beyond the impact on academic results, we studied if this methodology has the expected advantages associated to the formative assessment approaches (Darling-Hammond & Snyder et al., 2000, López-Pastor, 2008). During the activity, different evidence were generated, such as partial results of mini-cases (e.g. graphs or tables). The revision of intermediate products generated during the activities informed about the partial learnings. Although students used elements from webpages or other sources, the products were original. The registered results indicated that the activity promotes an improvement over traditional lectures or exercises, because the number of detected errors was lower.

Other source were the notes collected from face-to-face contacts between the instructors and students (40 random short interviews). A wide majority of students (95%) stated that the information of these partial tasks was a useful measurement of learning progress. Most of the students (80%) expressed that the employed methodology guided their learning and they were able to relate the failure in a specific task to the lack of specific concepts or skills. All students emphasized an improved connection to the professional field. Few pointed out that a better description of the industrial context should be helpful. In all students, the solving of real-world tasks strengthened their view about the meaningful application of essential knowledge. Therefore, interviews registered some evidences of the expected benefits of formative.
Students' perception on teaching/learning methods is important to obtain relevant conclusions about novel activities and (Vidal et al. 2020, Chen et al. 2021). The opinion of the innovative experience by a specific survey with two questions with Likert-scale answers, aimed to all participants (228 students). Students evaluate the experience one week after performing the activity, because we would promote thoughtful opinions (pros and cons). Figure 3 shows the frequency of each option for the data collected through the smartphone application. Most students (89%) considered that the activity was close to challenges to solve in their discipline (useful learning). Also, the

majority of learners (87%) gave a positive or very positive assessment of the impact of the activity on their learning, recommending it for next years. Therefore, these results coincide with the observations collected during the development itself and with the answers directly reported to the teacher. The proposed short-extension case study-based method is an accepted approach of direct assessing student skills in large classes and limited schedules.

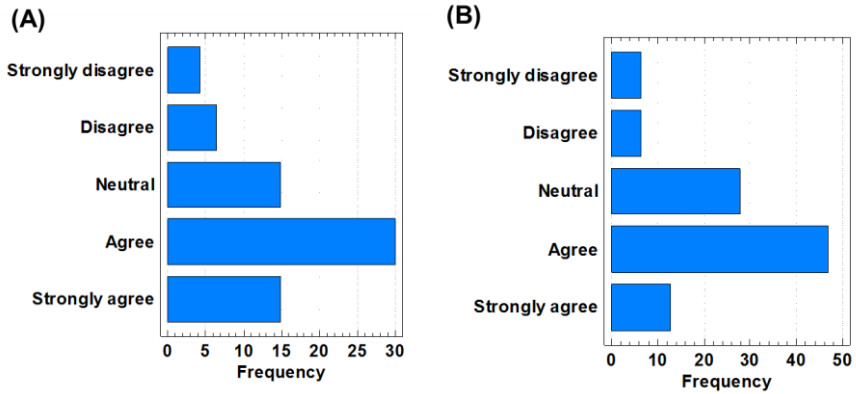

Figure 3. Global evaluation of the experience by the students. (A) Results of question 1: Benefits for your future professional activity. (B) Results of question 2: Recommendation of the activity for future students.

Advantages and Drawbacks

Our experience has shown that performing/assessing activities that involve an in-depth analysis of problems inherent to the discipline provides important profits, but they show certain limitations.

The main advantages derived from its integrating nature, combining short extension cases and formative assessment. First, the results indicated that it is a very useful methodology to establish the state of the learning process and encourage deeper knowledge. The tasks undertaken contributed to the integration and use of knowledge and skills as they are employed in practice. Each student better identifies the required knowledge and skills to perform tasks and to achieve objectives, together with a better contextualization and linking to professional tasks. Second, the typical complexity of the project-based assessment (or similar options) is reduced, without missing the essence

of authentic assessment. Third, at the same time, the teacher extracts those points where learning weaknesses can be easily generated. Fourth, the motivation is promoted because students perform "real-world" challenges whose solving involved the application of recently acquired knowledge and skills. Indeed, the experience has provided insights into its effective development and qualitative evidences of its learning impact.

Although, our case-based approach partially alleviates the described limitations of traditional assessment, some drawbacks can be identified. First, they have a low capacity to evaluate a wide range of contents per unit of time, compared to other tests (e.g. open questions, multi-option test). Second, the teacher effort is higher, because the selected topics must be the current professional field and be enforceable in the classroom sessions, without giving up essential elements of the program. Third, it requires the student to bring the subject up to date because it involves applying and analyzing some knowledge and skills that must have previously been internalized. Fourth, limited sources of evidence were collected over time and in diverse contexts. Also, the methodology can show low capacity to evaluate broad contents.

Conclusions

The guidelines of the university education system are focused on promoting training in competencies, and consequently, an assessment in line with this paradigm. The technological advances of e-learning platforms are opening new opportunities to incorporate professional-inspired activities. The current study has exposed a fruitful approach applied to a specific subject in the scientific field, but considering a generalist view to allow extrapolation to other subjects.

On the basis on the experience in this subject, several actions are essential for the viability of the proposal and to achieve the desired educational success. The importance of establishing the learning objectives in a clear way has been observed, so that, the student recognizes what is expected of his activity and how it should be evaluated from the different evidences that are generated in the process. Time control and the use of learning platforms is essential for large classes and/or on-line teaching. On the other hand, simple and specific criteria must be implemented in order to assess the control points

of the process. This is especially important in those parts that involve an analysis or reflection where heterogeneity among students is higher. Finally, a quantitative measurement of the learning impact should be included.

To conclude, it is to be highlighted that the university community must continue working to implement this assessment-evaluation methodology for learning. As indicated, it is the best way to promote the understanding and application of lifelong learning.

References

Bailey, R., & Garner, M. (2010). Is the feedback in higher education assessment worth the paper it is written on? Teachers' reflections on their practices. *Teaching in Higher Education, 15*(2), 187-198. https://doi.org/10.1080/13562511003620019

Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice, 18*(1), 5-25. http://doi.org/10.1080/0969594X.2010.513678

Bernholt, S., & Parchmann, I. (2011). Assessing the complexity of students' knowledge in chemistry. *Chemistry Education Research and Practice, 12*(2), 167-173. https://doi.org/10.1039/C1RP90021H

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development*, 18(1), 57-75. https://doi.org/10.1080/0729436990180105

Broadbent, J., Sharman, S., Panadero, E., & Fuller-Tyszkiewicz, M. (2021). How does self-regulated learning influence formative assessment and summative grade? Comparing online and blended learners. The Internet and Higher Education, 50, 100805.

Carless, D. (2007). Learning-oriented assessment: conceptual bases and practical implications. *Innovations in Education and Teaching International, 44*(1), 57-66. https://doi.org/10.1080/14703290601081332

Carless, D. (2015). Exploring learning-oriented assessment processes. *Higher Education, 69*(6), 963-976. https://link.springer.com/article/10.1007/s10734-014-9816-z

Darling-Hammond, L., & Snyder, J. (2000). Authentic assessment of teaching in context. *Teaching and Teacher Education, 16*(5-6), 523-545. https://doi.org/10.1016/S0742-051X(00)00015-9

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems, 49*(1), 5-22. https://doi.org/10.1177/0047239520934018

Chen, Z., Jiao, J., & Hu, K. (2021). Formative assessment as an online instruction intervention: Student engagement, outcomes, and perceptions. *International Journal of Distance Education Technologies*, *19*(1), 1-16. http://doi.org/10.4018/IJDET.20210101.oa1

Dochy, F. J. R. C., Segers, M., & Sluijsmans, D. (1999). The use of self-, peer and co-assessment in higher education: A review. *Studies in Higher Education*, *24*(3), 331-350. https://doi.org/10.1080/03075079912331379935

Gikandi, J. W., Morrow, D., & Davis, N. E. (2011). Online formative assessment in higher education: A review of the literature. *Computers & education*, *57*(4), 2333-2351. https://doi.org/10.1016/j.compedu.2011.06.004

González, J., & Wagenaar, R. (Eds.). (2003). *Tuning educational structures in Europe. Final report. Phase one.* Bilbao: University of Deusto.

Hughes, C., & Barrie, S. (2010). Influences on the assessment of graduate attributes in higher education. *Assessment & Evaluation in Higher Education*, *35*(3), 325-334. https://doi.org/10.1080/02602930903221485

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice*, *41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

López-Pastor, V. M. (2008). Implementing a formative and shared assessment system in higher education teaching. *European Journal of Teacher Education*, *31*(3), 293-311.

López-Pastor, V., & Sicilia-Camacho, A. (2017). Formative and shared assessment in higher education. Lessons learned and challenges for the future. *Assessment & Evaluation in Higher Education*, *42*(1), 77-97. https://doi.org/10.1080/02602938.2015.1083535

Mueller, J. (2005). The authentic assessment toolbox: enhancing student learning through online faculty development. *Journal of Online Learning and Teaching*, *1*(1), 1-7.

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in higher education*, *31*(2), 199-218. https://doi.org/10.1080/03075070600572090

Panadero, E., Andrade, H., & Brookhart, S. (2018). Fusing self-regulated learning and formative assessment: a roadmap of where we are, how we got here, and where we are going. *The Australian Educational Researcher*, *45*(1), 13-31. https://link.springer.com/article/10.1007/s13384-018-0258-y

Schuwirth, L. W., & Van der Vleuten, C. P. (2011). Programmatic assessment: from assessment of learning to assessment for learning. *Medical Teacher*, *33*(6), 478-485. http://doi.org/10.3109/0142159X.2011.565828

Stiggins, R. J. (1987). Design and development of performance assessments. *Educational Measurement: Issues and practice*, *6*(3), 33-42. https://doi.org/10.1111/j.1745-3992.1987.tb00507.x

Taras, M. (2005). Assessment–summative and formative–some theoretical reflections. *British Journal of Educational Studies*, *53*(4), 466-478. https://doi.org/10.1111/j.1467-8527.2005.00307.x

Tortajada-Genaro, L.A. (2014). Collaborative activities for solving multi-step problems in general chemistry. *Journal of Technology and Science Education*, *4*(4), 250-259. http://doi.org/10.3926/jotse.119

Vaino, K., Holbrook, J., & Rannikmäe, M. (2012). Stimulating students' intrinsic motivation for learning chemistry through the use of context-based learning modules. *Chemistry Education Research and Practice*, *13*(4), 410-419. http://doi.org/10.1039/C2RP20045G

Vidal, B., Ribera, M. L. F., Ribal, F. J., Sanchis, P., García-Rupérez, J., Bes-Piá, M. A., ... & Tortajada, L. A. (2021). Students' perception on learning methods in engineering disciplines. *Journal of Applied Research in Higher Education*. *14*, 1-12. https://doi.org/10.1108/JARHE-01-2021-0041

Villarroel, V., Bloxham, S., Bruna, D., Bruna, C., & Herrera-Seda, C. (2018). Authentic assessment: Creating a blueprint for course design. *Assessment & Evaluation in Higher Education*, *43*(5), 840-854. https://doi.org/10.1080/02602938.2017.1412396

Wiggins, G. (1993). Assessment: Authenticity, context, and validity. *Phi delta kappan*, *75*(3), 200-08.

Wiggins, G. (1998). *Educative Assessment. Designing assessments to inform and improve student performance*. Jossey-Bass Publishers, 350 Sansome Street, San Francisco, CA 94104.

Yilmaz, F. G. K., Ustun, A. B., & Yilmaz, R. (2020). Investigation of pre-service teachers' opinions on advantages and disadvantages of online

formative assessment: an example of online multiple-choice exam. *Journal of Teacher Education and Lifelong Learning*, *2*(1), 1-8.

Zeng, W., Huang, F., Yu, L., & Chen, S. (2018). Towards a learning-oriented assessment to improve students' learning—a critical review of literature. *Educational Assessment, Evaluation and Accountability*, *30*(3), 211-250. https://link.springer.com/article/10.1007/s11092-018-9281-9

Luis Antonio Tortajada Genaro is Professor at the Department of Chemistry of the Universitat Politècnica de València
ORCID: https://orcid.org/0000-0003-4021-5607

Contact Address: Camí de Vera, s/n. 46022 València. Spain.

Email: luitorge@qim.upv.es