This is an Accepted Manuscript of an article published by Taylor & Francis in Ainhoa Alvarez & Mikel Villamañe (2022) *Facilitating complex assessment using Moodle*, **Interactive Learning Environments**, on 26 Jun 2022, available at: https://doi.org/10.1080/10494820.2022.2091614.

Facilitating Complex Assessment Using Moodle

Assessment is a key element in any course, and providing students with a balance among formative and summative assessments is crucial. Defining such assessment process is a complex task for teachers and often entails a great workload. This makes it necessary to have tools to help in the assessment process definition and its monitoring. This paper first analyses the possibility of using Moodle. For that, we have carried out a bibliographical study, conducted semi structured interviews with teachers, and analysed their use of the Moodle gradebook. We have found that teachers find quite difficult to use the Moodle gradebook so they rarely take advantage of all its possibilities. Taking this into account, we present Forge, a system that facilitates the definition of assessment processes following the [deleted for review] methodology in such a way that the produced process can be exported to Moodle. We have analysed whether Forge, makes it easier or not the assessment definition process. For that, we have selected four courses to carry out a case study using Forge and interviewed the teachers again. We have detected that using Forge facilitates the assessment process definition and its monitoring taking advantage of the characteristics of the Moodle gradebook.

Keywords—Learning management systems, Student assessment, higher education, Moodle gradebook , Assessment definition tool.

Introduction

Assessment is crucial for student learning in any higher education context such as in the engineering classroom (Carless et al., 2017; Koretsky et al., 2022) and a key element in any instructional design (Guàrdia et al., 2017). It is used for grading students but when assessment is well implemented it positively affects students' learning and can improve the learning/teaching process. Teachers should centre in using the assessment for learning purposes, this is, an assessment which priority is to serve to promote learning (Carless et al., 2017). This kind of assessment should provide a balance among summative and formative actions (Sambell et al., 2013). Assessment in general includes recollecting data and analysing it with both formative and summative objectives. Formative assessment is oriented to giving judgement to the student in order to improve his or her learning process whereas summative assessment is usually oriented to grading or giving marks to a work (Hamodi et al., 2015). Both assessment types are relevant elements of any course (Lukas Mujika et al., 2016) and they should be combined to provide 'continuous assessment' processes. This continuous process should include a continuous analysis of the carried out tasks and treating this information in a formative way even if it is later also used to obtain the course grade (Hamodi et al., 2015). However, due to the different characteristics of educational environments, unique assessment processes are not possible (Shibani et al., 2019) and they must be specifically created for each context. The definition of such continuous assessment is not an easy task for teachers and tools to help them are required.

Teachers like to have an all in one integrated system because of the workload having more systems would generate [Reference deleted for blind review]. So we could consider to use Moodle as the tool to define the assessment components as it is the main

Learning Management System used in higher education institutions across the world (García-Murillo et al., 2020).

Therefore, the first research question of this paper (RQ1) is centred in the analysis of the Moodle gradebook as a tool to define assessment processes and it is defined as:

- RQ1: Is it easy to use the Moodle gradebook to define complex assessment processes? How do teachers use it?

This research question is analysed in the background section. As the answer to RQ1 is negative, we then present Forge, a system proposal based on the results of the analysis of the state of the art and the study carried out to answer RQ1. We also present the evaluation of Forge in order to answer RQ2 which is defined as follows:

- RQ2: Does the use of Forge make easier the assessment definition process and its support using Moodle?

This paper is structured as follows. First, the background of this work is presented. Next, the proposed Forge system is detailed. After, a case study is presented in which RQ2 is answered. Finally, the paper finishes with a discussion and conclusions section.

Background

Assessment is a very important element of the instructional design (Guàrdia et al., 2017), and if adequately defined and structured it positively affects student learning (Carless et al., 2017) (Lukas Mujika et al., 2016). However, defining a good assessment process is not an easy task. The reality of different educational environments is often not the same so the

definition of unique and closed assessment processes is not possible (López Pastor, 2009; Shibani et al., 2019). Courses usually have complex assessment processes that can include different evaluation or assessment Plans with different characteristics (Vujošević-Janičić et al., 2013). They can have, for example, different types of evaluation committees, various assessment instruments, or several combinations of individual assessable elements to obtain the student's grade Teachers need tools that facilitate the definition of the elements and automatically calculate the final grade. They also need tools that help them analysing what is happening in the course as this can improve the course design and can facilitate the process of generating pedagogic interventions (Pardo & Dawson, 2016; Tervakari et al., 2014).

Taking into account that Moodle is one of the more used LMS in higher institutions in the world (García-Murillo et al., 2020) and that teachers like to have an all in one integrated system [Reference deleted for blind review], the first approach would be to directly use Moodle as the tool to support the assessment definition process. However, Moodle has many significant challenges yet (Tran & Meacheam, 2020). In general, customising the different elements is complicated due to the fact that the interface is not user-friendly and also that the navigation through the available elements is very difficult (Szirmai, 2020). This is even more noteworthy in the process of the definition of the assessment process in (Hawking, 2017) so tools such as the gradebook are underused by teachers (Cheikh, 2020).

We have therefore stablished a research question to analyse whether it is easy to use the Moodle gradebook and how do teachers use it (RQ1).

To answer this first research question regarding the use of the gradebook by teachers, we have analysed the bibliography and carried out semi structured interviews with

26 teachers, with many teaching years of experience, and have analysed their course gradebooks in Moodle.

The remaining of this section first describes the main characteristics of the Moodle gradebook, then shows the results of the study carried out and finally presents the proposal of this paper that will be extended in following sections.

Moodle Gradebook

Many teachers define the course quizzes and exams in Moodle but do not use all the elements provided by its gradebook to automatically obtain the course grade due to its configuration complexity. Moodle provides the option to define grade calculations using the Gradebook Setup page (Barrington, 2014). Moodle has a set of pre-set calculations (Mean of Grades, Custom Weights…) but this can also be enriched using custom grade formulas to determine how the grades will be calculated (*Custom Grade Formulas in the Moodle Gradebook*, s. f.). Moodle manual recommends organising grade items into categories before defining the aggregation methods to be used.

Custom formulae can be used to define the calculus for both the course grade and for the partial grade of individual categories. Formulas are required in three different situations:

- When an item or category is used to calculate the grade of more than one item or category.
- When the grade depends on some condition.
- When the grades are not adequately sorted into categories.

To write custom formulae using existing grade items, an ID number in the form of a short text label must be provided to each item. In the formula, the grade items are referenced using double square brackets. For example, an item with label “Exam” will be referenced as [[Exam]]. The formula to be written in Moodle follow the patterns of formula in spreadsheet programs (i.e. “=average ([[Exam1]], [[Exam2]])”)

If the course includes different assessment Plans which need to use different formulae a new item must be included in Moodle. This item will serve to determine the formula to be used for each student according to the value given to it. This is, it will behave like an assessment Plan selection variable.

Writing the correct formula is not an easy task. In version 3.6 of Moodle it has been included the option to define conditionals what makes it easier to work with formulae to people with computing skills. However, it remains quite difficult for people without advanced computing skills.

Table 1 shows some formula examples in Moodle.

[Table 1 near here]

Even with the possibility of including conditionals in the formula, it is very easy to miss a bracket or a square bracket and incorrectly write the formula as Moodle does not provide any assistance for the formula definition but a text box.

We have described in detail the case of Moodle because it is one of the mainly used LMS in higher education institutions worldwide (García-Murillo et al., 2020). However, we have also analysed other LMS such as Blackboard. Blackboard facilitates a bit the formula definition with a specific interface, but the formula has fewer options than those of Moodle.

For example, they do not include the conditionals. Even with the help, the use of weighted items to calculate the grade is not an easy task.

Results of the interviews and analysis of gradebooks

As stated before, users usually use only the more basic aspects of the elements in Moodle because of the difficulty or lack of knowledge about how to adapt them. Many tools, such as the gradebook of Moodle, are underused by teachers (Cheikh, 2020) even if students ask for a more intensive and complete use of it (Ivanović et al., 2013). Moodle's gradebook is the perfect example of a very powerful tool, but which becomes very complex for teachers (Watkins, s. f.).

We have carried out an analysis of the use of the Moodle gradebook by teachers. In order to do that, we have asked 26 teachers of Computer Engineering, therefore with advanced computing skills, to show and describe the use of the Moodle gradebook in their courses. Next, the conclusions of this study are presented.

From the 26 teachers that took part in the study, only two use the Moodle gradebook to fully manage the assessment in their courses. Other 12 uses the gradebook, but only in a partial way (not all the assessment items are represented), and 12 teachers do not use the Moodle gradebook at all.

If customising different elements in Moodle such as the gradebook is complicated (Szirmai, 2020), the definition of the assessment process in Moodle is even more complicated (Hawking, 2017). Even among teachers with advanced computing skills, there is a complaint about the difficulty of the assessment process definition in the LMS. Due to this fact, many teachers (20 out of the 26) use a spreadsheet as a complement to Moodle.

They tend to download the information from Moodle and calculate the individual grades using spreadsheets. Others do not like to use spreadsheets as it is difficult to share with students and in some courses we have seen how teachers finish defining an alternative tab for defining the elements that form the assessment of the course, especially when those tasks are offline.

Figure 1 shows a real example of a technical course at our University. This course has some online assessment activities, but others are offline. The course teacher defined new activities for the offline tasks (the ones in the blue titled section in the figure) in order to be able to introduce the marks. Interviewing the teacher, she said that she did it this way because she did not know how to do it otherwise.

[Figure 1 near here]

Due to the regulation of the University of the Basque Country, nearly every course has at least two different assessment plans. One based in a continuous assessment process, and another one based in a final evaluation for those students who cannot follow the continuous process.

All 26 teachers that took part in the study has more than one assessment plan in their courses. But, from those 14 that uses the Moodle gradebook to some extent in their courses, only 2 define in Moodle all the assessment plans in their courses. The other 12 only define assessment items from one of the assessment plans of the course due to the difficulties they encounter.

FORGE: a System to define assessment processes following [Name deleted for blind review]

After the carried out analysis, it is clear that the Moodle gradebook is underused by teachers and that this is mainly due to the complexity of its use. To improve this, some complements could be created for Moodle, but institutions do not easily allow the use of complements due to security and data protection reasons. Therefore, intermediate solutions must be found. In this paper we propose a tool called Forge that helps in the process of the assessment definition and then generates a guide to define the process in Moodle.

Such a tool should also facilitate the complex assessment process definition and for that, it needs a methodological basis.

In this case, Forge takes as a basis the [Name deleted for blind review] methodology [Reference deleted for blind review] defined and evaluated at our University (López Pastor, 2009) that has shown to help teachers in the definition of adaptable assessment processes.

The proposed system architecture is shown in Figure 2 and is described next.

To facilitate the possibility of using different elements independently and including new functionalities, the system has a unique module that is accessible from the outside and has been developed as a REST (Representational State Transfer) Web service (Fielding, 2000) denoted FARA (Forge Assessment REST API). It is in charge of providing other systems with functionalities related to the definition of complex assessment processes. In order to provide those functionalities, the FARA module interacts with the Manager module that will be in charge of processing the requests from FARA by forwarding them to the system module that will be capable of dealing with them. This structure allows reducing the

communication among the internal modules (reducing their interdependencies) and facilitates the integration of new modules.

[Figure 2 near here]

The system has a knowledge base whose structure follows the ontology defined in the [Name deleted for blind review] methodology, as it will be detailed next.

Two are the system main modules. The first one provides the functionalities required to define the assessment approaches and all the elements defined in [Name deleted for blind review] (e^{2}Forja module). The second included module is `LMS_Module`. This module is in charge of providing some specific functionalities related to different LMS. Currently, `LMS_Module` incorporates a submodule in charge of aspects related to Moodle as described in the following sections.

Next all those elements are described in detail.

Knowledge Base

The system knowledge base includes all the elements defined in the e^{2}Forja ontology shown in Figure 3 and described next.

[Figure 3 near here]

Each of the different tasks, exams or exercises used for assessment in a course are called assessment Item. Those elements are combined in different ways to form the

Assessment Plans of a course. In a course, different Assessment Plans can coexist; each one can imply different Items and can represent different ways of combining the Items to obtain the final grade (represented with a Formula). For example, as commented before, in our university as in many other Spanish universities, at least two assessment Plans coexist in the courses. The first one is composed of different Items that are graded in a continuous way during the course whereas the second one only considers a final event (can be composed of different exercises or tests).

All the assessment Plans can be divided into assessment Bricks. Those Bricks will combine assessment Items with summative and formative functionalities. This is, some will be mainly used to provide feedback whereas other will be used for grading.

Teacher preferences can be accommodated defining and using those Bricks in different ways. Next, two examples are detailed to illustrate the Assessment Plan definition using the [Name deleted for blind review] methodology.

In the first example, the teacher divides the assessment Plan into different Bricks taking into account time intervals (see Figure 4). In the example, the teacher defines three Bricks, each lasting five weeks of the course. This is, each Brick defines a time period where assessment Items are carried out by students. Some of those Items will be graded and with those grades, a partial Brick grade will be obtained. At the end of the course, the different Brick grades will be combined using a teacher-defined formula to obtain the course grade. Different combination formula will generate those partial and course grades.

[Figure 4 near here]

The second example shows an assessment Plan that has been divided into Bricks not attending to time intervals but to assessment categories (see Figure 5). In the example, the

teacher has divided the assessment Plan into two Bricks. The first Brick is related to the theoretical part of the course and the second one to the lab sessions.

The theoretical part combines different assessment Items three of which are graded and used to obtain the partial grade of the Brick. The lab related Brick includes a lab session per week that is formatively assessed, and three graded Items that will be used to obtain the partial grade of the Brick. The partial grades for each Brick are combined at the end using a formula to obtain the course grade.

[Figure 5 near here]

Resuming, the assessment Plans are composed of assessment Bricks that include several assessment Items used with summative or formative aims. At the end, the partial grade of each Brick is combined to obtain the final grade of the student in the course. Those elements give flexibility to teachers for their assessment Plan definition.

Assessment plan definition

The functionalities provided by the e^{2}Forja module will be described through the description of their use in the current system web interface.

The definition interface has three main categories (see top of Figure 6): assessment Plans, Bricks and Items. Next, the definition process of each of them is described.

Teachers can define the different assessment Items that will be used in the course. For each of the Items, the teacher must define a code, a name, a description, and the minimum and maximum possible grade for the Item. The code will be the reference name to be used in the formula that will be automatically generated afterwards to obtain the

course grade. Teachers can at any time add, modify or delete assessment Items in the course.

[Figure 6 near here]

Teachers can also define the assessment Bricks involved in the Assessment Plans. For each Brick, teachers must define its general information: code, name, description, initial and final dates (see Figure 8).

Afterwards, teachers will have to select the Assessment Items that will be included in the Brick. Finally, they can generate the formula to obtain the grade for the Brick.

As previously depicted, the formula definition is not an easy task for teachers. In order to make it easier, the Forge definition interface shows a calculator that helps teachers through the definition process (see Figure 7). The calculator shows in the bottom the different assessment Items in the Brick and facilitates writing the formula that will be used for calculating the Brick grade. The system allows the inclusion of conditionals as it can be seen in the shown calculator. These conditionals are written in a more natural manner that the ones in recent versions of Moodle, which makes them easier to understand and use for non-digital literate teachers.

[Figure 7 near here]

The assessment Brick definition interfaces allows teachers to select a Brick in the left side of the interface and see the corresponding information in the right side of the screen. In the example shown in Figure 8, the assessment Brick named ProjectBrick is composed of Prac1 and Prac2 and its grade will be the sum of the two elements in the Brick.

[Figure 8 near here]

Finally, teachers can define the different assessment Plans of the course. In the example shown in Figure 9, there are two assessment Plans. For each, the teacher can define a code, a name, a description and the formula used to obtain the assessment Plan grade. Again, the formula is defined using a calculator like the one in Figure 9. In this case, the calculator will show and allow using to build the formula the assessment Bricks and Items defined for the evaluation of the assessment Plan.

[Figure 9 near here]

LMS_Module. Including the Assessment Structure definition into an LMS

We have detected in previous works that many teachers like to have all the grade aspects centralised in a single place (Álvarez-Arana et al., 2020). Some use spreadsheets and others find some tricks as previously depicted, but most of them would like to have everything connected to the LMS used in their institution. Therefore, for an assessment system to really be used it would be adequate to provide the possibility of integration with the LMS used by teachers.

Forge facilitates this integration process with Moodle through the Moodle submodule. Teachers can define the course assessment Plan in Forge and then run a process that generates a guide indicating the steps necessary to define the assessment Plan into Moodle. This is, Forge facilitates the definition of the elements of a complex assessment process in Moodle following the [Name deleted for blind review] methodology. In order to do so, Forge follows the algorithm shown in Table 2.

[Table 2 near here]

The teacher can ask at any time to generate the guide by clicking in a button in the definition interface (see Figure 10). Forge allows the generation of the formula for the different Moodle versions, the ones that incorporate the conditionals and those that do not include them.

[Figure 10 near here]

In the following section, an applied example of how this system works is described.

Case study

Forge has been tested in several courses of the Computer Engineering degree at the University of the Basque Country. The selected courses have been: “Object Oriented Programming”, “Data Bases”, “Analysis and Design of Information Systems” and “Information Security Management Systems”. These courses have been selected because of their assessment process definition complexity and the significant differences among them. Three teachers participated in this study.

We next detail the definition of the assessment structure of one of these courses in *Forge* following the [Name deleted for blind review] methodology and the later generation of the guide with the steps to be followed to translate this structure into Moodle. The selected course for the shown example is the Object Oriented Programming course at the university of [Name deleted for blind review].

Definition of the Assessment Process

This course has two assessment Plans (see Figure 11) a final one and a continuous one. The first one has a unique Brick with a unique assessment Item used to directly calculate the grades for the assessment Brick and Plan. The second assessment Plan has three Bricks. The theoretical one is composed of several assessment Items, some of which are used only with formative aims and others that are graded and are used, via a formula, to calculate the Theoretical part assessment Brick's grade. The second Brick is composed of several Items used in lab sessions and used for giving feedback and some writing exams. Finally, the continuous assessment Plan has a third Brick called Project that represents a Project included in the course where all the acquired knowledge will be applied. This Brick also has several assessment Items, some of which are graded and combined to obtain the Brick's grade.

[Figure 11 near here]

Once the teachers introduce all this information in Forge, the system generates a guide with the steps to be followed in Moodle to define the desired assessment process.

Importing in Moodle

As in this case there are more than one assessment Plans, a scale must be defined in Moodle with the name AssessmentPlanScale. In this scale (see Figure 12) teachers have to create two values: final and continuous. Once the scale has been created, an Item must be created that will serve to identify the assessment Plan for each student.

[Figure 12 near here]

Once these have been defined, teachers have to create all the identified assessment Items and give each of them the id given by Forge.

After, the system will indicate to generate a category for each assessment Brick identified in [Name deleted for blind review]. In this specific case four are the categories to be generated as shown in Figure 13. As it can be seen in the figure, the system also shows the formula to be used for each one of the Bricks.

[Figure 13 near here]

Finally, the system provides the formula to obtain the course grade. Figure 13 shows the formula generated for the course used in this example and that must be copied by the teacher into Moodle. As our University was using Moodle 3.5 in the moment this experiment was made, the formula was generated without conditionals.

[Figure 14 near here]

Teachers participating in the study were able to follow the guide generated by Forge and define all the assessment plans of their courses in such a way that the gradebook adequately reflected their assessment process. Teachers also indicated that the use of Forge made easier the definition of the assessment plans (RQ2).

Discussion and conclusions

This paper has presented the Forge system which helps defining complex assessment processes in Moodle. The tool has its basis in the [Name deleted for blind review] methodology that has been satisfactorily evaluated for the definition of Assessment Plans that consider both formative and summative assessment aspects.

Teachers of some selected courses have defined the assessment Plans using Forge and then they have translated this structure into Moodle. Satisfaction has been very high and teachers have indicated that they will like to use the tool for other courses. They also indicated that the tool was easy to use.

Moreover, teachers confirmed previous studies where it was seen that the reflection carried out by teachers to define the assessment process using [Name deleted for blind review] lead teachers to define assessment processes that included more formative aspects that the ones previously defined for their courses [Reference deleted for blind review].

Currently, the system generates a guide for the teacher indicating which the steps to be followed in Moodle are.

The option of generating a guide was the first selected as often it is not possible by users to integrate new modules in Moodle due to the policies that apply in their universities (as it is the case for example at the University of [Name deleted for blind review]). However, teachers that have used the system have expressed that they would like Forge to directly generate the elements into Moodle instead of generating the document indicating the elements to be created. Therefore, in the near future, we plan to automatise this process by providing a direct communication of Forge with Moodle using Learning Tools Interoperability (LTI) standard[1]. This way, those users from universities that give permission to stablish the LTI connection will be able to use this option that will facilitate their task.

[1] https://www.imsglobal.org/activity/learning-tools-interoperability

References

[Reference deleted for blind review]. (2019). …. *Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'19)*

[Reference deleted for blind review] (2020). Improving Assessment Using Visual Learning Analytics. *Education in the Knowledge Society (EKS)*,

Barrington, R. (2014). *Moodle Gradebook—Second Edition*.

Carless, D., Bridges, S. M., Chan, C. K. Y., & Glofcheski, R. (Eds.). (2017). *Scaling up Assessment for Learning in Higher Education* (Vol. 5). Springer Singapore. https://doi.org/10.1007/978-981-10-3045-1

Cheikh, I. (2020). *Exploring the Obstacles and Challenges of the Open-Source Platform Moodle The Case of Sciences of the Language Teachers at Biskra University*. http://archives.univ-biskra.dz:80/handle/123456789/16095

Custom Grade Formulas in the Moodle Gradebook. (s. f.). https://www.umass.edu/it/support/moodle/custom-grade-formulas-moodle-grade-book

Fielding, R. T. (2000). *Architectural Styles and the Design of Network-based Software Architectures* [Tesis doctoral]. University of California.

García-Murillo, G., Novoa-Hernández, P., & Rodríguez, R. S. (2020). Technological Satisfaction About Moodle in Higher Education—A Meta-Analysis. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, *15*(4), 281-290. https://doi.org/10.1109/RITA.2020.3033201

Guàrdia, L., Crisp, G., & Alsina, I. (2017). Trends and Challenges of E-Assessment to Enhance Student Learning in Higher Education. *Innovative Practices for Higher Education Assessment and Measurement*, 36-56. https://doi.org/10.4018/978-1-5225-0531-0.ch003

Hamodi, C., Pastor, V. M. L., & Pastor, A. T. L. (2015). Medios, técnicas e instrumentos de evaluación formativa y compartida del aprendizaje en educación superior. *Perfiles Educativos*, *37*(147), 146-161. https://doi.org/10.1016/j.pe.2015.10.004

Hawking, R. (2017). *The Utilzation of Moodle in the English Language Program at J. F. Oberlin University* (N.º 17; pp. 135-155). J.F. Oberlin University Academic Repository. https://obirin.repo.nii.ac.jp/?action=repository_uri&item_id=2211&file_id=22&file_no=1

Ivanović, M., Putnik, Z., Komlenov, Ž., Welzer, T., Hölbl, M., & Schweighofer, T. (2013). Usability and Privacy Aspects of Moodle: Students' and Teachers' Perspective. *Informatica*, *37*(3), Article 3. http://www.informatica.si/index.php/informatica/article/view/451

Koretsky, M. D., McColley, C. J., Gugel, J. L., & Ekstedt, T. W. (2022). Aligning classroom assessment with engineering practice: A design-based research study of a two-stage exam with authentic assessment. *Journal of Engineering Education*, *111*(1), 185-213. https://doi.org/10.1002/jee.20436

López Pastor, V. M. (2009). Una propuesta genérica de evaluación formativa y compartida para la docencia universitaria. En *Evaluación formativa y compartida en Educación Superior: Propuestas, técnicas, instrumentos y experiencias* (pp. 93-104). Narcea. https://dialnet.unirioja.es/servlet/articulo?codigo=2952641

Lukas Mujika, J. F., Santiago Etxeberria, K., Lizasoain Hernández, L., & Etxeberia Murgiondo, J. (2016). Percepciones del Alumnado Universitario Sobre la Evaluación. *Bordón. Revista de Pedagogía*, *69*(1), 103. https://doi.org/10.13042/Bordon.2016.43843

Pardo, A., & Dawson, S. (2016). Learning Analytics: How can Data be used to Improve Learning Practice. En P. Reimann, S. Bull, M. Kickmeier-Rust, R. Vatrapu, & B. Wasson (Eds.), *Measuring and Visualizing Learning in the Information-Rich Classroom* (pp. 41-55). Routledge. https://doi.org/10.4324/9781315777979

Sambell, K., McDowell, L., & Montgomery, C. (2013). *Assessment for learning in higher education*. Routledge.

Shibani, A., Knight, S., & Shum, S. B. (2019). Contextualizable Learning Analytics Design: A Generic Model and Writing Analytics Evaluations. *Proceedings of the 9th International*

Conference on Learning Analytics & Knowledge, 210-219. https://doi.org/10.1145/3303772.3303785

Szirmai, M. (2020). Moodle: The Ubiquitous Teacher. *Electronic Journal of Foreign Language Teaching*, *17*, 190-204.

Tervakari, A. M., Silius, K., Koro, J., Paukkeri, J., & Pirttilä, O. (2014). *Usefulness of information visualizations based on educational data*. 142-151. https://doi.org/10.1109/EDUCON.2014.6826081

Tran, T. P., & Meacheam, D. (2020). Enhancing Learners' Experience Through Extending Learning Systems. *IEEE Transactions on Learning Technologies*, *13*(3), 540-551. https://doi.org/10.1109/TLT.2020.2989333

[Reference deleted for blind review] (2020). CASA, ….. *IEEE Access*,

Vujošević-Janičić, M., Nikolić, M., Tošić, D., & Kuncak, V. (2013). Software verification and graph similarity for automated evaluation of students' assignments. *Information and Software Technology*, *55*(6), 1004-1016. https://doi.org/10.1016/j.infsof.2012.12.005

Watkins, S. (s. f.). *Using Moodle Gradebook Effectively*. https://swatkins.wordpress.ncsu.edu/files/2016/04/moodle_gradebook_20160420.pdf

TABLE 1. Formula Examples in Moodle

Returns the average of *item1* and *item2* if both have 5 of more, and 0 otherwise.	
Previous to Moodle 3.6	=average([[item1]];[[item2]]) * min(1;round((min(1;round([[item1]]/(2*5))) + min(1;round([[item2]]/(2*5))))/(2*2)))
After Moodle 3.6	=IF(AND([[item1]]>=5;[[item2]]>=5);([[item1]]+[[item2]])/2; 0)
Returns the average of the maximum and the minimum values among *Quiz1*, *Quiz4* and *Assignment1* if *Test* is equal or greater than 5 and the minimum among *Quiz1*, *Quiz4* and *Assignment1* otherwise	
Previous to Moodle 3.6	=(average(max([[Quiz1]];[[Quiz4]]; [[Assignment1]]); min([[Quiz1]];[[Quiz4]];[[Assignment1]])) * (min(1;round([[Test]]/(2*5)))) + (min([[Quiz1]];[[Quiz4]];[[Assignment1]])*(1-(min(1;round([[Test]]/(2*5))))))
After Moodle 3.6	=if([[Test]]>=5;average(min([[Quiz1]];[[Quiz4]]; [[Assignment1]]);max([[Quiz1]];[[Quiz4]];[[Assignment1]])); min([[Quiz1]];[[Quiz4]];[[Assignment1]]))

TABLE 2. Algorithm to define the elements to be included in Moodle

1. If the course has more than one assessment Plan
   1.1. Create a new scale with name scaleAssessmentPlan with the values provided by Forge (the names will be the ones of the identified assessment Plans)
   1.2. Create an assessment Item with the name assessment Plan, with id assessplan, with the selected grading type scale and in the scale select scaleAssessmentPlan
2. For each assessment Item that is part of the grading process and is related to un activity in Forge
   2.1. Create an activity of the appropriate type
   2.2. Introduce the id number provided by Forge
3. For each assessment Item that is part of the grading process and is not related to an activity in Moodle
   3.1. Create a new grade Item
   3.2. Introduce the id number and the code provided by Forge
4. For each Brick
   4.1. Create a category with the same name than the Brick (that will be provided by Forge) and introduce the id number and code provided by Forge
   4.2. Write the Brick formula as provided by Forge
5. Write the formula for the course as provided by Forge

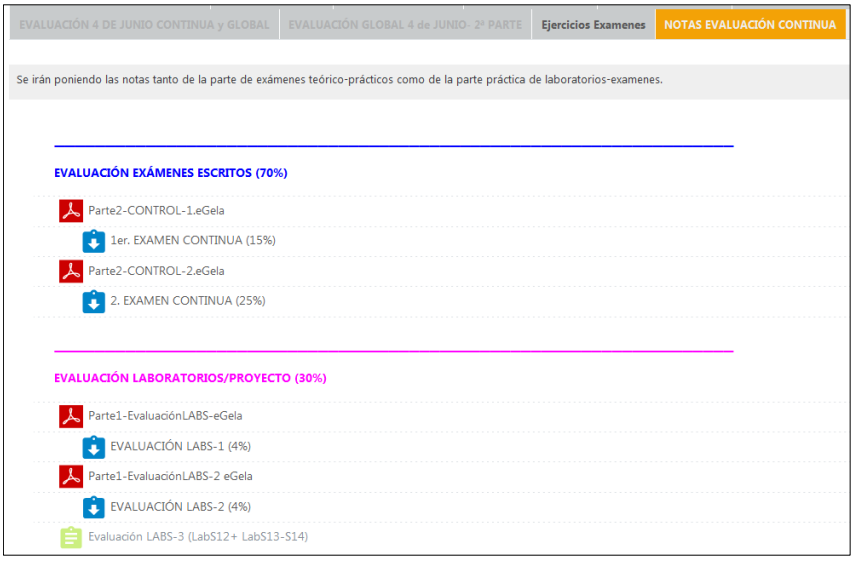

Figure 1. Alternative way to create the elements for the course assessment

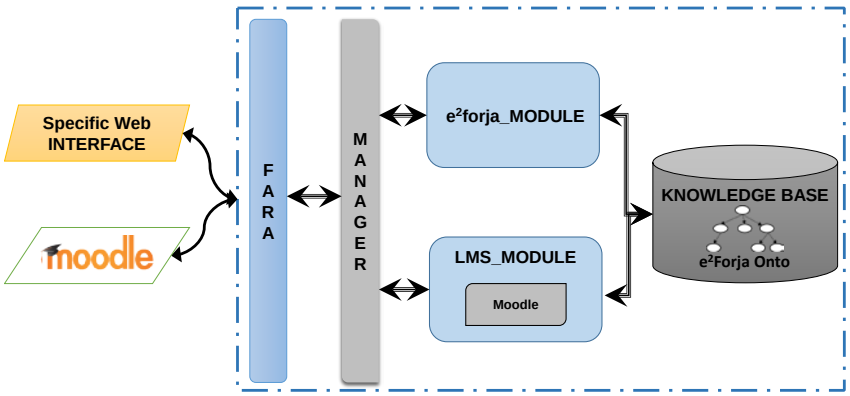

Figure 2. Architecture of the Forge system

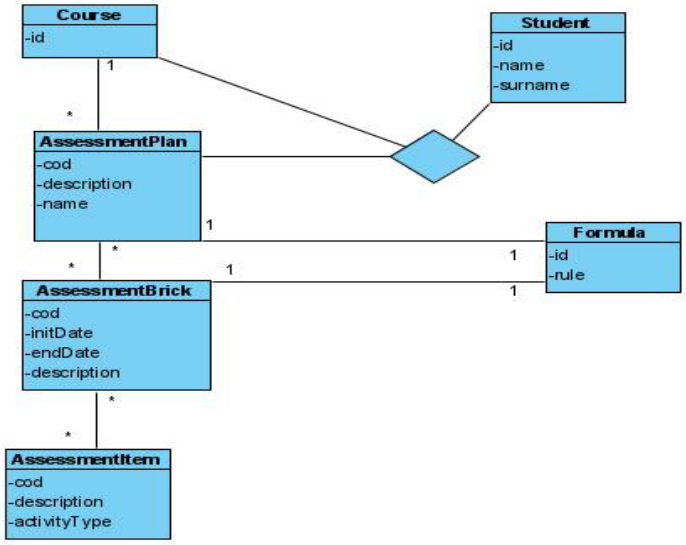

Figure 3. Ontology for formative and summative assessment

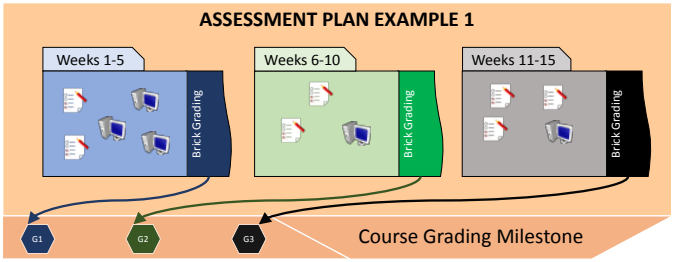

Figure 4. Assessment Plan example 1, time Bricks

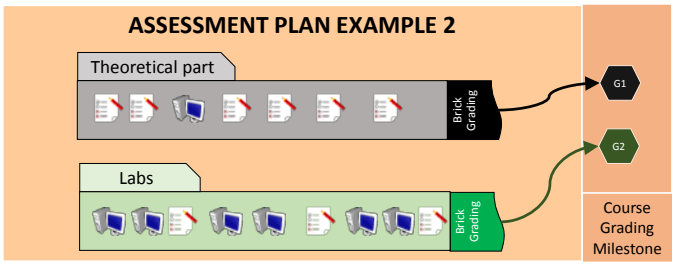

Figure 5. Assessment Plan example 2, assessment type Bricks

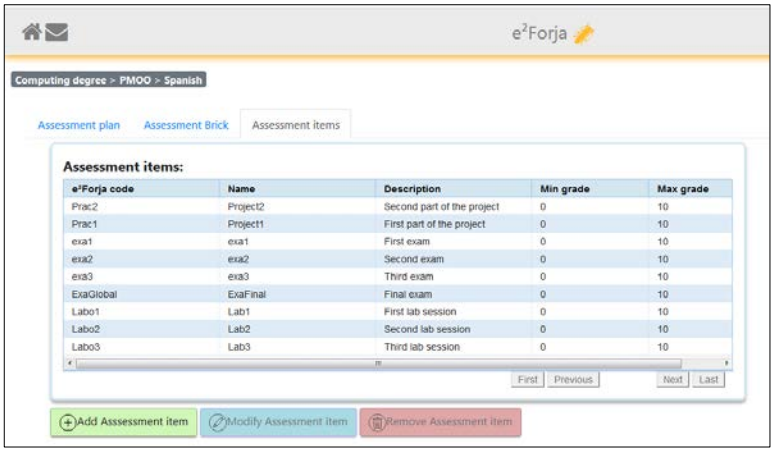

Figure 6. Assessment Item definition

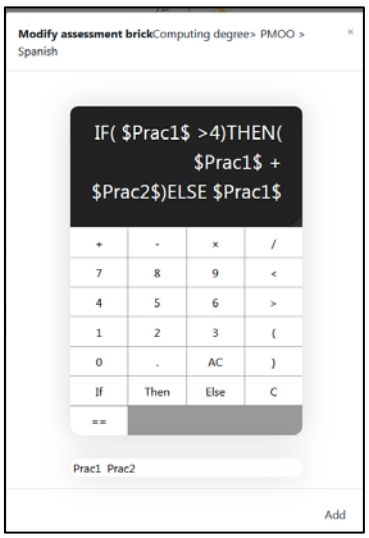

Figure 7. Grading formula definition interface

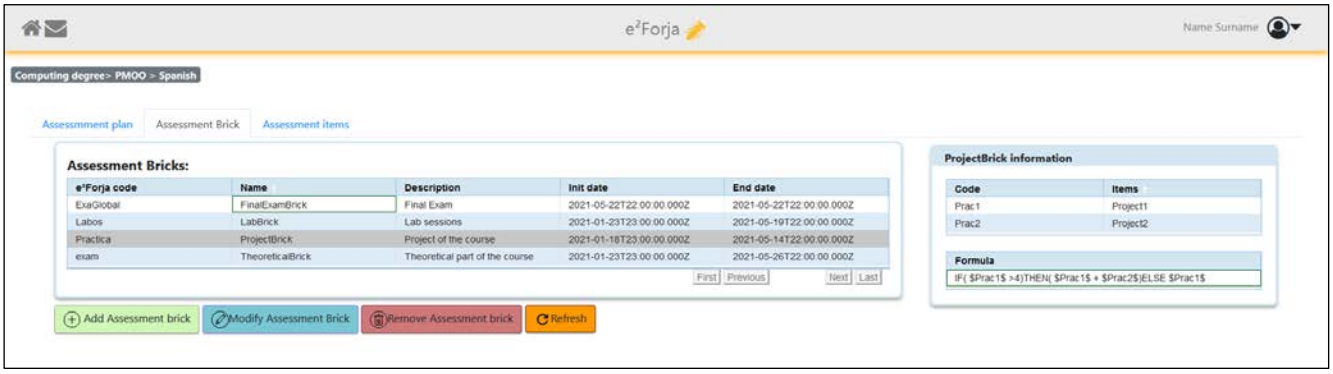

Figure 8. Assessment brick definition

Figure 9. Assessment Plan definition

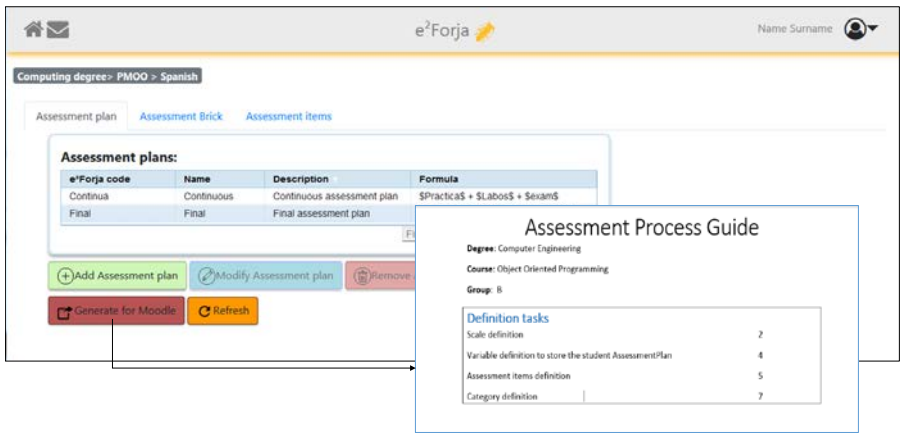

Figure 10. Definition guide generation

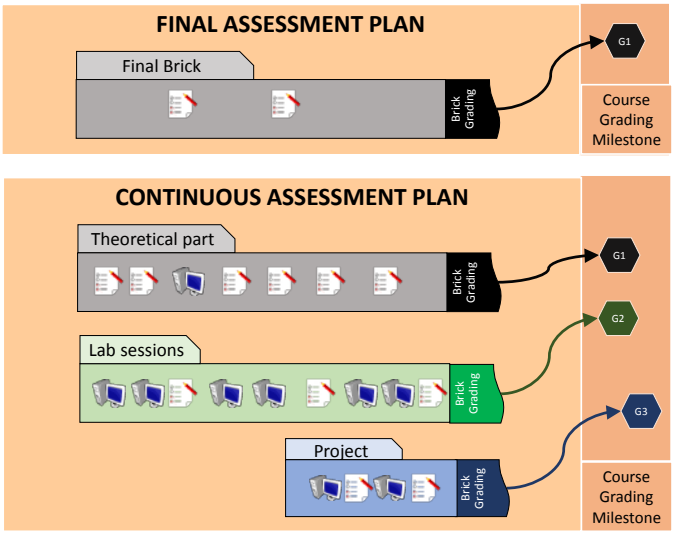

Figure 11. Two assessment Plans for the Object Oriented Programming course

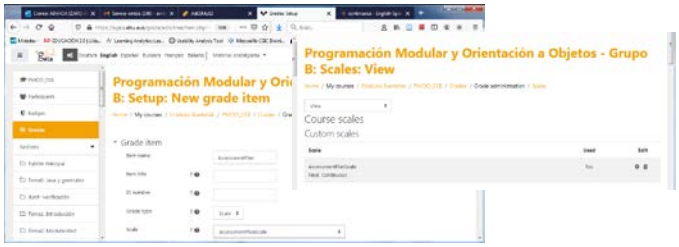

Figure 12. Scale and items to identify the assessment Plan for each student

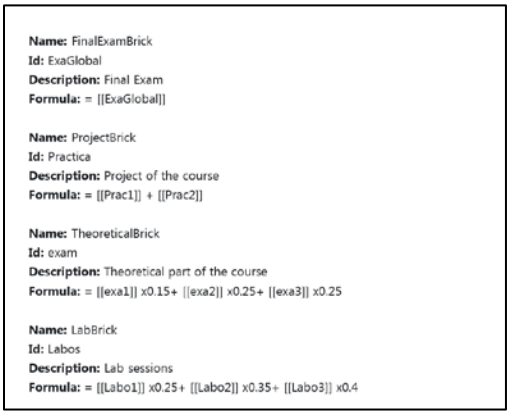

Figure 13. Categories to be defined in Moodle

Formula: =((min(1;round([[scaleAssessmentPlan]]/(2*1))) * ([[Practica]] + [[Labos]] + [[exam]]))*(1-

min(1;round([[scaleAssessmentPlan]]/2*2)))) + (min(1;round([[scaleAssessmentPlan]]/(2*2))) * ([[ExaGlobal]] x0.8+ [[Practica]] x0.2))))

Figure 14. Formula to obtain the course grade in Example 1

Figure captions

Figure 1. Alternative way to create the elements for the course assessment

Figure 2. Architecture of the Forge system

Figure 3. Ontology for formative and summative assessment

Figure 4. Assessment Plan example 1, time Bricks

Figure 5. Assessment Plan example 2, assessment type Bricks

Figure 6. Assessment Item definition

Figure 7. Grading formula definition interface

Figure 8. Assessment brick definition

Figure 9. Assessment Plan definition

Figure 10. Definition guide generation

Figure 11. Two assessment Plans for the Object Oriented Programming course

Figure 12. Scale and items to identify the assessment Plan for each student

Figure 13. Categories to be defined in Moodle

Figure 14. Formula to obtain the course grade in Example 1