Evaluations in the Moodle-mediated Music Teaching-Learning Environment

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Abstract

This study presents the use of automated data analysis procedures in the teaching-learning process, mediated by telematics platforms. It is based on the application of the principles of virtual learning, the use of the Internet and the automation of data analysis of information collected in Moodle. The application of analysis procedures for the assessment of music competences is proposed based on the data collected in an exam administered at the end of the course. The sample of the study consists of 1,327 students (n = 1327) in the first year of Compulsory Secondary Education in Spain and measures the level of acquisition of the key competences denominated "cultural and artistic". The results are subjected to the K-means classification technique. This technique is used to obtain homogeneously distributed conglomerates which allow for an objective evaluation of the levels of acquisition of the key musical competences.

Keywords: Assessment, Educational Software, Free Software, ICT, Music Education, Telematics Resources.

1. Introduction

Several studies have been published regarding technologies as effective tools for facilitating learning in music (Cho, Baek, & Choe, 2019; Hansen, 2019; Johnson, 2017; Koutsoupidou, 2014). Online music teaching and learning represents an emerging, fast-changing environment for music participation (Kenny, 2013). The present research is focused on the field of Applied Telematics of Musical Education (the union of computer technology, telecommunications, education, and music) applied to the level of Compulsory Secondary Education (12 year-old-students). The use of digital technology in the teaching-learning process has multiplied in recent years. New teaching methods, apps, and educative online resources appear every day. (Cano, 2016; García-Carmona & Marín, 2013; Mullins, Hicks, Ogle, Schilder & van Hover, 2016) This fact makes the study of them within the educational sciences quite necessary. In the case of music education, these digital tools provide students with musical comprehension and abilities in a more individualized environment. (Bauer, 2014; Edward, Asirvatham, & Johar, 2018; Hansen, 2019). Therefore, the specific use of a telematics platform which favours an elevated level of control of the teaching-learning process is presented. In this process some variables are very helpful, such as the test scores to evaluate the level of knowledge of the student. They are registered and saved for later analysis and detailed study, allowing the teacher to adapt their educational practices.

This study focuses on the application of resource technologies to the evaluation of student competence; *competence* being defined as "the combination of attributes and aptitudes which allows the student to put his/her acquired knowledge and abilities in practice," according to the UNE 66173 (2003, p. 4). This also includes the capacity to solve problems and the set of skills that are utilized for finding solutions. The focus

on competence, which appeared a few years ago in the educational field, has become a new necessity in the world of change and reform in educational politics (González & Wagenaar, 2003; Jover & García Fernández, 2015; Roegiers, 2007), this not being exempt from its critics (Barnett, 2001).

Within this framework, this study focuses on the evaluation of musical competences through the use of telematics platforms and the information collected from the Learning Management System (LMS), Moodle. Music contributes to the development of "cultural and artistic" competences. These competences imply knowing, understanding, and valuing different cultural and artistic manifestations with a critical spirit. More specifically, the particular competences established in the curriculum, (MECD, 2014,) for the subject of music involves the management and use of abilities and skills typical for instrumental or vocal musical interpretation. Other abilities are also developed, such as the reading of music, the use of classic and modern harmony, music analysis, elements connected to technical composition, and melodic accompaniments with polyphonic instruments like the guitar, piano, xylophone, or wind chimes. Moreover, both soloist and chamber music interpretation competences are developed. Learning drills are carried out in real contexts, with the opportunity to perform concerts in different theaters and to collaborate with other educational centers in the organization of musical events where the students play along with music professionals.

The competence evaluation has traditionally been one of the more complex subjects within the focus of teaching through competences (Castro Morera, 2011; Fernández-de-Álava, Quesada-Pallarés, & García-Carmona, 2017; Rodríguez-Conde, Martínez-Abad & Olmos-Migueláñez, 2013). The tool used for data collection and evaluation of musical competences is Moodle, (Modular Object-Oriented

Dynamic Learning Environment). It is comprised of free software for the learning development and the production of courses based on the use of the Internet. Moodle is used for the execution of massive online courses (MOOC), blended learning, distance learning, flipped classroom, etc., within the framework of .the socio-constructivist theories.

2. Theoretical Framework

Several studies have described various advantages of the Moodle platform (Bullock, 2016; Cabero-Almenara, Arancibia, & Del Prete, 2019; Karkina, Singh, & Valeeva, 2019; Selwyn, 2012). Some of the advantages of this platform according to these studies are: a) it supports socio-constructivist pedagogy (collaboration, learning activities, and critical reflection), b) it is appropriate for both face to face and remote education, c) it presents a compatible interface with any navigator, d) it is easy to install on the majority of platforms (including smartphones or tablets), and it is easy to administer (Aydin & Tirkes, 2010; Kearney & Levine, 2015; Kop, 2011). Thus the students can create their own accounts with an online profile that strengthens the communication and the exchange of information in the musical teaching-learning processes (Himonides & King, 2014; Montgomery, 2015). This study employs an educative platform which creates a virtual learning community (VLC). A learning community (LC) favours the comprehension and development of a common system of criteria for the evaluation of ideas (Cuthbert, 2003) and is designed independently from the time-space barriers (Monedero-Moya, Cebrián-Robles, & Desenne, 2015).

In this line of studies one can take advantage of the benefits of Big Data techniques. This involves the use of statistical models containing large volumes of information, such as those generated today in massive online courses (Bizer, Boncz, Brodie, & Erling, 2011; García-Carmona & Fuentes, 2016; Lin, Yeh, Hung, & Chang,

2013). This option provides detailed information about the function of the educative agents of these communities (the participation of parents, teachers, students, and educational institutions) (Etscheidt & Curran, 2012; García-Carmona, 2014). It also provides information about the learning objectives, (chats, forums, self-evaluation tests and collaborative activities) within the framework of tele-education platforms or LMS (Espigares & Bautista, 2018). The tele-education platforms allow for a virtual learning development at an optimal level (Chan, Galeana y Ramírez, 2007; Shayan y van Zaanen, 2019).

This study proposes the evaluation of music competences in Moodle as a learning management tool, due to its possibilities when offering immediate feedback on the student's work and the centralization of the information. Based on this information, teachers can also draw on a variety of materials to facilitate the process of curricular development in the subject of music in secondary school, which fosters the implementation of an open and flexible curriculum (Johnson, 2017; Rodríguez & Vicente, 2017).

The Moodle platform serves as a base for the production of statistical models and their future analysis. Regarding the classification of the information, one of the models that proves useful is the K-means model, which classifies combinations of data into different groups, or conglomerates (Celebi, Kingravi, & Vela, 2013). This method defines a fixed number of conglomerates in a repeated manner, assigning registers to the conglomerates and adjusting the centres of the conglomerates until it can no longer improve the model (Lin et al., 2012). Instead of trying to predict a result, the K-means model uses a process known as unsupervised learning (Feldman, Schmidt, & Sohler, 2013) to reveal the patterns of the combination of the fields of entrance.

According to Irigoien and Arenas (2006, p. 261) the cluster analysis, or clustering "is a collection of statistical methods which allows for the grouping of cases on which variables or characteristics are measured." The clusters or groups that are formed through the K-means analysis are unique in that previous information is not taken into account, but rather is suggested from the essence of the data. One of the characteristics of the K-means is that it is a non-hierarchical method of cluster analysis and that the quantity of clusters that will be formed are fixed in advance (Espigares & Bautista, 2018). From there, the objects are grouped to obtain said combinations with some optimization criteria. As far as the nature of the employed data, this technique uses quantitative variables and is ideal for the analysis of large volumes of data or collected information in the teaching-learning processes mediated by telematics platforms (Mairal, Bach, Ponce, & Sapiro, 2010), as in the case we are presenting.

3. Objective of the Study

This study seeks to demonstrate the utility of the automated processes of analysis in Moodle, specifically, for the analysis of educative musical data in the evaluation of cultural and artistic competences. The cluster type model is the K-means model and it is obtained from and automated system of analysis of educative musical data, which makes it possible to collect data and save it for future analysis.

4. Method

This study is carried out using a quantitative methodology. The data of the students' test responses is processed in real time and through an algorithm of data analysis which allows for the production of a statistical model that groups and

organizes the information in a structured way, based on educational and didactic criteria.

4.1. Participants

For this study, thirty Secondary Schools in the autonomous community of Andalusia (Spain) were invited to participate (n=30). The schools that participated in the study were chosen at random and their participation in the research was solicited by email. The sample of study consists of 1,327 students of the first grade of 'ESO' (Obligatory Secondary Education) between the ages of 12 and 13.

4.2. Instrument: the music evaluation test

Data was collected through an exam consisting of eight questions to measure the level of the key "cultural and artistic" competences of the students. The themes address different thematic blocks of the basis of the musical language such as sound characteristics, differentiation between musical symbols, classification of voices and musical instruments, music and ICT, distinction between different musical keys or musical hearing (see Annex I).

4.3. Procedure

Data collection was conducted during the last two weeks of the 2014-2015 academic year. The tests were answered in complete confidentiality. All personal information that could identify the student was deleted, and each exam was assigned a code that guaranteed anonymity.

The tool employed for the production of the study was a Moodle telematics platform located in the server and the statistical modelling software Clementine, version 11.1.

The analyses were administered by the SPSS Clementine 11.1, a programme which specializes in the analysis of large volumes of data (through automated analysis of

educative data procedures) and the production of statistical models. This software was connected to the database of the Moodle telematics platform allowing for the monitoring of the exams and the obtainment of detailed information about the whole process. It has allowed us to automate the task of analyzation, such as the acquirement of information and the exportation of the results to the system using the Moodle tele-educative platform and its database.

The procedure of the analysis consists of three phases:

1. Exploratory technique through the K-means cluster model.
2. Definition of the educational criteria which establishes the competence levels starting with the grouping done through the exploratory cluster model.
3. Application of a formula of the totality of the test data, from the cluster model and the established ranges related to the competence acquisition levels.

Firstly, an exploration of the information and the production of the cluster model is administered. In this section the analyses made with SPSS are reflected. The analyses are based on the work divided into three perfectly delimited phases. Initially, when we work with automated procedures of analysis, the data is subjected to a purification and selection of information. Specifically, the variables or the object variable of the study are selected, in this case the grades of the final evaluation, and we eliminate the void values that do nothing for the obtainment of the cluster type model. Secondly, the K-means technique is applied and the number of conglomerates that we want to obtain is selected. In this case, the groups of students were divided into four levels of basic competence acquisition: not acquired, partially acquired, acquired and totally acquired; four being the number of clusters that is selected when configuring the model. In this way the space of each conglomerate appears delimited by this classification criteria and will show an index of distance with respect to the

centroid or the value around which the data will be categorized in each group. Thirdly, the four conglomerates obtained and grouped by a K-means algorithm is shown in a graph.

Following the process of the analysis automation, one can see that, first and foremost, one connects to a database. This is the place where the registers and variables subjected to the study are found. In the first phase, the aforementioned variables are selected and the void values are discarded in the sample. The totality of the data obtained from the database is put into a sample. Afterwards, a K-means model is created, and once the model is obtained, we show the data of the model corresponding to the basic statistics and its distribution according to the conglomerates or clusters obtained. In the second phase, the competence ranges and educational criteria of the classification of the information are established. In the third phase, we apply the established criteria from the second phase about the levels of competence acquisition to the total information collected. This application is created from the mathematical formula that establishes the competence ranges and groups each student exactly to his/her educative level. In the analysis procedure one can observe that the exploratory K-means techniques are used to observe the different conglomerates that establish the levels of competence acquisition. The models produced are hierarchical since they define the groupings or categories which are established: in total four, which are the competence levels of the students. This value is defined in advance following the educative criteria.

Table 1 shows the distinct homogeneous and differentiated groups. From the exploration we define, through a formula, a concrete criteria of grouping of each level of competence acquisition:

Levels of competence acquisition	Points	Grade
Totally acquired	9-10	A
Acquired	7-8	B
Partially acquired	5-6	C
Not acquired	0-4	D

Table 1. Levels of competence acquisition

In summary, the distinct analytical phases of the information of the conglomerates are shown. This allows for the visualization of different groupings of the results of the tests carried out. It also illustrates the application of a formula that allows for exact grouping connected to each ID of the sample, which represents each student with his/her level of competence acquisition.

4. Results

This section presents an overview of the automated processes of analysis in Moodle for the analysis of educative musical data in the evaluation for competences. Table 2 shows basic statistical data and the distribution of the sample. It also presents a recounting of valid registers of 1,327 in total (n=1327), meaning that this number corresponds to the student identified as an "ID", denoting a unique identification number linked to the name and personal information in the database. This allows us to be aware in every moment of which subjects we are dealing with and to monitor their work.

Below we will show the production of the K-means model step by step, the images of the configuration of the model, and the results obtained. In the following model (Table 2) we can see four blocks, conglomerates or clusters, and the detailed

information of each one of the clusters. These clusters represent levels of competence acquisition obtained from the final evaluations.

Number of cluster	*Cluster 1*	*Cluster 2*	*Cluster 3*	*Cluster 4*
N (size)	445	48	634	200
Average	72.652	23.16	95.702	54.762
Typical deviation	5.41	12.274	5.146	5.762
Proximity Index	*cluster* 1-*cluster* 4: 0,78892 *cluster* 1-*cluster* 3: 0,230502 *cluster* 1-*cluster* 2: 0,49492	*cluster* 2-*cluster* 4: 0,316028 *cluster* 2-*cluster* 1: 0,49492 cluster 2-cluster 3: 0,725422	*cluster* 3-*cluster* 1: 0,230502 *cluster* 3-*cluster* 4: 0,409394 *cluster* 3-*cluster* 2: 0,725422	*cluster* 4-*cluster* 1: 0,178892 *cluster* 4-*cluster* 2: 0,316028 *cluster* 4-*cluster* 3: 0,409394
Level of competence acquisition	Acquired competence	Competences not acquired	Competences totally acquired	Competences partially acquired

Table 2. *Clusters* of the study: size, average, proximity indexes and competence acquisition levels.

In summary, conglomerate 1 presents a sample of 445 registers. The average is 72.652 on a scale of 0 to 100. This cluster defines the group formed of students with a level of "competence acquisition acquired".

Conglomerate 2 reflects a sample of 48 registers. The average is 23.16 on a scale of 0 to 100. This cluster defines a group formed of students with a level of "competence acquisition not acquired".

Conglomerate 3 contains a total of 634 registers. The average is 95.702 on a scale of 1 to 100. This cluster defines a group formed of students with a level of "competence acquisition totally acquired".

Conglomerate 4 contains a total of 200 registers. The average is 54.762 on a scale of 1 to 100. This cluster defines the group formed of students with a level of "competence acquisition partially acquired".

Below we will show the sample of the K-means model in graph form (Figure 1) with a high grade of reliability and validity which generates as value 1.00. We can also see through sector and bar graphs the sample of the model exposed with the clusters that establish the levels of competence acquisition.

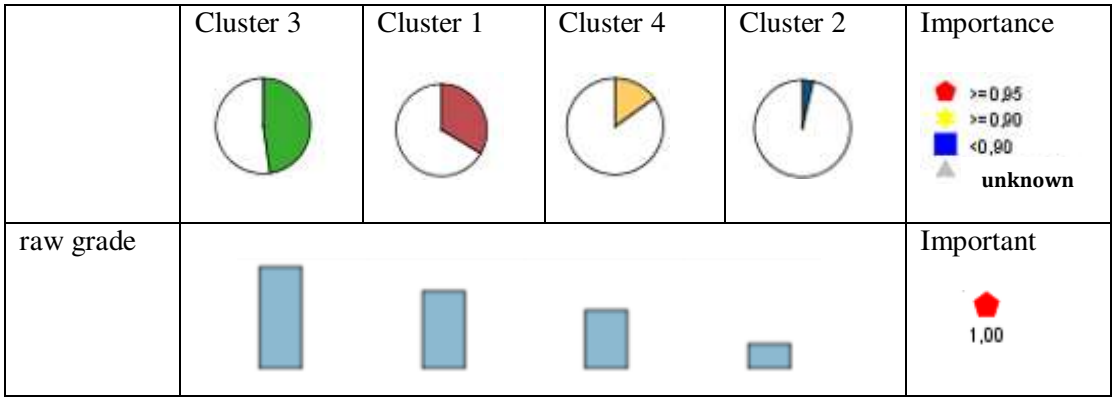

Figure 1. K-means model generated representing the high reliability of the model and the sector and bar graphs with the distribution of the simple in distinct competence levels.

In Figure 2 below we can see the graph with the model, corresponding to the obtained grades and the different conglomerates. In this picture we can observe the

four levels that we presented in our theoretical framework: totally acquired competences (cluster 3), acquired competences (cluster 1) partially acquired competences (cluster 4) and non-acquired competences (cluster 2). These reflect the different levels of competence acquisition of the students who participated in the study.

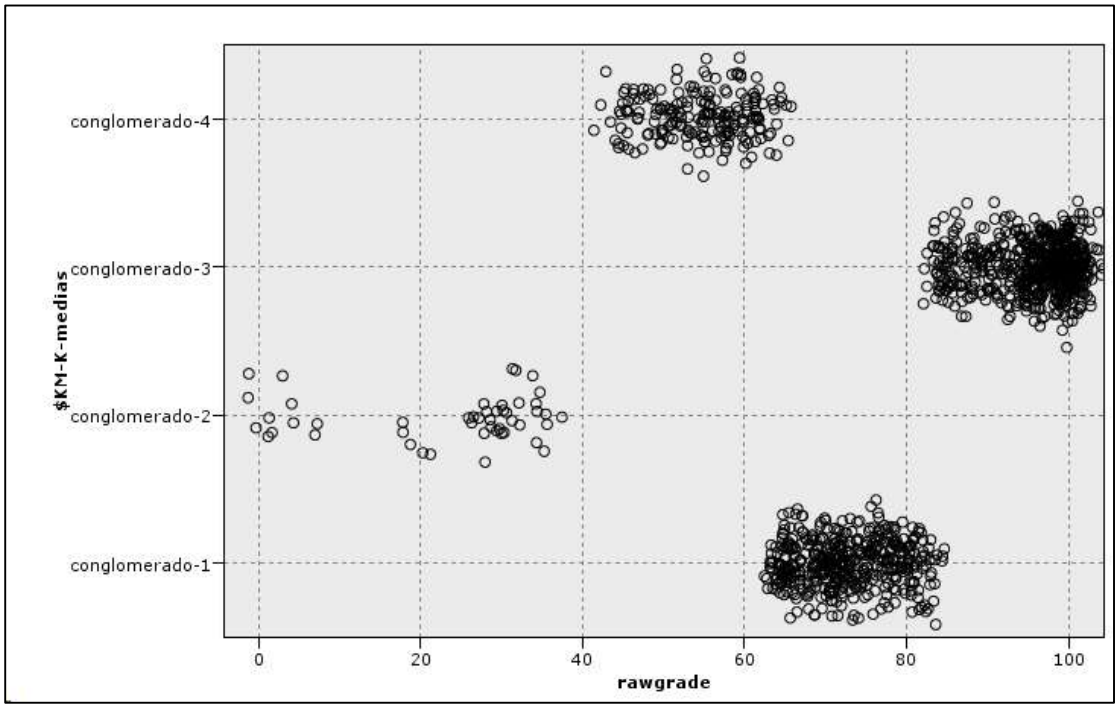

Figure 2. K-means Model obtained with the levels of competence acquisition (totally acquired, acquired, partially acquired and non-acquired).

4. Discussion

The objective of this article is to demonstrate the usefulness of the automated procedures for the analysis of educative musical data, which forms part of the evaluation of competences.

In this sense, authors like Kop (2011) or Yang, Zhang, Su, & Tsai (2011) have supported digital platforms for the management of students' education, with the clear advantage of looking at music subjects and the variables which are established from the beginning.

Likewise, the application of the K-means model has allowed the obtainment of detailed information of each of the clusters or groups of data in different categories (or conglomerates). This model enables, as noted by Lin et al. (2012) and Celebi, Kingravi and Vela (2013), grouping to measure variables or characteristics, in our case music competence acquisition levels obtained from the final evaluations.

The study of the obtained information from the cluster analysis has allowed us to visualize the different conglomerates related to the results of the evaluation administered, and following that, the conceptualization on a determinate educational level. The application of this formula facilitated an exact categorization, linked to each ID of the sample, which represents each student with his/her competence acquisition level.

As Feldman, Schmidt and Sohler (2013) and Celebi, Kingravi and Vela (2013) indicate, The K-means method of analysis is efficient and effective for learning. It has provided precise knowledge of the levels of musical competence of the students.
In this sense, technology allows for a more precise and personalized focus on the teaching-learning processes, as pointed out by Lin et al. (2013), Sagitova (2014), Twyman (2014) and Kearney and Levine (2015).

Specifically, technology allows for the obtainment of more useful and detailed information for a personalized learning, which is of maximum interest (RAND Corporation, 2014; Redding, 2014a, 2014b; García-Carmona and Fuentes, 2016). As a result, technology makes monitoring, exploration, and prediction possible.

4. Conclusions

The results of this study allow us to conclude the following:

1. Through the automated procedures of analysis, one can monitor and establish *basic competence acquisition levels.* In particular, in our study the K-means model was

programmed for the production of four different groups defining the levels of musical competence acquisition as *not acquired, partially acquired, acquired, and totally acquired.* This makes it possible to strengthen personal education in the school and to address the educative diversity in the classroom in a useful and efficient way, as is reflected in the different groups established by the competence levels of the students. Specifically, the clusters obtained show an elevated level of student representation with an acquired and totally acquired competence level. Nevertheless, the non-acquired and partially acquired competences are the ones that present the lowest sample size.

2. The study carried out allows the teacher to monitor the music evaluation at any moment throughout the process. Through the use of this analysis, it is possible to have a high level of control over the data collected and to make adaptations in real time to the information collection processes and the analysis of the obtained results.

3. Regarding the nature of the collected data, the projects of educative data analysis based on automated procedures allows us to *redefine the utilized models* (exploration, descriptive, classification or predictive models).

4. The employment of the automated analysis procedures in Moodle allows us to make educative decisions based on the process of the analysis of the information. It also allows us to develop the different levels a competence acquisition in the classroom. The objective is to establish learning itineraries and strategies adapted to the needs of the students.

5. This model is *reproducible and repeatable*. In this way we attend to two basic principles of the scientific method: reproducibility and repeatability, allowing the model to be applicable to other research contexts in which one has to classify student

information in academic performance: competence totally acquired, competence acquired, competence partially and competence not acquired.

In conclusion, this article reflects that the use of a telematics platform, in particular, Moodle, favors a high level of control over the teaching-learning process. Within this framework, variables such as the exam results are very useful, given that they are registered and saved for future analysis, which allows the teacher to adapt the educative practice to the particular needs, interests and motivations of the student (attention to diversity). In this way, the use of the online environment provides a wide range of possibilities in the teaching-learning framework.

LMS has provided important changes in relation to its availability, the accessible information, the increase of communication, etc., within the teaching-learning process. In this way, the knowledge of the level of competences of the students online allows us to identify the ones who need help or additional challenges within the framework of the music teaching-learning environment.

In this sense, it was discovered that the pedagogic elements of online music teaching-learning includes the teacher, the students and the wider community, all within the framework of a socio-constructivist design. This makes for a favorable teaching-learning environment.

It also allows for the evaluation of key music competences from the data collected through the telematics platform. By the use of advanced statistical techniques and automated analysis, originating from the Big Data (K-means, cluster models or conglomerates) applied to the online musical teaching-learning processes, it proves to be efficient, useful and innovative, as an objective to establish the different

levels of musical competence acquisition in the teaching-learning processes mediated through ICT.

As far as the *prospective limitations of the study*, it would be interesting to develop and achieve a larger grade of integration of the analytical tools of the educative data of the online and face-to-face music courses. In this way, the open code telematics platforms like Moodle would offer the teachers detailed information about the music teaching-learning processes. It would also offer the administration of online activities and the monitoring of the educative processes, as well as the creation of valid and reliable statistical models. All of this would be of great use for teaching tasks, for musical research, and for academic management. Although of course, we must consider the possible limitation of the "educative musical data" as it is defined in this study, since it is defined by the knowledge of the standard western notation system and the Eurocentric musical terms and values

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ANNEX I

Example of one of the student evaluation activities, which works with different aspects of learning, both practical and theoretical, developing the levels of competence acquisition specifically related to the music material required in the first year of Obligatory Secondary Education.

FINAL EVALUATION TEST

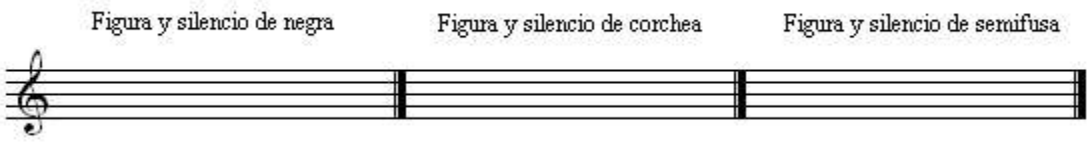
MUSIC DEPARTMENT

FIRST YEAR OF OBLIGITORY SECONDARY EDUCATION

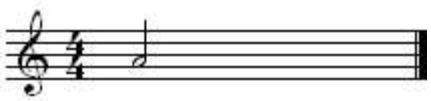
NAME AND SURNAMES:

COURSE AND GROUP:

1. On a staff, draw the notes and the rests: crotchet, quaver and 64th note. 2 Points



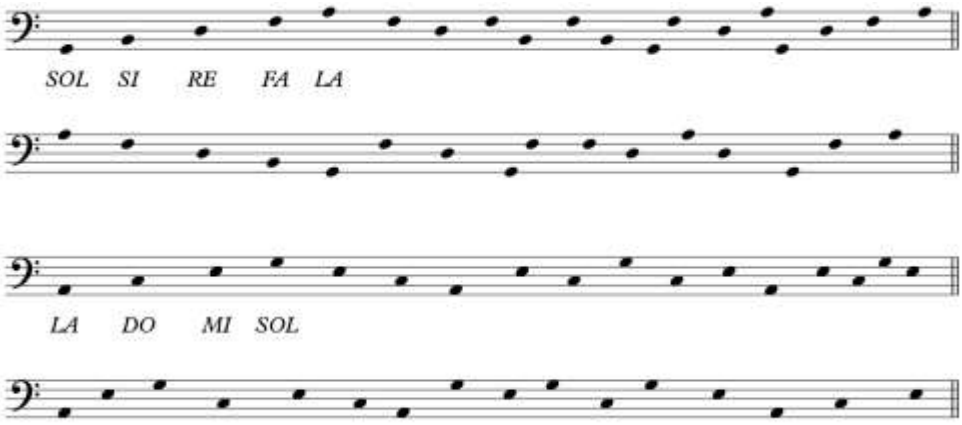
2. Indicate how many beats there are in a half note, in a dotted quarter note and in a quarter note. 1 POINT
3. What effect does a fermata have? Represent it. 1 POINT
4. Fill in the following staff with a treble clef, in 4/4 time with the missing note or notes and indicate how many 8th notes would go in 4/4 time. 1 POINT



5. Classify the human voices and the musical instruments and give examples of each family. 1 POINT

6. Point out the types of musical textures that a listening session can have.1 POINT

7. Do this quiz about the name of the notes in the bass clef on the 4th line of the following page. 1 POINT.



8. Comment on everything you know about the relationship between music and technology. 2 POINTS