VNIVERSITAT DE VALÈNCIA

Influence of the Learning Environment on the Representational Strategies of Middle School Music Students: An Intervention-Based Study

THESIS

Submitted to the Faculty of Teacher Training at the University of Valencia in Partial Fulfilment of the Requirements for the Degree
"Doctoral Studies in Specific Didactics".

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2015

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Contents

List of Tables

List of Figures

Abstract

The purpose of this study was to examine the effects of a hypermedia learning environment on middle school students' meta-representational competence (MRC) in the domain of music. Particularly, we aimed at determining whether an educational intervention influenced the accuracy with which middle school students matched sounds (sonic fragments) to symbols (graphic representations). The students were randomly allocated to the experimental condition. An intervention was set up so that the experimental group students (E) were provided with scaffolding aimed at enhancing their use of constructive resources to generate representations and their critical capabilities to judge them. On the other hand, the control group students (C) followed a similar educational program lacking in such scaffolding. Both E and C groups were given the same pretest and posttest, which measured students' MRC by means of six representational criteria. One month after the posttest, a retention test took place. We hypothesized that the experimental program would have a positive overall effect on the students' MRC, which was partially supported, since such positive effect happened irrespective of the intervention. We also predicted a lasting effect of the intervention for the students who received scaffolding during the intervention, and that finding was also confirmed. As to the students' perception of the learning environment, the E group students overall scored their experience with the lesson in a more positive way than the C group, despite this trend was not confirmed for all the subscales of the survey. In addition, we inquired into the effectiveness of the treatment for participants with different levels of music experience, resulting an overall benefit from the intervention. As to the partial effect for the six representational criteria involved in the study, a significant overall effect because of the intervention was found for two non-epistemic criteria, namely formality and parsimony. Finally, regarding the partial effect for the three music parameters studied, a significant overall effect because of the treatment was found for pitch.

Acknowledgements

I would like to thank my supervisor at the University of Valencia, Prof. Dr. Jesús Tejada, for his help and advice in this project; my academic hosts at the University of Leuven, Prof. Dr. Lieven Verschaffel and Prof. Dr. Mark Reybrouck for their decisive support; prof. Dr. Alistair Edwards and associates from the University of York for their help on music aptitude measurement; the students who participated in the study, without whom there would have been no research; the principal of the high school where this research took place for her willingness to consent the study; my family, for having provided me with a household background which has allowed me to reach this academic degree; and my wife, Maria dels Àngels Cebrià, for her support and patience.

Part I

DOCTORAL THESIS

Chapter 1

Introduction

1.1 Context of the study

In 2006, The European Parliament and The Council of the European Union recommended the Member States to "develop the provision of key competences for all as part of their lifelong learning strategies" (The European Parliament & the Council of the European Union, 2006, p. 11) and provided them with a Reference Framework so as to harmonize their educational policies. This framework distinguished eight key competences, which were meant to promote an active citizenship according to the challenges of an increasingly globalized world. One of the key competences is 'cultural awareness and expression', in which music education has its place.

Prior to this recommendation, the Member States ratified the UNESCO Salamanca Statement and Framework for Action in Special Needs Education (1994), which highlighted principles such as "equal opportunities in terms of genuine access to learning experiences, respect for individual differences and quality education for all focused upon personal strengths rather than weaknesses" (Bauer, Kaprova, Michaelidou, & Pluhar, 2009, p. 13). From this inclusive approach of education, special education needs (SEN) are seen as a challenge to the Member States education systems, since it is claimed that "pupils with SEN have a right to a curriculum that is appropriate to their needs" (Watkins, 2007, p. 16).

Taking these European recommendations into account, it becomes obvious that music education has much to offer to learners' comprehensive education, starting from two major premises: a) music must contribute to achieve essential social and civic values such as citizenship, equality, tolerance and respect; and b) not only the gifted, but every learner, whichever social background they have, deserve access to music education. The claims are appealing, and the means to achieve them call forth this research. More specifically, our study focuses on a subset of music education, namely graphical representation of music, as a means for middle school students to improve their sense-making of the sounding environment.

1.2 Statement of the problem

Paynter (2008, p. 102) reminds us that "it was not until the 1950s and 1960s that music's potential as 'an education' in which the majority of school pupils could participate began to be vigorously promoted and very gradually accepted." In fact, in the early 1970s, pioneer works appeared in Great Britain and Canada accounting for work that had been in progress in schools for several years. As a rule, those works were written by composers who highlighted the "educational potential [of music] for all pupils" (Paynter, 2008, p. 97) and claimed a new approach to music education alternative to representing music by means of standard music notation, since "it is no longer adequate to cope with the meshing of the worlds of musical expression and the acoustic environment" (Schafer, 1977/1994, p. 124).

Recently, Verschaffel, Reybrouck, Jans, and van Dooren (2010, p. 476) adopted a quite similar approach to Shafer's statement in a study about children's graphical representation of music:

> Taking into account that scientific, technological, and societal developments have completely changed the "representational landscape" for most sciences, it does not make sense any longer to teach only a few standard representational forms.

The above quoted study is part and parcel of a body of research (Reybrouck, Verschaffel, & Lauwerier, 2009; Verschaffel, Reybrouck, Degraeuwe, & van Dooren, 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Janssens, & van Dooren, 2010) in which authors "gradually became aware of the potential relevance of the theoretical notion of 'metarepresentational competence' [MRC]" (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 692), as decribed by diSessa and associates (diSessa, 2002, 2004; diSessa, Hammer, Sherin, & Kolpakowsky, 1991; diSessa & B. L. Sherin, 2000).

This body of research has the merit of having first studied children's notations of sound or music from a metarepresentational approach. To date, however, the mentioned studies are ascertaining studies which "aim mainly at describing how learning occurs under given conditions of instruction" (de Corte & Verschaffel, 2002, p. 519), and therefore the authors have claimed the need of undertaking design experiments so as to explore the extent to which MRC is supported across multiple domains, being music among them.

In a pilot study (Gil, Reybrouck, Tejada, & Verschaffel, in press), we partially addressed these claims by studying the influence of subject variables (age, music experience) and task variables (educational intervention) on middle school students' MRC, and suggested as further research a "possible change in the educational intervention in a future study, such as an improvement of the learning environment, by means of hypermedia resources." Now, we take such a challenge as a starting point for this study, in which a technology-enhanced learning environment (TELE) was set so as to allow a differentiated educational intervention according to the experimental condition.

1.3 Study focus

This research explores the extent to which an educational intervention can enhance the learners' representational skills, so as to improve their sense-making of the sounding environment. From an epistemological perspective, our concern for activities deals with the ways in which the activity context of learning affects what is learned. One of the main concepts in this study is the meta-representational competence (MRC), described as "the faculty to generate, critique, and refine representational forms" (diSessa, Hammer, et al., 1991, p. 118). In detail, diSessa (2002, p. 105) defines MRC as:

> ...the full complex of abilities to deal with representational issues. MRC includes, centrally, the ability to design new representations, including both creating representations and judging their adequacy for particular purposes. It also includes understanding how representations work, how to work representations for different purposes, and, indeed, what the purposes of representation are.

Although the use of the prefix "meta" may evoke a connection to metacognition, no link is meant between this construct and MRC. Instead, "meta" is used to emphasize that no specific representational skills are implicated (diSessa, Hammer, et al., 1991, p. 118; diSessa & B. L. Sherin, 2000, p. 386; diSessa, 2004, p. 294).

Two outstanding processes are important within the context of representational design: a) 'constructive resources' refer to a set of ideas and strategies for generating representations; and (b) 'critical capabilities' entail judging the effectiveness of the result and redesigning to ameliorate limitations (diSessa, 2002, p. 107).

In the course of their research on MRC, diSessa, Hammer, et al. (1991, p. 148) observed that students seemed to follow a regular pattern in designing representations for motion, and put forward a list of meta-representational criteria. In a further study, diSessa (2002, p. 115) developed a coding scheme with four a priori categories: (a) make-centered criteria focus on the process of construction of the representation; (b) use-centered criteria involve judgements concerning the representation's use; (c) epistemic fidelity criteria refer to how accurately does a representation reflect the actual state of the world; and (d) formal criteria concern the representation's formal properties.

In addition to this categorization, diSessa (2002, p. 116) completed his coding scheme with four categories based on his "experience attempting to code students' discussions", namely: (a) inexplicit/assertional category encompasses quality claims with no evident justification; (b) aesthetic criteria refer to non-scientific arguments related to presence or absence of a pleasant visual effect; (c) social criteria focus on favourable or unfavourable social consequences of judgements; and (d) meta category concerns comments or reflections on criteria themselves.

1.4 Conceptual framework

1.4.1 Overview

The theoretical basis of our study relies on two major conceptual fields, supported by the overall background of constructivism as a paradigm for teaching and learning. First, regarding how children make sense of the sounding environment, an ecological approach grounded on J. J. Gibson (1966, 1982) acts as a core nexus between musical epistemology and musical semantics. Second, with respect to the educational intervention aimed at improving the students' representational skills (see Chapter 3), the cognitive apprenticeship model (Collins, Brown, & Holum, 1991; Collins, Brown, & Newman, 1989) provides us with the framework for designing a powerful learning environment, according to general principles of instructional psychology.

1.4.2 Making sense of the sonic world

Broadly speaking, our theoretical approach entails an organism –conceived as music user– who copes with an environment –conceived as sonic world– while trying to make sense of it by means of cognitive maps. In doing so, the music user extracts cues from the sounding material and organizes them according to certain grouping criteria in a cognitively less demanding way.

On this view, dealing with music can be considered at a more general level as a generic term that encompasses categories other than traditional musical behaviours. Accordingly, a category broader than listeners or performers to denote subjects that deal with music is required, and hence we speak of music users (Reybrouck, 2001, 2002, 2004, 2005a, 2005b, 2006a, 2006b, 2008, 2009, 2012). Instead of behaving as mere recipients that passively register an outer sonic world, music users are thought to actively pick-up information (Windsor, 2004, p. 183; Shepard, 1984, p. 421), insofar as the sounding environment allows them to do so. This approach involves a redefinition of the sense organs as perceptual systems, what stresses their active rather than passive performance (McAdams, 1993; Michaels & Carello, 1981; J. J. Gibson, 1966, 1982; Reybrouck, 2005a, 2005b). In addition, affordances are understood here as what the sounding environment offers music users (Windsor, 2004, p. 183):

> ...the organism neither reacts to stimuli, nor does it interpret them; rather, the organism discovers the affordances of events and objects through the pick-up of stimulus information.

The concept of affordance brings perception and action together (Clarke, 2005, p. 38; Michaels & Carello, 1981, p. 47). It follows from this that coping with music is not merely a conservative process, but a proactive and retroactive process as well, "allowing the music user to navigate through the sound by relying upon memory and imagination" (Reybrouck, 2004, p. 411). Conceiving of music users as navigators who try to find their way in a sounding environment appeals to music broadly considered as a sonorous unfolding through time, where the listener goes from one place to another (Reybrouck, 2003, 2008, 2010). This going from "here" to "there" adds a spatial component to music perception, what leads us to cognitive maps, conceived as "interpretative frameworks of the world which exist in the human mind and which affect actions and decisions as well as knowledge structures" (Reybrouck, 2003, p. 299).

Cognitive maps are "built up by the extraction of salient features or 'hallmarks' which are put together in some coherent way (Reybrouck, 2010, p. 193). Such salient elements or cues that are "prominent at the musical surface" are related to perceptual dimensions of music, whose mental organization brings us close to Gestalt notions (Deliège, 1996, 2001, 2007; Deliège & Mélen, 1997). The cue abstraction allows the music user to segment the sonorous unfolding in organized units which reduces the amount of information to be stored in memory, to the extent that "if the memory trace left by a given cue is not 'refreshed' by a simple or varied repetition, it is erased from the memory" (Deliège & Mélen, 1997, p. 403).

Cue abstraction and memory are related in terms of cognitive economy, understood in terms of quick and efficient perception, rather than slow and contemplative (J. J. Gibson, 1966, p. 286), what fits in with the biological approach that "organisms have to reduce the amount of information that come in from the outside world, deciding which information is relevant to their survival" (Snyder, 2000, p. 81). What are those mechanisms to avoid overloading memory? Authors highlight melodic segmentation (Ahlbäck, 2007), grouping (Deliège & Mélen, 1997) and categorization (Snyder, 2000) as processes that allow the music user to cope with the sonic world in a less demanding way (Reybrouck, 2005b).

1.4.3 Designing a learning environment

Here, in broad outline, the design of a powerful learning environment is linked to instructional psychology, described as a subset of educational psychology (de Corte, 1996, 2001; Mayer, 1996). Definitions and features of learning environments are explored, as well as principles for their design, what leads us to the cognitive apprenticeship model (Collins, Brown, & Newman, 1989). Scaffolding –one of the teaching methods of this model– is highlighted as a central concept in our approach.

In his seminal review of instructional psychology, Gagné and Rohwer (1969, p. 381) regretted the "remoteness of applicability to instruction" of previous studies of human learning, many of them with a disciplinary orientation linked to behaviourism. Subsequent reviews (Gagné & Dick, 1983; Glaser, 1982; Pintrich, Cross, Kozma, & McKeachie, 1986; Snow & Swanson, 1992) have revealed an upturn in studies with an educational orientation, in the context of cognitive psychology. de Corte (2001, p. 7569) defines instructional psychology as:

> ...the study of the processes and outcomes of human learning in a variety of educational and instructional settings, and of the nature and the design of environments that are appropriate to elicit those learning processes aiming at the attainment of competence and of a

> disposition toward skilled learning, thinking, and problem solving in a given domain.

Elaborating and validating a coherent framework of principles for the design of powerful learning environments is a central task for instructional psychology research (de Corte, 2001, p. 7571; Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001, p. 382), since "studies conducted over the past 30 years have provided convincing evidence that the quality of the classroom environment in schools is a significant determinant of student learning". (Dorman, Fisher, & Waldrip, 2006, p. 2).

Definitions of learning environments emphasize the atmosphere, ambience, tone, or climate that pervades an educational setting (Fraser, 1996, p. 679; Dorman et al., 2006, p. 2), which implies "physical surroundings, psychological or emotional conditions, and social or cultural influences" (Hiemstra, 1991, p. 8). van Merriënboer and Paas (2003, p. 3) highlight that learning environments are aimed at developing "complex and higher-order skills, deep conceptual understanding, and metacognitive skills", while Fraser (1998, 2012) conceives of learning environments "in terms of the shared perceptions of the students and teachers".

Effective learning has been seen as "a constructive, cumulative, self-regulated, goal-directed, situated, collaborative, and individually different process of meaning construction and knowledge building" (de Corte, 1996, p. 37), which is in line with a framework for the design of effective learning environments that is learner-centered, knowledge-centered, assessment-centered, and community-centered (de Corte, Verschaffel, & Masui, 2004, p. 367). In a nutshell, a key feature of powerful learning environments is that they foster high-quality learning (Vermunt, 2003, p. 121).

The guiding principles that we have followed for the design of our learning environment can be summarised as follows (de Corte, 2000, p. 254): (a) inducing and supporting constructive, cumulative, and goal-oriented acquisition processes in all learners; (b) fostering students' self-regulation of their learning processes; (c) embedding acquisition processes as much as possible in authentic contexts; (d) flexibly adapting the instructional support; and (e) integrating the acquisition of general (meta-)cognitive skills within the subject-matter domains. In other words, our learning environment is intended to support active learning and guide the students towards the acquisition of self-regulated processes (Vosniadou et al., 2001, p. 382).

According to cognitive load theory, human cognitive architecture consists of "a limited-capacity working memory that interacts with an unlimited long-term memory" (van Merriënboer & Paas, 2003, p. 14). Our learning environment is designed so that it efficiently deals with the limitation of working memory and the potential of long-term memory, what is in line with cognitive economy related to cue abstraction, as we described earlier (Snyder, 2000).

Cognitive apprenticeship (Collins, Brown, & Holum, 1991; Collins, Brown, & Newman, 1989) is the model for the design of innovative learning environments that became most influential in the early 1990s (de Corte, 1996, p. 40). The framework describes four dimensions that constitute any learning environment: content, method, sequence, and sociology (Collins, Brown, & Newman, 1989, p. 476). Content is domain-specific and includes "the conceptual and factual knowledge and procedures explicitly identified with a particular subject matter" (Collins, Brown, & Newman, 1989, p. 477). With respect to method, "modeling, coaching, and scaffolding are the core of cognitive learning apprenticeship, designed to help students acquire an integrated set of cognitive and metacognitive skills through processes of observation and of guided and supported practice" (Collins, Brown, & Newman, 1989, p. 481). Regarding to sequence, a simple-to-complex sequencing of learning tasks is hoped to reduce the intrinsic aspects of cognitive load (van Merriënboer & Paas, 2003, p. 14). At the same time, high variability of learning tasks is used "to promote meaningful learning by stimulating learners to compare the solutions to the different learning tasks and to abstract more general knowledge for solving a wide range of problems" (van Merriënboer & Paas, 2003, p. 14). Finally, as far as sociology is concerned, Collins, Brown, and Newman (1989, p. 489) highlight "the importance of creating learning environments in which students perform tasks because they are intrinsically related to an interesting or at least coherent goal, rather than for some extrinsic reason, like getting a good grade or pleasing the teacher". Students intrinsically motivated are more likely to seek out and master challenges, which need to be within their reach (Maehr, Pintrich, & Linnenbrink, 2002, p. 361). To this respect, technology has motivational benefits as a "hook" that enhances students' participation and promotes cognitive engagement (Blumenfeld, Kempler, & Krajcik, 2002, p. 484), understood here as the intensity and quality of participation in classroom activities (F. S. Azevedo, diSessa, & Sherin, 2012, p. 270).

Scaffolding, one of the teaching methods that we have just dealt with, refers to "support provided so that the learner can engage in activities that would otherwise be beyond their abilities" (B. Sherin, Reiser, & Edelson, 2004, p. 391). This definition is influenced by Vygotsky (1978, p. 86) conception of the zone of proximal development (ZPD), which is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Lajoie, 2005; Sharma & Hannafin, 2007; Puntambekar & Hubscher, 2005; Pea, 2004).

Scaffolds are "tools, strategies, and guides which support students in attaining a higher level of understanding; one which would be impossible if students worked on their own" (B. Sherin et al., 2004, p. 391). In face-to-face interactions, scaffolds are usually adaptive, since "human tutors have the ability to continuously monitor and diagnose the student's emerging understanding" (R. Azevedo, Cromley, Winters, Moos, & Greene, 2005, p. 387). In the case of technology-enhanced learning environments (TELEs), "scaffolds are often static and do not change dynamically as individual circumstances evolve" (Sharma & Hannafin, 2007, p. 30). Once learners demonstrate competence, "hints or scaffolds are removed (or faded gradually) to ensure that learners can independently demonstrate their competence and articulate their knowledge without assistance" (Lajoie, 2005, p. 543). Fading is characteristic of adaptive scaffolding, since fixed scaffolds in hypermedia environments do not admit such procedure, or at least not in a so subtle way.

1.4.4 Definitions

The following is a list of definitions of six meta-representational criteria that will be used for purposes of this study.

Correctness "A representation is considered to be correct when it accurately shows the articulation of certain sonic parameters over time" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482). Since we are dealing with symbolic systems that do not fulfil the requirements to be considered notations, it remains unclear to what extent a given representation could be assessed as correct.

Completeness "A representation is considered to be complete when it represents the whole of the music fragment, and not only a part" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482). Both correctness and completeness are quite similar criteria, with a subtle difference between them. The distinguishing aspect is the integrity of the representation, which is a necessary, but not a sufficient condition to correctness.

Transparency "When a representation contains an additional element that shows or suggests systematic variation that does not refer to any corresponding variation in the sound fragment that is to be represented, the representation is considered as misleading. When such misleading elements are absent, the representation is called transparent" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482).

Formality "A representation is considered to be formal when it uses signs, symbols, rules, and/or conventions that belong to a formal notational system" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483). Despite the existence of alternative notational systems, we have restricted this study to the standard musical notation, since it was the main musical code that the students of our sample were taught during their schooling.

Parsimony "A representation is considered parsimonious when it contains no redundant information" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483). This is not to say that it is always easy to decide whether redundancy could be seen as beneficial, since "if a representation were intended for one purpose or another, features would be more or less fitting" (diSessa, 2002, p. 115).

Beauty "This criterion refers to the presence or absence of a pleasant visual effect" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483). This is a controversial issue, as warns diSessa (2002, p. 116), who conceive of it as no scientific.

1.5 Aim and scope of the study

1.5.1 Aim

The primary concern of this study is to examine the effects of a hypermedia learning environment on middle school students' MRC.

1.5.2 Hypotheses

H1 Our first hypothesis was that the experimental program would have a positive overall effect on students' MRC, to be measured by assessing the more appropriate answers on several items of a test. We predicted a significant increase in the number of more appropriate answers from pretest to posttest for the experimental group, who received an educational intervention. For the control group, who did not receive this intervention, no significant increase from pretest to posttest was expected. In our pilot study (Gil et al., in press), the overall gain was to a great extent due to a decrease in the score of the control group at posttest, while the gain in the experimental group was rather small. By means of an improved learning environment, we expected to overcome this outcome and to get a significant difference in favour of the experimental group at the posttest.

H2 Our second hypothesis was that the positive effect of the experimental program would be lasting. As such, we predicted that the expected significant difference in the number of more appropriate answers in favour of the experimental group would not disappear in a retention test. Although a lasting effect was found in both experimental and control group in our pilot study (Gil et al., in press), we predicted a decrease in the score of the control group at the retention test, since the absence of scaffolding during the experimental program would have reduced the students' interest to remember the contents of the intervention.

H3 We also hypothesized that the students allocated to the experimental group would assess the learning environment in a more positive way than the students allocated to the control group, as evidenced by their responses to the Constructivist On-Line Learning Environment Survey (COLLES).

1.5.3 Questions

Besides the aforementioned hypotheses, we also raised three additional research questions:

1. Was the experimental program equally effective for children with different levels of musical experience (i.e., for the high, medium, and low experienced students)?
2. Was the experimental program equally effective for the six representational criteria involved in the program?
3. Was the experimental program equally effective for the three music parameters involved in the program?

1.6 Significance of the study

In his seminal research, diSessa (2002, p. 107) argued that "MRC shows best and may be developed best in the context of representational design". This finding is consistent with those reported by other studies related to fields such as representation of motion (B. L. Sherin, 2000) and representations of terrains (F. S. Azevedo, 2000). In the realm of music, recent studies have suggested that “music may be a very promising domain for the elaboration of children’s MRC” (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 709) and have claimed “a need for more research [...] in the context of both experimental studies and also intervention-based studies, such as design experiments” (Verschaffel, Reybrouck, Jans, et al., 2010, p. 500).

Our research humbly picks up the gauntlet and sets an experimental design in a real educational environment, namely a music classroom in a state high school. Having opted for real education in a real setting is not gratuitous, since the study aims to go beyond the theoretical inquiry and contribute to education improvement, according to the two major premises stated earlier. As far as methodology is concerned, despite intervening odd variables, as one could expect in an educational setting, one of the strengths of the study is the learners’ random allocation to the experimental condition. That was possible by means of an on-line platform (Moodle), which allowed us to keep the classrooms intact, with the students simultaneously receiving different treatments.

With respect to epistemology, we provide our research with a sound basis from theoretical studies on ecological perception. Reybrouck (2010, p. 196) among others, whose work we shall be looking at shortly, has claimed “the need of empirical research with a major focus on two questions: (i) which elements does a listener extract from the sounding environment? and (ii) which are the cognitive elaborations which are done on these elements?”. Our study conveniently addresses these and other claims, as we partially did in a pilot study (Gil et al., in press).

1.7 Summary

Studies on the nature of children’s graphical notations are related to research on symbolic representation of music and visual representation of music perception (Reybrouck et al., 2009, p. 190). Many of them are ascertaining studies that have looked at the relationship between sonorous stimuli and their graphical representations by studying subject and task variables in educational settings, with learners ranging from kindergarten to adulthood (Barrett, 1997, p. 3). However, few intervention-based studies have investigated how students' ability to deal with representational issues can be enhanced, and, as far as music is concerned, how this improvement may benefit students' sense-making of their sounding environment. This is in a nutshell our challenge, which is consistent with the aims and focus of our pilot study (Gil et al., in press).

In doing so, we try to transcend a mere research on theoretical issues to reach the status of practical usefulness in real education, and hence our glance to European guidelines that support our study, and our preference for real educational settings. In addition, diverse fields such as representation, ecological perception, music ability testing, or learning environment design provide this research with a sound theoretical ground, which allows us to conceive of it as a multidisciplinary research.

Chapter 2

Literature review

2.1 Introduction

In the 1950s, experimental psychologists in the US definitely rejected behaviourism and the so called *cognitive revolution* started (E. E. Smith, 2001, p. 2140). One of the major figures of that change of paradigm states (Miller, 2003, p. 141):

> In 1951, I apparently still hoped to gain scientific respectability by swearing allegiance to behaviorism. Five years later, inspired by such colleagues as Noam Chomsky and Jerry Bruner, I had stopped pretending to be a behaviorist. So I date the cognitive revolution in psychology to those years in the early 1950s.

After years of experimental research, it was not until Neisser's "Cognitive Psychology" (1967) that the new discipline gained coherent unity and was given its name (E. E. Smith, 2001, p. 2143; Levitin, 1999, p. 495). In subsequent years, ranging from the 1970s to the early 1980s, cognitive science was much concerned with issues about mental representation (E. E. Smith, 2001, p. 2144). Simultaneously, psychology of music emerged as an autonomous and interdisciplinary academic speciality (Gjerdingen, 2013, p. 699). To this respect, Diana Deutsch's "The Psychology of Music" (1982) must be seen as a landmark book which contributed to establish this new discipline (Deutsch, 2013, p. xiii) and encouraged new publications as "Music Cognition" (Dowling & Harwood, 1986) and "Music as Cognition" (Serafine, 1988).

This scenario of growing interest in mental representation and emergence of psychology of music would be incomplete without mentioning another landmark book for research in social sciences. We are talking about Cook and Campbell's "Quasi-experimentation" (1979), which clarified the experimental approach to causal research in field settings beyond the laboratory conditions and allowed social scientists acquainted with descriptive research to access to inferential statistics (Cook & D. T. Campbell, 1979, p. 1).

In this context, *sound-to-symbol matching* became one of the major issues within the broader body of research conducted on children's graphical representations of music. Over the years, researchers have set their sights on two main themes, namely a) *Categorization of children's graphical representations of music* (Bamberger, 1980, 1982; Carmon & Elkoshi, 2010; Elkoshi, 2002, 2007, 2014; Reybrouck et al., 2009; Tan & Kelly, 2004; Upitis, 1987, 1990; Verschaffel, Reybrouck, Janssens, et al., 2010); and b) *Study of invented symbolic systems as an alternative to standard music notation* (S. R. Cohen, 1985; Davidson & Colley, 1987; Davidson & Scripp, 1988; Elkoshi, 2004a; Gromko, 1994, 1995; Gromko & Poorman, 1998; Gromko & Russell, 2002; Lee, 2013; K. C. Smith, Cuddy, & Upitis, 1994; Tan, Wakefield, & Jeffries, 2009; Walker, 1978, 1981a, 1981b, 1987).

In addition, other approaches have arose, such as the study of graphical representation of music related to *colour* (Elkoshi, 2004b), *motion* (Fung & Gromko, 2001; Sadek, 1987), and *shape* (Küssner & Leech-Wilkinson, 2013; Küssner, 2013).

But the keystone of this field of research to our aims, and something on which this literature review is focused, is the *meta-representational approach* to children's graphical representation of music (Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Gil et al., in press), after diSessa's experiences in the domain of mathematics and science learning (diSessa, 2002, 2004; diSessa, Hammer, et al., 1991; diSessa & B. L. Sherin, 2000), who, in turn, had been influenced by Bamberger's work on spontaneous representations of music (Bamberger, 1991b).

In short, this literature review is aimed at *exploring* (Light & Pillemer, 1984, p. 26) how children's graphical representation of music has been approached over the years, as a necessary step to contextualize our research. In doing so, we will establish certain criteria to include/exclude potential studies, as we will describe next.

2.2 Methods

2.2.1 Review approach

Methods of conducting literature reviews can be broadly distributed into four categories: *integrative reviews*, *meta-analyses*, *qualitative reviews*, and *systematic reviews* (Whittemore & Knafl, 2005, p. 547). Our review matches the first type, as described by Cooper (1989, p. 13): "Integrative reviews summarize past research by drawing overall conclusions from many separate studies that are believed to address related or identical hypotheses". Performing a meta-analysis or a systematic review is incompatible with the field we are exploring, where hypotheses and research problems that studies deal with are far to be comparable. Similarly, potential studies to be reviewed often combine both quantitative and qualitative analyses, which exclude undertaking a qualitative review.

Whichever method of conducting a literature review is chosen, there are three common formats to organize research reviews: *historically*, *conceptually*, and *methodologically* (Cooper, 1988, p. 109). Our approach entails combining all of them. First, literature has been organized conceptually so as to explore the main topics of the field. Second, methodological affinities are highlighted among studies belonging to a given topic. Third, works are sorted chronologically. Our approach is grounded on a functional model, as proposed by Light and Pillemer (1984, p. 14):

$$Y = f(T, X) + Error$$

Where Y represents an outcome of interest, T represents a treatment of interest, and X represents features of participants that can influence research outcomes.

Finally, according to Whittemore and Knafl (2005, p. 548), “without explicit and systematic methods specific to undertaking an integrative review, the risk of error increases exponentially”. Those methods and strategies will be clarified next.

2.2.2 Inclusion/exclusion criteria

Performing a literature search in such a broad field as graphical representation of music yields many potential articles for review. In order to select the most appropriate literature to our research interests, there exist a number of criteria capable of tipping the scales in favour of including or excluding a retrieved paper (Cooper, 1988, p. 109; Fink, 1998, p. 53; Foster & Hammersley, 1998, p. 618; Light & Pillemer, 1984, p. 40). The following is a list of criteria which have been taken into account so as to filter our pool of findings:

Date of publication The selected literature ranges from 1978 to nowadays. It would not make sense to look for previous studies, mainly due to two reasons: a) as Deutsch (2013, p. xiii) recognizes, “In 1982 [. . .] few music theorists acknowledged the relevance of empirical research”. Among these scattered researchers, Bamberger (1980, 1982) and Walker (1978, 1981a, 1981b) provided us with seminal research whose influence still remains, what justifies their inclusion in our review; b) from a methodological view, related to research in social sciences, one could not expect a sound research design before the publication of the influential book “Quasi-experimentation” (Cook & D. T. Campbell, 1979). Indeed, music researchers lacked clear guidelines on this matter until that moment.

Methodology Studies in which children in an *educational setting* were asked to represent sounding music or to select the most appropriate representation to a given sonic stimulus among several options have been selected. This criterion highlights two outstanding features of our research, namely the relationship with formal schooling, and the drawing activity. The above mentioned educational setting in which children are allocated in classrooms is linked to the sample size, as described next.

Research design Experimental, quasi-experimental and ascertaining studies with a large sample ($n \geq 30$) have been included, while case studies with small samples have been excluded. Despite being a controversial concept (J. Cohen, 1990, p. 1304), considering samples above 30 as large samples remains as a somewhat of a rule of thumb, and something common in current statistics textbooks (Thurman, 2008, p. 104).

2.2.3 Search strategy

The *classic model of information retrieval* entails a single query asked by the user, according to his o her information needs, which matches to the database contents and yields a single output set (Bates, 1989, p. 409). But in real-life searches, users dealing with a broad topic may end up moving through a variety of sources, and hence the original query may evolve in part or whole as a result of new cues. This kind of search is called *berrypicking* "by analogy to picking huckleberries or blueberries in the forest. The berries are scattered on the bushes; they do not come in bunches. One must pick them one at a time" (Bates, 1989, p. 410).

The berrypicking approach has been recently described as *cluster searching*. The following is a list of terminology associated with this concept (Booth et al., 2013, p. 4).

Cluster searching A systematic attempt to identify papers or other research outputs that relate to a single study.

Key pearl citation A key work in a topic area.

Kinship study A study related to an original study of interest.

Sibling paper A paper identified as being an output from the same study.

Study cluster A group of papers or other research outputs related to the same single study.

Our search strategy is grounded on the six search techniques suggested by Bates (1989, p. 412), which are common to the CLUSTER methodology (Booth et al., 2013, p. 9). First, our *key pearl citation* was Verschaffel, Reybrouck, Jans, et al. (2010), with a *sibling paper* (Verschaffel, Reybrouck, Degraeuwe, et al., 2013) and two *kinship studies* (Reybrouck et al., 2009; Verschaffel, Reybrouck, Janssens, et al., 2010). These four papers constitute a *study cluster* in which our review, as well as our pilot study (Gil et al., in press), heavily rely. Second, *footnote chasing* and the checking of the reference lists enabled us to retrieve previous literature, with some other key pearl citations being considered (Bamberger, 1980; diSessa & B. L. Sherin, 2000). Third, by means of *citation searching* we retrieved the most recent literature related to our topic of interest (Elkoshi, 2014; Küssner, 2013; Küssner & Leech-Wilkinson, 2013). Fourth, a variant of *area scanning* –updating the physical collocation into parent directory collocation, as Booth et al. (2013, p. 9) do– was performed by browsing Jeanne Bamberger's web page[1] in order to identify her publications. Fifth, *subject searches* and *author searching* were performed in ERIC® and PsycINFO® databases by means of ProQuest® platform. As an example, some of the terms searched were:

- Auditory Perception
- Graphical Displays
- Knowledge Representation
- Metacognition
- Music Education
- Music Perception

Tu sum up, the berrypicking approach allowed us to go beyond "topic-based search techniques that are specified a priori towards more creative, intuitive and iterative procedures for evidence identification" (Booth et al., 2013, p. 2). Hence our interest in being explicit with respect to the search strategy, so

[1] `http://web.mit.edu/jbamb/www/`

as to achieve the three characteristics that a literature review should have, namely *systematic*, *transparent*, and *reproducible* (Booth et al., 2013, p. 2; Fink, 1998, p. 15).

2.3 Results

After performing the literature search as explained, we retrieved 68 references (Bamberger, 1972, 1980, 1982, 1991a, 1991b, 1994, 1996, 1998, 2003, 2005, 2006, 2007a, 2007b, 2010; Bamberger & Brody, 1984; Bamberger & diSessa, 2004; Barrett, 1991, 1997, 1999, 2000, 2001, 2002, 2005; M. R. Campbell, 1991; Carmon & Elkoshi, 2010; S. R. Cohen, 1985; Davidson & Colley, 1987; Davidson & Scripp, 1988, 1989/1994; Davidson, Scripp, & Welsh, 1988; Davidson & Welsh, 1988; Elkoshi, 2002, 2004a, 2004b, 2007, 2014; Fung & Gromko, 2001; Gil et al., in press; Gromko, 1994, 1995; Gromko & Poorman, 1998; Gromko & Russell, 2002; Hair, 1993; Hargreaves, 1978; Küssner, 2013; Küssner & Leech-Wilkinson, 2013; Lee, 2013; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Janssens, et al., 2010; Reybrouck et al., 2009; van Oers, 1997; Pramling, 2009; Sadek, 1987; K. C. Smith et al., 1994; Tan & Kelly, 2004; Tan, Wakefield, et al., 2009; Upitis, 1987, 1989, 1990, 1993, 1992/2010; Walker, 1978, 1981a, 1981b, 1983, 1985, 1987).

The inclusion/exclusion criteria determined that 29 references were accepted ($\simeq 43\%$) and 39 references were rejected ($\simeq 57\%$). The main reasons for exclusion are shown in Figure 2.1.

The selected references were tagged and analyzed by means of Qiqqa™ software ("Qiqqa," 2010–2014), which allowed us to extract four main themes, as showed in Figure 2.2. In addition, we created a *word cloud* (Feinerer & Hornik, 2014; Fellows, 2014) from the articles' titles, which was also useful to provide insights into research threads within this field of research (Figure 2.3).

Next we relate the main themes to the sample size and the target population of experiments, and date of publication of studies, according to an strategy for combining different types of information in a review, namely "quantifying descriptive reports" (Light & Pillemer, 1982, p. 14). With respect to *sample size*, the box plot in Figure 2.4 reveals that medians are moderate ($N < 200$), despite some outlier values. This feature may be related to the fact that many of the studies on this topic were carried out single-handed (Figure 2.5), and only the most recent studies involve a research team (Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Gil et al., in press). As an exception, Walker (1978, 1981b) and Sadek (1987) managed to deal with very large samples ($N > 750$) despite working alone.

Regarding the *target population*, the scatter plot in Figure 2.6 yields a positive correlation between low limit age and high limit age. Axis box plots

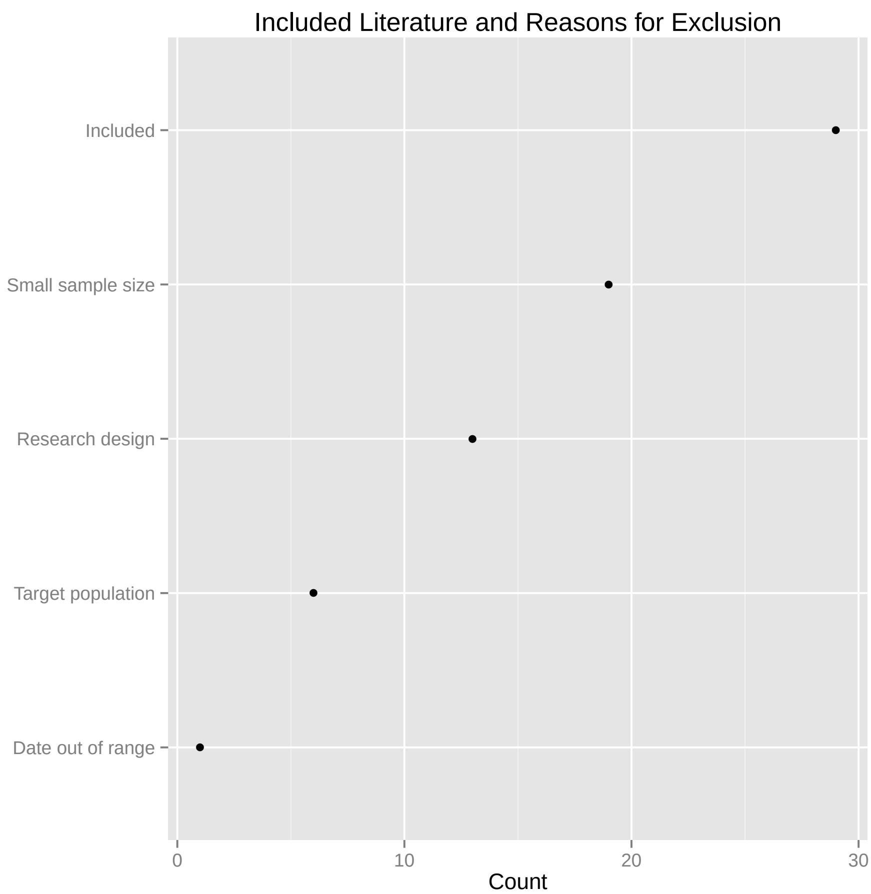

Figure 2.1: Included literature and reasons for exclusion.

show that the most of studies focused on children aged 5-12, belonging to primary school. To this respect, a smooth curve "loess" (Jacoby, 2000) becomes flatter in the interval between about 6 to 8 years old on the horizontal axis, which corresponds to 12 years old on the vertical axis.

Figure 2.7 shows how the research literature on graphical representation of music has grown from the late seventies until now. As far as *date of publication* is concerned, the box plot in Figure 2.8 reveals that medians of "sound-to-symbol matching" and "categorization of representations" themes are located about 1990, while median of "attributes of pictures" theme is a decade later. It seemed that research on graphical representation of music

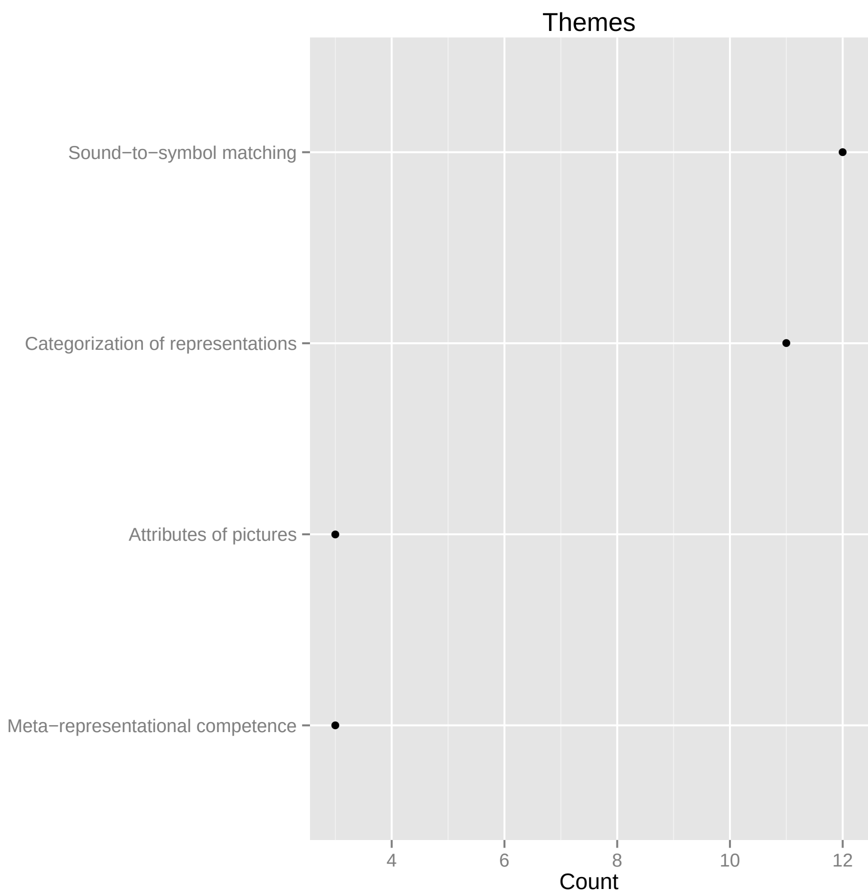

Figure 2.2: Main themes of the reviewed literature.

was already exhausted when recent studies on MRC were carried out and the field soared up again.

Finally, a brief comment on publications and authorship follows. First, with respect to where the mentioned literature was published, there is an outstanding journal which encompasses almost a quarter of the selected studies, namely *Psychology of Music*. A third part belongs to four journals, while the rest is spread among several publications, including book chapters (Figure 2.9). Second, regarding the amount of citations between authors, the network graph in Figure 2.10 shows a more closely-woven net at the left side of the circle, which corresponds to the research group working on MRC.

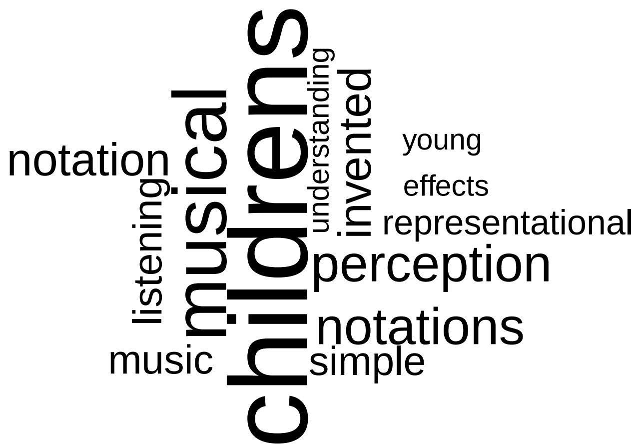

Figure 2.3: Word cloud of the reviewed literature.

2.4 Discussion and Conclusions

As stated earlier, a conceptual approach is presented herein as a means to gain an insight into this area of research. Besides the four main themes in which our review is organized, theoretical, methodological, and educational implications are discussed.

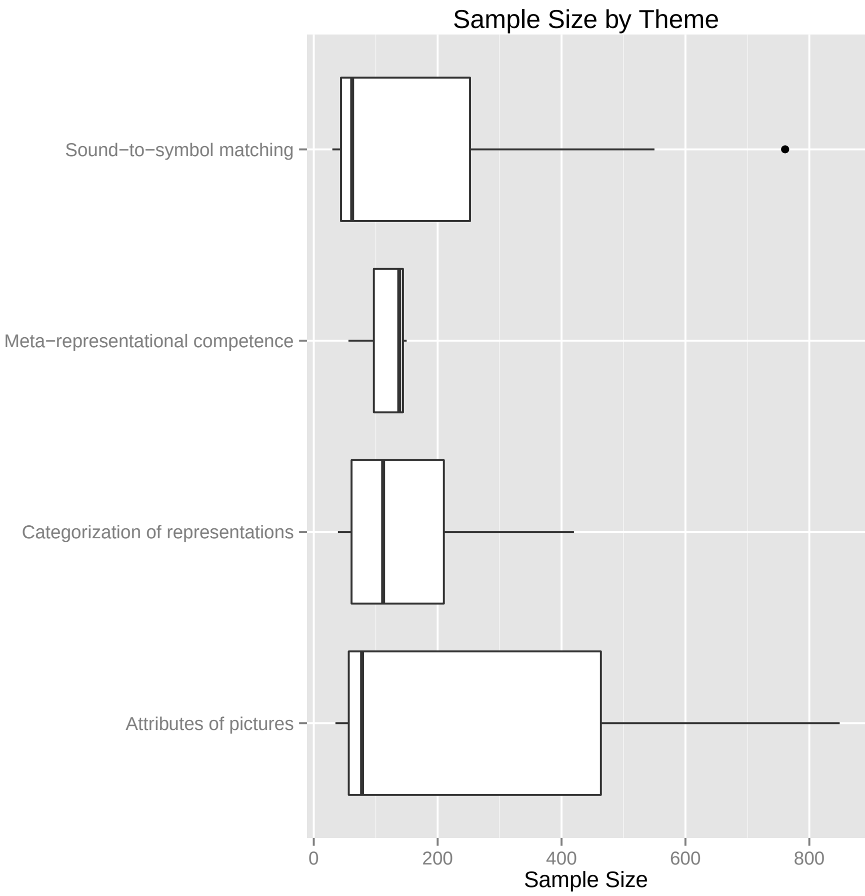

Figure 2.4: Sample size by theme.

2.4.1 Main themes

Sound-to-symbol matching

Research on this field focuses on the appropriateness of the standard music notation (SMN) as the ideal device for children to deal with music as performers and/or composers, versus their informal account of acoustic phenomena by means of self-invented representations. Hence the importance of cross-domain relationships between fields such as sounding environment and visual space.

As Upitis (1990, p. 91) points and we will be looking at shortly, "Most of

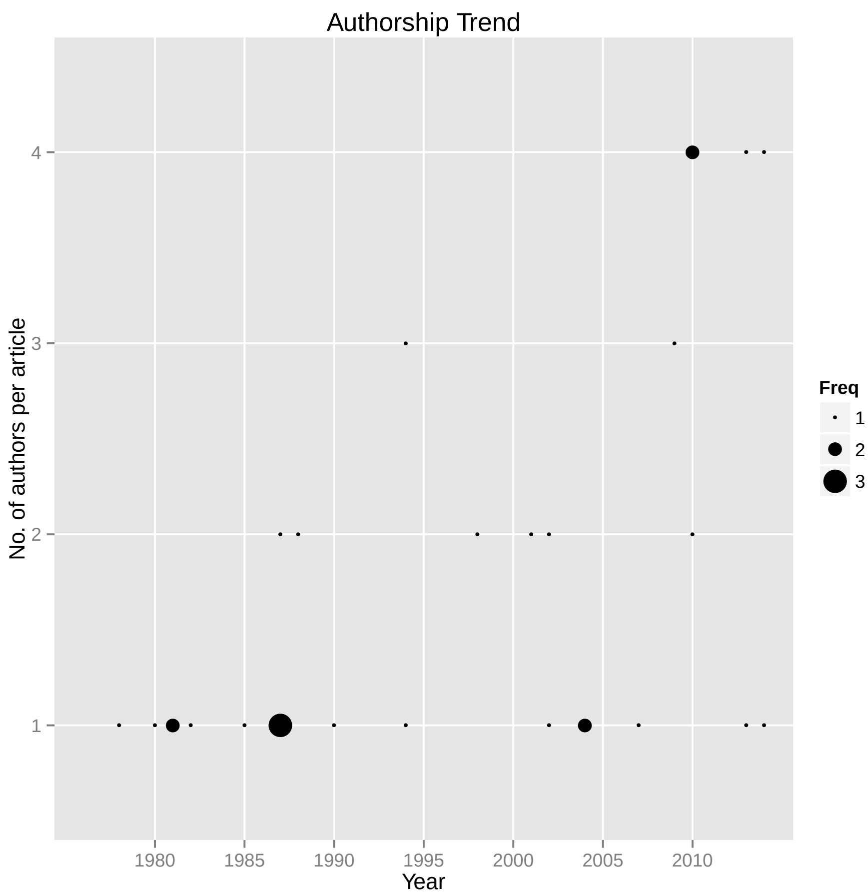

Figure 2.5: Number of authors per article.

the research conducted on young children's notations of melodies provided by the researcher, both familiar and unfamiliar, has been conducted by members of Harvard's Project Zero". Project Zero had been founded at the Harvard Graduate School of Education in 1967 by the philosopher Nelson Goodman (Bamberger, 2013, p. 171), who aimed at undertaking psychological research in the arts as a necessary step to promote changes in educational technology (Goodman, 1969, p. 265).

Besides his importance as promoter of Project Zero, Goodman must be acknowledged for having stated the five principles to define the class of notational systems; in other words, which conditions must comply symbol sys-

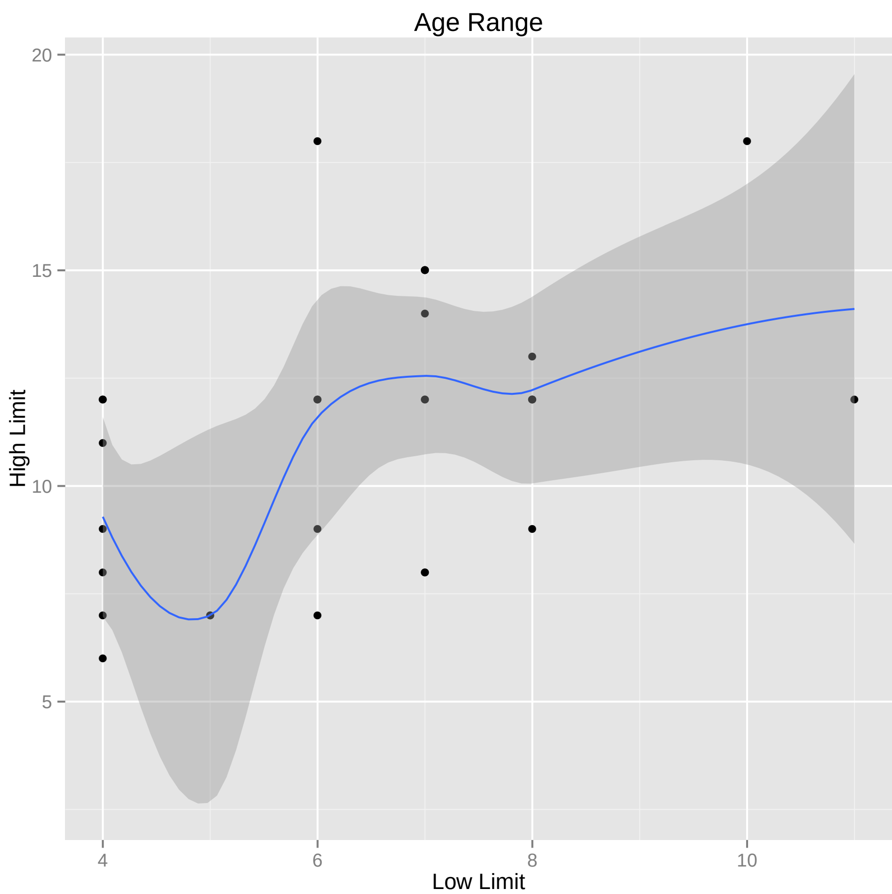

Figure 2.6: Age range of studies.

tems so as to be considered notations, namely, (a) syntactic disjointness, (b) syntactic differentiation, (c) unambiguity, (d) semantic disjointness, and (e) semantic differentiation. In a nutshell, S. R. Cohen (1985, p. 177) highlights three essential conditions that notations must comply:

1. Each symbol should have one and only one meaning.

2. Each meaning should be represented by one and only one symbol.

3. In addition, the same symbol-meaning relations should describe both encoding and decoding.

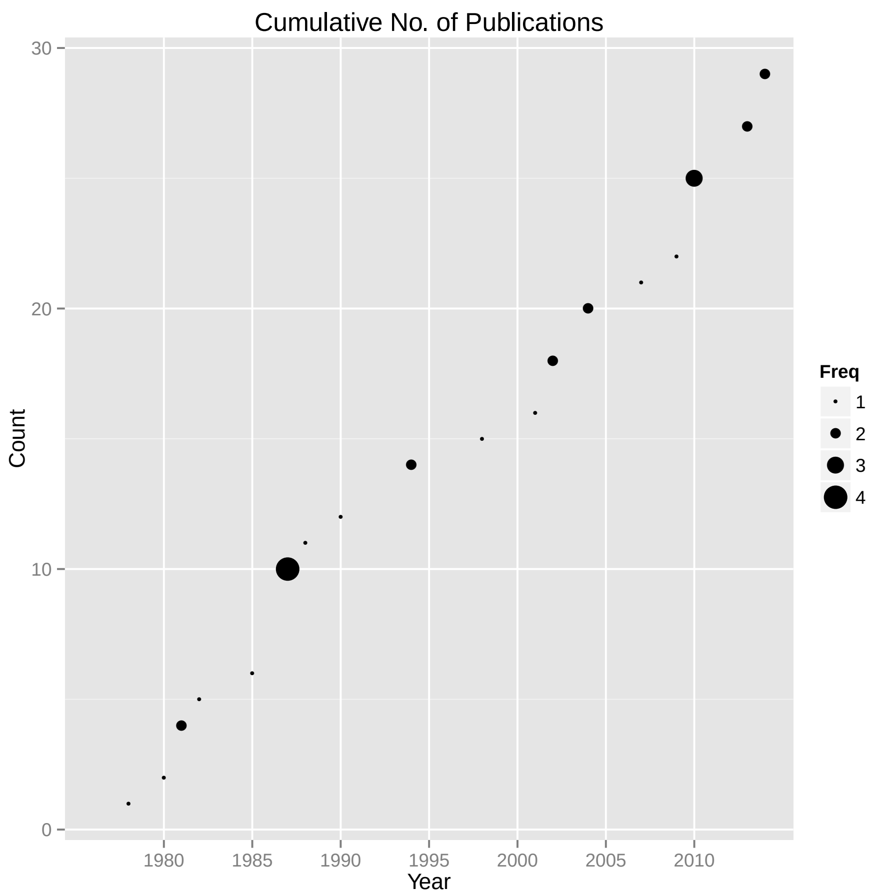

Figure 2.7: Increase of literature on graphical representation of music.

Given the communicational needs of humans, notational systems are conceived as “tools to solve a variety of problems” (S. R. Cohen, 1985, p. 177), but not always using them is easy nor evident. In the domain of music, (Walker, 1981a, p. 31) complains that “one of the areas of music education most fraught with difficulties is the early stage when staff notation is first introduced”. The same author criticizes teachers who use SMN for “presenting a perceptually confusing, inaccurate, learning situation to children” (Walker, 1981b, p. 110). In the same line, as already mentioned in Section 1.2, Davidson and Colley (1987, p. 109) warn us that “notation-based definitions of rhythmic structure may have contributed to a mismeasurement of

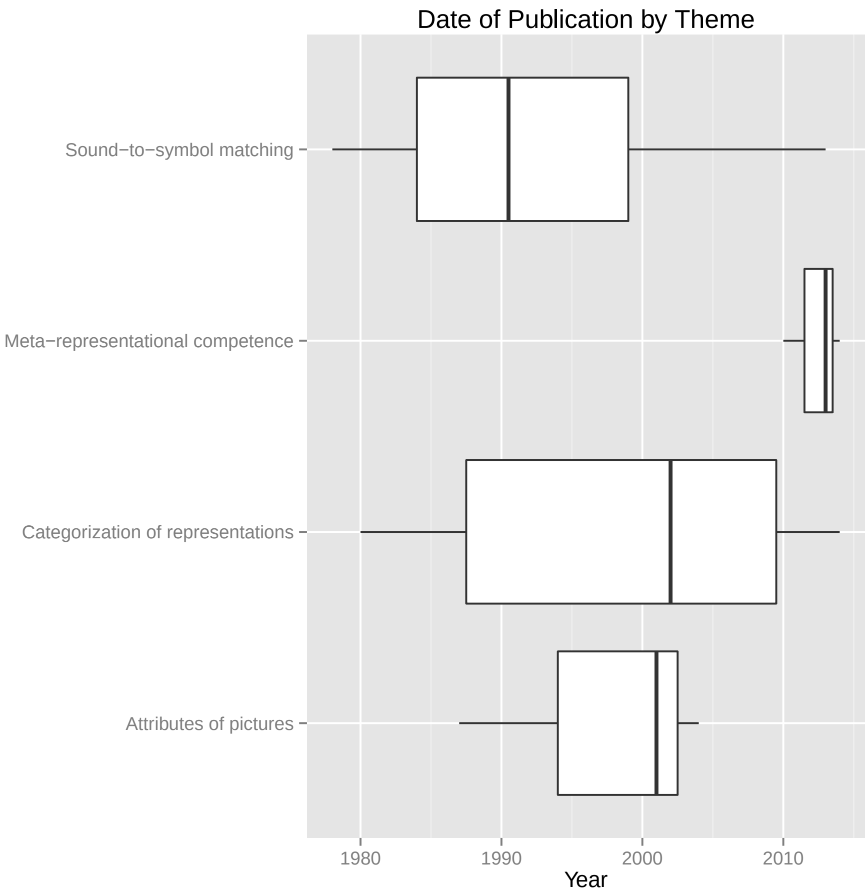

Figure 2.8: Chronological order of themes.

rhythmic perception". To this respect, Bamberger (1982, p. 205) described the *wipe-out phenomenon*, with serious implications for teaching:

> The wipe-out phenomenon means once you internalize the coherence of some phenomena in terms of the conventions of a formal symbol system associated with a domain, the way you thought and how you saw the phenomena before is wiped out.

Overall, authors highlight the arbitrariness of SMN and their lack of direct relationship with the auditory events it symbolizes (Walker, 1978, pp. 21,22,108; Bamberger, 1980, p. 171), despite its mnemonic value to allow musical actions

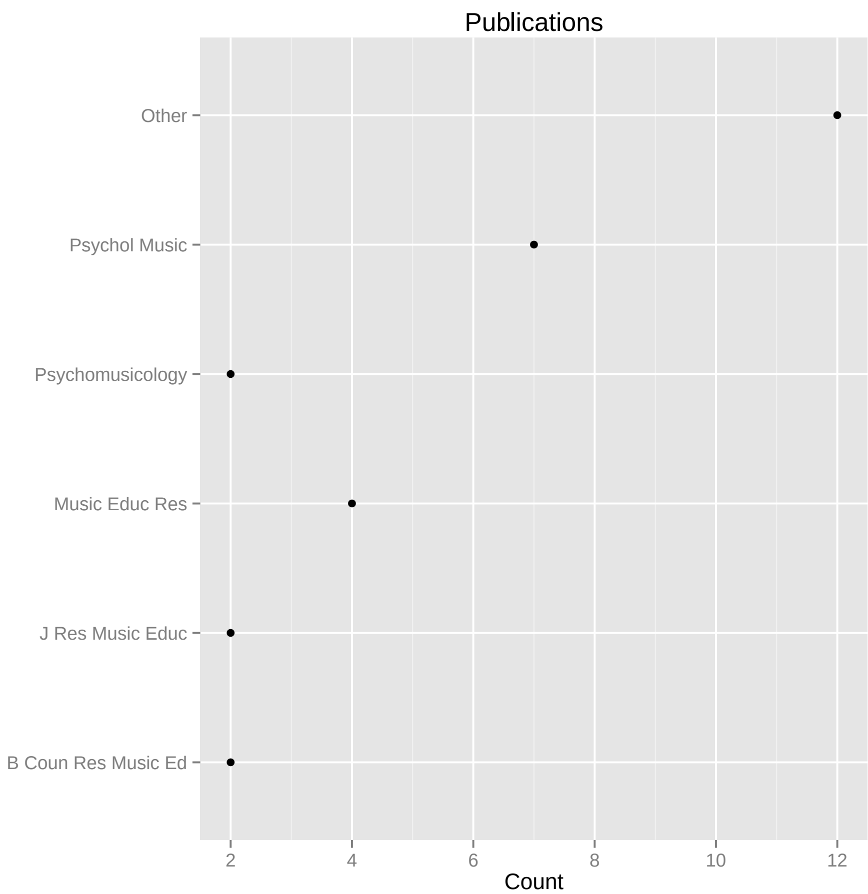

Figure 2.9: Count of publications.

over the centuries (Walker, 1981b, p. 110).

To this respect, Walker set an experiment as a response to the claim that "the practice of music might be better served by adoption of an alternative form of notation in which the symbols employed directly represented the intended sounds" (Walker, 1978, p. 21). The null hypothesis that "traditional symbols are arbitrary and represent sounds only in a notational way" (Walker, 1978, p. 22) was accepted and therefore it was concluded that "non-traditional symbols are capable of direct phonetic interpretation though perception of correlation between auditory and visual space" (Walker, 1978, p. 24).

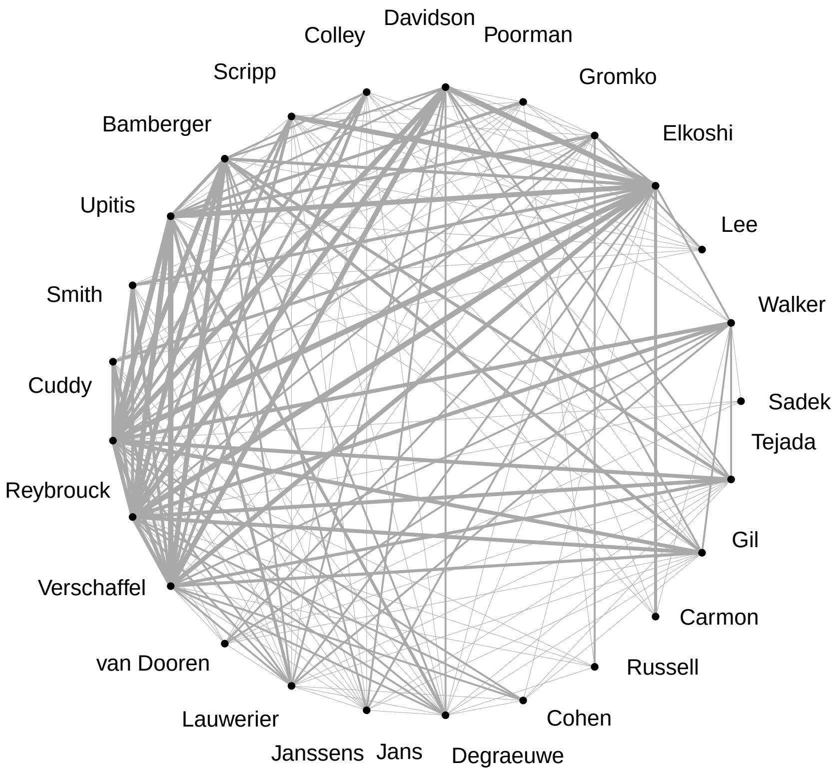

Figure 2.10: Inbound and outbound citations.

Research has shown that children employ a variety of representational strategies, ranging from literal symbols to informal symbol systems and idiosyncratic drawings (Upitis, 1990, p. 89; Davidson & Scripp, 1988, p. 197; Elkoshi, 2004a, p. 77; Verschaffel, Reybrouck, Jans, et al., 2010, p. 478; Lee, 2013, p. 397; Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 695), but not always children's representations reveal their knowledge nor their understanding of acoustic phenomena (Bamberger, 1982, p. 223; Elkoshi, 2004a, p. 78).

Children's invented notations are known to follow a developmental pattern, parallel to children's skill in perception of musical parameters, namely pitch, duration, loudness and timbre (Davidson & Colley, 1987, p. 111; Davidson & Scripp, 1988, p. 197; Gromko & Poorman, 1998, pp. 16,17,20; Fung & Gromko, 2001, p. 129). Two major variables, namely age and literacy, are supposed to influence children's representations (Davidson & Scripp, 1988, p. 222; Upitis, 1990, p. 91; Lee, 2013, p. 403), despite existing some controversy among authors' explanations. Indeed, Walker (1981a, p. 31) claims that literacy is not a requisite to performance in both musical and verbal language, while defends that "musical training is the most important single factor in choices of visual metaphor for sounds" (Walker, 1987, p. 500). This conclusion is at odds with Davidson and Scripp (1988, p. 228), who argue that "children, without explicit musical training in notation, can represent an increasingly sophisticated understanding of the music they perform". More recently, Elkoshi (2004a, p. 78) pointed that *illiterate* children are sensitive to a chronological succession of sounds, which implies than no instruction is needed for them to achieve this goal at this stage of development.

Such developmental course of children's use of notations in general have suggested that "there must exist an internal system of coding which is independent of language systems written down in the manner they have evolved in Western culture" (Walker, 1981a, p. 31). As far as music is concerned, "cross-relationships among visual phenomena and sounds as well as mutual terminology, imply cognitive interconnections among the auditory and visual arts" (Elkoshi, 2004a, p. 61). In other words, "the perception of musical sound may evoke internal musical images that can be made visual by drawing" (Gromko & Poorman, 1998, p. 22).

As to this, Walker (1981a, p. 38) reported as an outcome of an experiment that "the use of cross-modal matching symbols [...] induced better results, and therefore better understanding of the concepts involved, than traditional notional symbols", which is in line with previous literature (see Section 1.2). This issue, however, is still controversial, since in a recent study Lee (2013, p. 403) found that "children employed conventional rhythmic notations to record rhythms [...] as well as pitches", which is at odds with the widely extended view among researchers.

Research on cross-modal correspondence between auditory environment and visual space through representation have yielded some interesting findings. First, frequency changes are thought to be linked to placement along a vertical axis, while durations match horizontal lengths, and amplitude differences are related to sizes (Walker, 1987, p. 492). Second, despite the commonly accepted premise that "the direction of a musical path tends to follow the prevailing direction of writing for the language of the country" (Elkoshi, 2004a, p. 64), results of an study showed "an abundance of organizational strategies including free use of diversified directionalities, recurrent visual patterns and various forms of demonstrating grouping and separation" (Elkoshi, 2004a, p. 77). Third, the auditory environment in which children have been acculturated may influence the way in which they make sense of the sounding world by means of cross-modal matching with mental imagery (Walker, 1987, p. 493).

Categorization of representations

About a third part of the selected literature consists of ascertaining studies concerned about categorizing children's representations of music or sonic fragments. A first body of research took place in the eighties (Bamberger, 1980, 1982; Davidson & Scripp, 1988; Upitis, 1987, 1990), while new typologies have more recently arisen (Elkoshi, 2002; Reybrouck et al., 2009; Verschaffel, Reybrouck, Janssens, et al., 2010). As a rule, the above studies are not comparable with respect to the settings where children's drawings were collected, the participants age range, and the sampling selection criteria (Barrett, 1997, p. 3), as well as regarding "methodology and the musical dimensions recorded by the children" (Barrett, 1997, p. 4).

The first proposal of categorization came from Bamberger (1980, p. 172), who found that children's drawings of simple rhythms fell into two general types, namely figural and metric/formal. Despite the main trend was that individuals tended to be either one type or another one in their descriptions (musically untrained adults and older children tended to be figural, while trained subjects tended to be formal), some drawings hardly fitted into these typologies, and therefore they were named *hybrid* drawings (Bamberger, 1982, p. 192). To this respect, years after "Upitis found that no child could be classified as having either metric understanding alone or figural understanding alone" (K. C. Smith et al., 1994, p. 119).

Bamberger perfected her original scheme by adding several subcategories, namely type 0 drawings, early/full figural drawings (F1/F2), and early metric, metric, and full metric drawings (M1/M2/M3) (Bamberger, 1982, p. 194). The starting point are type 0 drawings, which are made by the youngest children, consisting of scribbles or icons. In the following stage, despite F1/M1 type drawings showing properly the number of sounding events, M1 type drawings are more perfect when differentiating discrete units. F2/M2 type drawings reflect children's thought on their actions, but M2 type drawings are more complete. Finally, M3 type drawings "might be called the beginnings of a formal symbol system" (Bamberger, 1982, p. 203).

In a subsequent study, Upitis (1987, p. 59) found that

> ... graphic and numeric descriptions made by children of simple rhythms of varying durations, as well as descriptions of the underlying invariant beats, could be classified by typologies, similar but not identical to the typologies developed by Bamberger (1982) for categorizing descriptions of simple rhythms.

As such, Upitis (1987) follows mainly the typology put forward by Bamberger, with the only substantial difference of encompassing F1/F2 type drawings into an only category named *formal* drawings. Further differences are related to the tagging of subcategories, namely M1/M2/M3 type drawings correspond respectively to *counting*, *durational metric* and *true metric* drawings.

In a three-years longitudinal study within the context of Harvard Project Zero, Davidson and Scripp (1988) explored children's representations when they were requested to write a song "so that someone else who doesn't know the song can sing it back" (p. 202). As a result, children's drawings were grouped into five symbol systems, namely pictorial, abstract patterning, rebus, text, and combinational elaboration (Davidson & Scripp, 1988, p. 204). Pictorial notations "do little more than record the song as a global event or action", while the abstract patterning system hints at melodic units. The rebus and text systems are concerned with the text of the song, the former dealing with icons, conventional signs, and words, and the later consisting of words, letters, or imitations of conventional language symbols (Davidson & Scripp, 1988, pp. 205-206). Finally, the combinational elaboration symbol system "features simultaneous use of abstract symbols and words to represent the text and musical dimensions together" (Davidson & Scripp, 1988, p. 208).

Barrett (1997, p. 4), reminds us that "parallels may be drawn between the typologies developed by Bamberger and Davidson and Scripp", as previously put forward Upitis (1992/2010, p. 48). Indeed, the *pictorial* symbol system would correspond to Bamberger's type 0 drawings, and Upitis' *icons* drawings. In turn, the *abstract patterning* symbol system would match Bamberger's M1 type drawings, and Upitis' *counting* drawings. The rest of symbol systems proposed by Davidson and Scripp (1988) do not have an exact correspondence with Bamberger's and Upitis' typologies, since they portray the songs' textual content, which was not taken into account in previous categorizations. To this respect, recently Lee (2013, p. 402) pointed out that "those notations [rebus and text categories] did not provide a precise memory cue for pitch and rhythm".

A rather different categorization was put forward at the beginning of the twenty-one century by Elkoshi (2002, 2004a, 2004b, 2007, 2014), as a result of the MSC method of analysis. MSC stands for morphological (M), structural

(S), and conceptual (C) analyses, which focus, respectively, on the description of the visual phenomenon, the description of the interrelationships between its parts, and the content of the drawing (Elkoshi, 2004a, pp. 65-66). Based on the conceptual analysis (C), the following categories were proposed (Elkoshi, 2002, p. 202; Elkoshi, 2004a, p. 66; Elkoshi, 2004b, p. 8):

Category 0 (Zero) when the drawing represents an idiosyncratic reaction, which is totally detached from the experimental task.

Category A (Association) when the drawing yields associative images, metaphors or story factors.

Category P (Pictogram) when the drawing includes pictograms, namely a description of musical instruments that took part in the performance of the musical stimulus.

Category F (Formal Response) when a chronological sequence of sound events is represented in the drawing.

Category G (Growth) when the drawing yields features of grouping and division of the musical gestalt, for example, the division of a musical phrase into units

To the best of our knowledge, the most recent categorization of children's informal representations was put forward by Reybrouck et al. (2009) and Verschaffel, Reybrouck, Janssens, et al. (2010), as a previous step before their study of children's invented drawings from a meta-representational approach. Their scheme distinguishes between

> ...categories that capture the music in a *global* way [...] and categories that are more *differentiated* in trying to capture the temporal unfolding of at least one of the musical dimensions. A second major distinction was the difference between *simple* categories, which consist of only one type of graphical notation and *compound* categories, which contain elements that belong to different categories (Reybrouck et al., 2009, p. 193).

Table 2.1 shows the classification grid (Verschaffel, Reybrouck, Janssens, et al., 2010, pp. 266-267), with slight variations (marked with italics) with respect to the original categorization (Reybrouck et al., 2009, p. 193).

No reaction		
Rest category		
Simple	Global	Instrument
		Several instruments
		Evocation
		Music icon
	Differentiated	Sounding object or action
		Analogous image
		Non-formal graphical musical notation
		Formal-conventional notation
Compound	Global	
	Differentiated	
	Global + differentiated	

Table 2.1: Children's invented drawings' categorization grid.

Overall, this recent categorization is in line with a *maturational* point of view, according to which "children might be encouraged to invent their own notational systems as they perceive the need for conveying their musical ideas" (Davidson & Scripp, 1989/1994, p. 61).

Attributes of pictures

Apart from the study of musical parameters such as pitch, duration, loudness and timbre, other attributes related to representation of sounding environment, namely motion and colour have been paid much less attention in research. With respect to the influence of motion while listening, Sadek (1987, p. 149) pointed out that, as musically trained individuals favoured musical notation in order to symbolically express musical concepts, those without musical training would benefit from expressing musical concepts through movements. A subsequent study carried out by Fung and Gromko (2001, p. 135) revealed that "children's spontaneous movements while listening to unfamiliar, Korean music enhanced their perception of rhythm and phrasing".

As far as influence of colour on children's drawings is concerned, Elkoshi (2004b, p. 6) alerts that the "relationship between colour and music [...] has not yet been systematically investigated". In her study aimed at unraveling colour expression in schoolchildren's graphic notations, she concluded that colours had been observed "to appear as a means of notational organization" (Elkoshi, 2004b, p. 13). In addition, no relationship was found between colour and the chronological succession of sounds, which implies a children's preference for shapes instead of colours when they represent a sequence of sounds (Elkoshi, 2004b, p. 15). This subset of inquiry about representational issues, as well as the former one, is still awaiting further research.

Meta-representational competence

Research on children's invented graphical notations of sonic or music fragments has commonly relied on theoretical grounds such as general theories of cognitive development, perceptual learning, and symbol use, tool use, and modeling (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, pp. 692,706). A different approach entailing a systematic analysis from a *meta-representational* perspective was recently implemented (Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Gil et al., in press), instead of focusing on the nature of children's self-generated representations, as the majority of previous studies did.

Despite being originated in the domain of mathematics and science-related activities, the notion of meta-representational competence (MRC) owes a lot to Bamberger's research on children's spontaneous representations of rhythms, as the authors explicitly acknowledge (diSessa, Hammer, et al., 1991, p. 122; diSessa & B. L. Sherin, 2000, p. 393; diSessa, 2004, p. 304). The fact that the studies described in this section are the first attempt to adopt such approach in the field of music education (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 696) would demonstrate that representational issues are cross-domain, which implies that a given domain would benefit from achievement in another one (Bamberger & diSessa, 2004).

Research on MRC (diSessa, 2002, 2004; diSessa, Hammer, et al., 1991; diSessa & B. L. Sherin, 2000) distinguishes two complementary central resources, namely *constructive resources* and *critical capabilities*, the former denoting "a set of ideas and strategies for generating new representations", and the later referring to "the ability to judge the effectiveness of the results of such constructive effort and to re-design these results in order to ameliorate their shortcomings" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 476). Three main findings derive from the above mentioned studies, as Verschaffel, Reybrouck, Jans, et al. (2010, p. 477) point out:

> First, students' critical capacities with respect to representations were, generally speaking, rich and generative. [...] Second, students' knowledge seemed relatively "scientific," in the sense that they did not respond in ways that were obviously different from what would be expected from (adult) experts in these scientific fields. [...] Third, students' criteria tended to be rather implicit, which means that they had a lot of trouble in formulating and using verbal renditions of their criteria.

Studies dealing with MRC in music education (Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Gil et al., in press) confirmed the above quoted findings, after identifying *subject variables* (age and level of music training) and *task variables* (kind of sonic or musical material, and experimental settings and instructions) which determine children's performance. However, there are a number of caveats which concern the validity of the results, such as the characteristics of the sonic phenomena presented to children (Verschaffel, Reybrouck, Jans, et al., 2010, pp. 480,485; Gil et al., in press), and the setting in which the research took place (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, pp. 694,701; Gil et al., in press).

2.4.2 Theoretical implications

Developmental psychology had a great influence on researchers studying children's graphical representation of music, mainly in the eighties (Pramling, 2009, p. 276; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 261). Indeed, seminal works such as those written by Bamberger (1980, 1982) and Davidson and Colley (1987), Davidson and Scripp (1988) rely on the piagetian premise that "children's drawings [. . .] provide direct access to the child's view of the world through their attempts to reproduce it" (Hair, 1993, p. 41). As a result, developmental trajectories of children's musical understanding have been suggested as an evidence of the notational strategies they employ (Barrett, 2000, p. 44; Barrett, 2001, p. 34).

Taking for granted a general conception in developmental psychology, namely that "conceptual change is self-directed, in the sense that humans are intrinsically motivated to understand the world around them" (Glaser & Bassok, 1989, p. 642), the most of the reviewed studies posite age as the main subject variable that explains children's differences when drawing music. To this respect, it seems that seven years old is somewhat a threshold age in which certain changes happen. For instance, Walker (1978, p. 46) argues that "as early as their seventh year, children have acquired the conceptual competence necessary to enable them to employ phonetically representational musical orthography". Similarly, S. R. Cohen (1985, p. 188) points up that "at some point near the age of 7 years, children begin to coordinate encoding and decoding in a useful way".

Despite the clear evidence that children's informal representation of music is age-related, a growing body of research suggests other factors intervening. First, the nature of the task (i.e. procedure, instructions given, constraints) is likely to influence children's notational strategies (Barrett, 2000, p. 45; Barrett, 2001, p. 35; Barrett, 2002, p. 56; Reybrouck et al., 2009, p. 204; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 261). Second, instead of following a developmental path, with clear notational strategies according to each developmental stage, children are thought to move back and forth between a range of notational strategies (Barrett, 2000, p. 45; Barrett, 2001, pp. 34-35; Barrett, 2002, p. 56; Reybrouck et al., 2009, p. 204). Third, previous exposure to musical training seems also to affect those strategies (Barrett, 2000, p. 46; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 261).

2.4.3 Methodological implications

In order to assess children's invented drawings' adequacy to music or sonic stimuli, researchers have invented a number of activities over the years. What follows is a categorization of the main types found in our literature review.

Performing and drawing Children are requested to perform an existing or invented piece and to represent it by means of a drawing on a sheet of paper (Carmon & Elkoshi, 2010, p. 77; Elkoshi, 2004a, p. 67; Elkoshi, 2004b, p. 7; Elkoshi, 2007, p. 359). In some cases, children are told to draw the music fragment so that they can remember the piece in the future, or to help someone else to learn it (Bamberger, 1980, pp. 173,187).

Listening and drawing Children are exposed to a music or sonic fragment, played by the teacher/researcher (S. R. Cohen, 1985, p. 180) or recorded (Elkoshi, 2014, p. 4; Fung & Gromko, 2001, p. 132; Gromko & Russell, 2002, p. 333; Reybrouck et al., 2009, p. 192; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 266), and asked to fix it on a sheet of paper.

Imitate and drawing This kind of activity is somewhat a variation of the precedent one. After listening, children are told to imitate the music or sonic fragment (i.e. singing, clapping, playing with Orff instruments), before drawing it (Davidson & Colley, 1987, p. 114; Davidson & Scripp, 1988, p. 202; Gromko, 1994, p. 139).

Matching pairs Children are given a booklet with contrastive pairs of drawings, which are related to a music or sonic fragment. After listening it, children are asked to choose to most appropriate drawing according to their opinion (S. R. Cohen, 1985, p. 191; Verschaffel, Reybrouck, Jans, et al., 2010, p. 481; Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 697; Gil et al., in press). Random procedures are common to prevent order bias (Verschaffel, Reybrouck, Jans, et al., 2010, p. 487; Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 700)

2.4.4 Educational implications

Over the years, researchers have investigated how children represent music, to what extent their invented notations allow them to gain an insight into the cognitive processes they experience when coping with sounds. Right from the beginning, the issue of whether children's self-generated drawings should replace standard music notation, at least in the first years of schooling, arose: "whether phonetic notations might advantageously be introduced into the classroom are issues for the musician and music educator to resolve" (Walker, 1978, p. 46).

Parallel to musicians and music teachers who have been claiming alternative systems to standard music notation since the seventies (Paynter, 2008; Schafer, 1977/1994), researchers commonly have agreed to highlight the benefits of using children's invented notations as a "shorthand system to represent musical actions" (Walker, 1981b, p. 111), as a way to enhance creativity and to "acquire the representational concepts needed to handle the complex shape relations of standard notations" (Elkoshi, 2002, p. 210), or as a "clue for music teachers and art teachers to understanding a child's individual musical perception" (Elkoshi, 2004a, p. 79).

Overall, despite differences in methodology and approach, research on children's representation of music have shown that "the rigid conventions of standard notation may not be the best way to learn to graphically encode music" (Verschaffel, Reybrouck, Jans, et al., 2010, p. 500), since "essential qualities and aspects of a composition are presented in music notation, but not the complete sounding music" (Hultberg, 2002, p. 187). To this respect, children's self-expression would benefit from verbal or written explanations of their own drawings (Elkoshi, 2004a, p. 79), from using colour when intuitively organizing sounds (Elkoshi, 2004b, p. 16), or from "active movement while listening to musical sound" (Fung & Gromko, 2001, p. 136). Last but not least, both music teachers and researchers should avoid considering children's spontaneous notations as "less appropriate" than standard music notations, due to their professional or scientific bias (Bamberger, 1980, p. 172; Bamberger, 1982, p. 224; Upitis, 1987, p. 59; Elkoshi, 2004a, pp. 62,79).

2.5 Summary

A great deal of the research conducted on children's invented representations of music has been carried out by members of Harvard's Project Zero (Upitis, 1990, p. 91) or researchers linked to some extent to this program, which has provided this field with a sound theoretical background. Inquiry on children's spontaneous drawings has allowed both music teachers and researchers to gain an insight into cognitive mechanisms taking place when children make sense of their sounding environment. To this respect, a number of drawings' typologies have been put forward over the years in order to categorize children's representations, as an alternative to standard music notation. Lately, research on meta-representational competence has suggested that "music may be a very promising domain" so as to study this generic competence (Verschaffel, Reybrouck, Jans, et al., 2010, p. 499; Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 709). Hence a need for more research on this field has been claimed.

Chapter 3

Methods

3.1 Introduction

The purpose of this study was to examine the effects of a hypermedia learning environment on middle school students' MRC in the domain of music. Particularly, we aimed at determining whether an educational intervention –namely, the implementation of the aforementioned learning environment– influenced the accuracy with which middle school students ($n = 41$) matched sound (sonic fragments) to symbol (graphic representations). We hypothesized (H_1) that the experimental program would have a positive overall effect on the students' MRC, and that such effect would be lasting. We also predicted that the experimental group students would have a more positive perception of the learning environment. In addition, we inquired into the effectiveness of the educational intervention for participants with different levels of musical experience, as well as into the partial effect for six representational criteria and three music parameters.

3.1.1 Design of the study

A pretest-posttest control group design was used in this study. Two conditions were fulfilled, namely stratified random assignment (R) of participants to the experimental condition, and pretest and posttest (O) assessment of units. Between the pretest and the posttest, an educational intervention was carried out by means of a virtual classroom (Moodle) so that the students allocated to the experimental (E) group were provided with both fixed and adaptive scaffolding, while the control (C) group students did not. Such a scaffolding consisted of small hints and reminders provided by the teacher to help students carry out tasks In addition, around one month after finishing the intervention, a retention test was performed in order to measure the lasting effect of the program (see Table 3.1).

R_E	O	X	O	O
R_C	O		O	O

Table 3.1: Study design.

3.1.2 Pilot study

During the academic year 2011–12, an intervention-based study was performed in a Majorcan high school different to the one which held this study. Similarly, it was aimed at determining whether middle school students showed an increase in MRC after an educational intervention. Three classes of students aged 11–14 participated in the teaching experiment: one experimental class (E) and two control classes (C). An intervention on MRC was carried out on the E class during the hours that were allocated for the regular music lessons, while students from the C classes followed the regular music curriculum. E and C classes were given the same pretest and posttest, which measured students' MRC by means of six representational criteria. One month after the posttest, all classes completed a retention test. The results revealed an overall effect in favour of the E group, despite the negative results for two representational criteria. Moreover, the overall gain was due to a great extent to a decrease in the score of the C classes, while the gains in the E class were rather small.

Although both pilot and current studies share mainly the overall research design, a number of changes have been made in the latter so as to make up for the weaknesses of the former. First, the participants have been randomly assigned to the experimental condition, while in the pilot study random assignment was only possible with the whole class as a beforehand predefined group in the high school. Second, items from the pilot study's pretest, posttest, and retention test were randomly mixed so as to obtain parallel tests and therefore to increase reliability. Third, paper-and-pencil tests and tasks, as carried out in the former study, were put aside in favour of equivalent materials in a hypermedia learning environment, such as Moodle virtual classroom (Team, 2008), and a drawing tablet. Fourth, the participants' academic background has been taken into account in the latter study. Five, the educational intervention took one more week than in the pilot study. Finally, both the E and the C groups in the current study were taught the same contents with slightly different instructional techniques, while we were unable to follow the C group in the pilot study.

3.2 Participants

3.2.1 Sampling design

The target population or universe of this study were first year middle school students (11–12 years old) in Palma (Majorca, Balearic Islands). The sample was drawn from a high school in the outskirts of the city, and consisted of 100 first students enrolled in the 1st grade school music course. The average families whose children study at this centre had a medium socio-economic level. Twenty-five students were removed from the study for not attending to two or more than two sessions of the experimental program. As a result, the analysed sample consisted of 75 students (see Figure 3.1).

The participants were assigned to the experimental condition from *strata*, in order to "increase the likelihood that conditions will have similar pretest means and variances" (Shadish, Cook, & Campbell, 2002, p. 305). Before the beginning of the experiment, the students had been allocated into four classes, namely A, B, C, and D, with significant differences with respect to academic level existing ($\chi^2 = 17.94$, $df = 3$, $p = .0005$). Therefore, instead of respecting this *a priori* academic setting, we stratified the students on their musical experience. Thereafter we randomly assigned the strata, namely 'high-experienced', 'medium-experienced', and 'low-experienced', to treatment and control in a separate way. So as to obtain the above strata, this continuous variable was binned into three levels by means of 'natural' method, where cut points between bins were determined by a k-means clustering (Fox, 2005). Since "researchers should probably avoid simple random assignment with total sample sizes less than 200" (Shadish et al., 2002, p. 297) and that was our case, we performed a restricted random assignment (R Core Team, 2014) so as to get equal sample sizes in each condition. Low-experienced students assigned to the experimental group were slightly favoured to the detriment of medium-experienced students, so as to not turn out underrepresented (see Table 3.2).

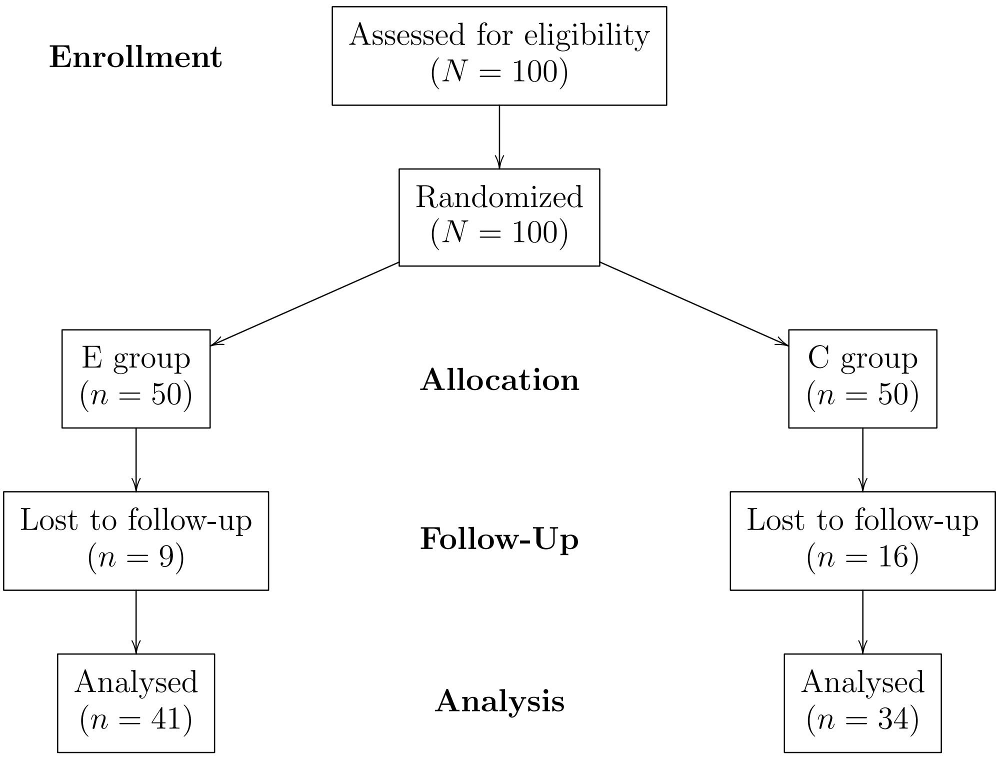

Figure 3.1: Flow diagram.

3.2.2 Sample size

Our pilot study allowed us to obtain the effect size from the scores of the control group and the experimental group at the posttest. Thereafter we hypothesized an slight improvement and worsening, respectively, for the experimental and control group, and therefore a better effect size (h = .68). According to this parameter, we obtained an estimated sample size for our current study (N = 33.49, p = .05, β = .80). As a conclusion, at least 68 participants were supposed to take part in our study (34 for each experimental condition). As above stated, our analysed sample after attrition slightly exceeded this amount (N = 75), what is likely to guarantee a good effect size.

3.3 Variables

The study was designed so as to test hypotheses regarding the extent to which an educational intervention would improve the students' MRC, as measured after (pretest) and before (posttest and retention test) that intervention took place. There were two main independent variables or factors, namely 'Allocation to the experimental condition' ('Experimental', 'Control'), and 'Time' ('Pretest','Posttest','Retention test').

The dependent variables were generated by combination of three sound parameters (pitch, duration, and loudness) and six representational criteria (correctness, completeness, transparency, formality, parsimony, and beauty). Therefore there were 18 dependent variables for each measurement (pretest, posttest, and retention test). All of them were qualitative and dichotomous.

Musical experience	Control	Experimental	Total
High	9	9	18
Medium	31	28	59
Low	10	13	23
Total	50	50	100

Table 3.2: Distribution of music experience as stratified variable.

As such, they followed a binomial distribution, where ‘0’ stood for ‘less appropriate representation’, and ‘1’ stood for ‘more appropriate representation’ (see an extract in Table 3.3).

Variable	Parameter	Criterion
prepitcor	pitch	correctness
prepitcom		completeness
prepittra		transparency
prepitfor		formality
prepitpar		parsimony
prepitbea		beauty
predurcor	duration	correctness
predurcom		completeness
predurtra		transparency
predurfor		formality
predurpar		parsimony
predurbea		beauty
preloucor	loudness	correctness
preloucom		completeness
preloutra		transparency
preloufor		formality
preloupar		parsimony
preloubea		beauty

Table 3.3: Dependent variables for the pretest.

For analysis purposes, the dependent variables were grouped so as to allow the particular study of each representational criteria and each music parameter, as well as to obtain an overall effect of the educational intervention. As such, the new variables thus created were supposed to follow a Poisson binomial distribution (Hong, 2013, p. 41), what determined our data handling (see Section 3.8). The rejection level for all statistical analyses was set at $p = .05$.

3.4 Ethical compliance

This study was characterized by the fact that the researcher was in turn the music teacher of the students involved in the research. This dual role has been argued as a potential source of ethical concerns, since "[t]eachers' primary obligations are to their students,' while researchers have obligations to the field to which they seek to make a contribution" (Hammack, 1997, p. 250), and therefore "the criterion of service to the student is potentially jeopardized by needs determined by the research" (Hammack, 1997, p. 255).

The above statements may suggest that research conducted by teachers in their own educational setting is particularly controversial, and therefore to advise against carrying out it. On the other hand, it has been also pointed that "examination of ethical issues surrounding classroom research is best done when those who know the context well –teachers interested in research– are involved (Hammack, 1997, p. 261). The following is a list of ethical principles as described by Lankshear and Knobel (2004, p. 103), which proof our strict compliance with them.

Have a valid research design

We relied on a common research design (see Section 3.1.1) as described in Shadish et al. (2002), with the students being randomly allocated to the experimental condition. However, "[f]or some researchers, random assignment is undesirable for practical or ethical reasons, so they prefer quasi-experiments" (Shadish et al., 2002, p. 502). Admittedly, this study must not be conceived as experimental in a strict sense, since the educational setting where it took place entailed odd variables possibly intervening. However, we used a (stratified) randomized design, since the benefits outweighted the (very improbable) harms. To this respect, we were incapable of thinking in any undesirable consequence of randomization, neither ethical concerns were raised.

Obtain informed consent

Ethical principle stress the need of allowing participants to decide whether or not to participate in the research, so as to "[rule] out any kind of deception, though deception is also sometimes rejected on the grounds that it causes harm" (Hammersley & Traianou, 2012). However, there were a number of reasons that justified our decision of not asking the students about their consent, which are in compliance with ethical guidelines.

First, "where research involves all persons under sixteen years of age, consent should be obtained from parents or from those 'in loco parentis"' (Morrow & Richards, 1996, p. 93). Since our students were aged 11—12, we obtained the informed consent from the principal of the high school where the research was carried out, who acted as a 'gatekeeper'.

Second, it has been argued "the potentially coercive nature of teachers as researchers when they request student participation in their own research" (Hammack, 1997, p. 257). In this context, both the students and their parents' freedom to decide whether to participate would be severely compromised, since they "may be disinclined to refuse to participate for fear of losing favour or gaining a reputation for being uncooperative (Homan, 2001, p. 341). In addition, "children who are required to participate in research in schools may not feel in a position to dissent, simply because most (if not all) tasks and activities in school are compulsory" (Morrow & Richards, 1996, p. 101).

Third, "[i]n educational research, then, it is frequently the case that the principle of informed consent, which is central to the ethical control of all social research, is directed not at those whose behaviour is the subject of an enquiry but at one who takes a decision on their behalf (Homan, 2001, p. 329). Furthermore, researchers "may feel unwilling to jeopardize their research project by asking the children explicitly for their 'informed consent"' (Morrow & Richards, 1996, p. 94). Overall, gatekeepers usually hold that "there is a greater good in educational research than the entitlement of pupils to opt out" (Homan, 2001, p. 338) and therefore allow the investigators to proceed.

Avoid deception

The fact of not informing the students about the research could be seen as somewhat deceptive. To this respect, the British Educational Research Association (BERA, 2011, p. 6) "recommends that approval for any course of action involving deception should be obtained from a local or institutional ethics committee. In any event, if it possible to do so, researchers must seek consent on a posthoc basis in cases where it was not desirable to seek it before undertaking the research." Despite we reaffirm the ethical compliance of our decision, as stated above, we applied for and obtained a consent from the University of Valencia's Ethical Review Board (see Appendix B.1), which certified the correctness of the procedures that we followed.

Minimize intrusion

It is needless to say that the intrusion, as such, was non-existent, given the dual role teacher-researcher. What is more, the procedures carried out during the educational intervention, as well as the materials put at the students' disposal, are not likely to have lead them to think that something different was happening. Similarly, there was no time intrusion to modify the students' weekly timetable, given the absolute coincidence of the experiment with the time allocated for music in the high school. Overall, our research resembled a common music lesson to the learners' eyes, who dealt with the content according to the curriculum guidelines.

Ensure confidentiality

As Hammersley and Traianou (2012) points, "[a] central feature of research is to make matters public, to provide descriptions and explanations that are publicly available. But what should and should not be made public?" So as to preserve the anonymity of the students, each participant was assigned a code made by concatenation of the two last letters of their names and surnames, by means of Apache OpenOffice™ Calc concatenate function. This way, the researcher itself was unaware of the students identities when handling the data. In addition, no reference about the exact high school where the research took place is provided throughout this report, neither it will be provided in forthcoming public presentations. As an example, a white strip masks the name of the high school in the Moodle's snapshots provided in the Appendices.

Minimize risk of harm

Given the nature of our research, consisting of an intervention in an educational setting, with the researcher being also the music teacher of the students, no harm was inflicted to any of the participants. One could think that, since our experimental design entailed two different treatments, the students allocated to the control group could have been at a disadvantage with respect to those allocated to the experimental group, and therefore their school marks for the lesson could have been affected. So as to ameliorate this drawback, all the students –independently of their allocation– were scored in the school report with the best mark obtained by a student in the experimental group.

Demonstrate respecting

In compliance with educational guidelines, there was no differentiated treatment for the participants, independently of their personal circumstances. In addition, we declare that no-one was unfairly favoured or discriminated according to their performance in the experiment.

Finally, "when teachers conduct research in their own classrooms, the lived experience is a blending of the two. This ambiguity may confound teachers' efforts to enact both roles responsibly" (Hammack, 1997, p. 256). Despite the handicap that could entail such a challenge, we hope to have provided enough clues to give an account of the ethical compliance of our research.

3.5 Instruments

This section describes in detail the instrumentation used to measure three major constructs, namely the students' music aptitude, the extent to which their MRC improved due to the educational intervention, and the students' perceptions of the virtual classroom environment where the teaching took place.

3.5.1 Music aptitude measurement

In what follows, an instrument consisting of a set of aural discrimination tests and a music experience questionnaire is reported (Hankinson, Challis, & Edwards, 1999; Pirie, 1999; Edwards, Challis, Hankinson, & Pirie, 2000). We adapted both of them for using with the students in a hypermedia learning environment.

Music aptitude test (MAT)

MAT consists of eight on-line tests which measure subjects' aural discrimination with respect to pitch, rhythm, harmony, and dynamics. All of them are matching tasks, as described elsewhere by McAdams (1993, p. 160):

> A test stimulus is presented and then several comparison stimuli are presented, one of which is of the same class or category as the test stimulus. The listener is asked to say which of the comparison stimuli matches the test stimulus.

According to the students' profile and the time allocated for music at the high school, three tests from the original instrument were selected, namely pitch awareness, rhythm-duration, and dynamic awareness. The reason for this choice is that they refer to the musical parameters related to measurement of MRC. Thereafter we reduced the amount of questions for tests one and two (20 questions instead of 40 for pitch awareness, and 10 questions instead of 25 for rhythm-duration), and finally we made the test available for students through a Moodle virtual classroom (see Appendix A.1). Presenting the tests by means of a Moodle interface allowed the researcher to obtain the students' scores in a unified way, instead of having to retrieve the marks of each student from the computer that they used. The drastic reduction of questions with respect to the original instrument was intended to allow the students to take the three tests in a only session, in order to prevent a possible fatigue factor, as the authors themselves warned (Pirie, 1999, p. 19; Edwards et al., 2000, p. 4). For a complete description of the original instrument, see Hankinson et al. (1999).

Regarding the reliability of measurements, some starting points must be clarified. First, "reliability is not a property of a test *per se*, but rather a property of a scale applied in a given context to a particular population" (Dunn, Baguley, & Brunsden, 2013, p. 3). Therefore, it must be also taken into account "the level of reliability of the reliability estimate itself" (Dunn et al., 2013, p. 6). Second, despite Cronbach's α being the most common measure of internal consistency in literature, it has been shown "only to be representative of a measure's internal consistency when the assumptions of the essentially τ *equivalent* model are met" (Dunn et al., 2013, p. 4), which seldom happens for psychological scales[1]. Third, many authors have endorsed the benefits of using a *congeneric* model instead, which is less restrictive than the essentially τ equivalent model. McDonald's ω, which adheres to the congeneric model, "has been shown by many researchers to be a more sensible index of internal consistency" (Dunn et al., 2013, p. 7).

According to Dunn et al. (2013) approach, McDonald's ω was calculated for each of the three subscales which MAT consists of (Kelley & Lai, 2012). Besides the estimated reliability coefficient, the confidence level and the lower and upper bounds of the computed confidence interval are shown. Since McDonald's ω ranges from 0 to 1, it is commonly assumed that a coefficient above .70 indicates a good internal consistency. As far as our version of MAT is concerned, any of the subscales reached such a level, what threatens the

[1]There exist three models for measuring internal consistency, namely *parallel*, τ *equivalent*, and *congeneric*. The first one is the most restrictive, since it assumes constant item means, item variances, and error variances; the second one only assumes constant item variances; and the third one is the least restrictive of the three: means, variances and error variances are allowed to vary (Dunn et al., 2013, p. 4).

reliability of the measurement, and the subsequent inferences (pitch: $\omega = .68$, 95% CI [.46, .86]; duration: $\omega = .36$, 95% CI [.04, .62]; loudness: $\omega = .35$, 95% CI [.01, .48]).

Music experience questionnaire (MEQ)

A paper-and-pencil questionnaire was devised as a complementary instrument to MAT so as to find correlations between subjects' self-reported information about their musical background, and their performance in MAT (Pirie, 1999, p. 20). The questionnaire consisted of two parts: part A asked for general background details of participants (sex, age, ethnicity, occupation, hearing impairment, and computer literacy), and part B was concerned with information about their musical background (music skills, music training, music interests, self-definition, related skills, and other information). For a complete description of the original instrument, see Pirie (1999).

Our adaptation of this questionnaire focused on part B, since most of the details asked in part A were irrelevant to our aims (with the only exception of 'sex' and 'age'). Similarly to MAT, we reduced the overall amount of questions, and we made the test available for students through Moodle. Finally, our instrument (MEQ) consisted of 23 Likert-type items distributed into five subscales (see Appendix A.2). Subscales 1 and 2 focused on general skills as demonstrated by instrumental playing. Subscale 3, on self-definition, was designed to measure self-awareness of musical ability. Subscale 4 asked for information on formal music training, while Subscale 5 aimed at determining how often participants listened to certain music genres. McDonald's ω was computed for each of the five subscales, with only sets three and four showing a good internal consistency (subscale 1: $\omega = .65$, 95% CI [.43, .82]; subscale 2: $\omega = .59$, 95% CI [.21, .88]; subscale 3: $\omega = .81$, 95% CI [.74, .86]; subscale 4: $\omega = .81$, 95% CI [.37, .97]; subscale 5: $\omega = .57$, 95% CI [.32, .71]).

3.5.2 MRC measurement

Verschaffel, Reybrouck, Jans, et al. (2010) devised a paper-and-pencil test to measure children's MRC. The instrument consisted of 18 items, "each containing two contrastive representations according to a specific representational criterion set by the researchers" (Verschaffel, Reybrouck, Janssens, et al., 2010, p. 483). For each item, only one representation matched best a given sonic fragment, generated by the researchers so as to enhance a salient musical parameter (pitch, duration, and loudness). Overall, each of the 18 items resulted from combining three music fragments and six representational criteria related to diSessa's (2002) framework (correctness, completeness, transparency, formality, parsimony, and beauty).

Our version of this instrument closely followed the original one, with the following remarks. First, we turned the instrument into a multiple choice Moodle task, so as to allow the students to access the test by means of a hypermedia interface. So as to avoid the students to get confused or distracted with so many pictures, we segmented each test into three parts, each one referred to a music parameter (see Appendices A.3, A.4, and A.5).

Second, as far as representations and sonic fragments are concerned, we relied on the material that we designed for the pilot study (Gil et al., in press), namely three sets of 18 items, and three sets of three sonic fragments (see Table 3.4 for an overview of Set 1).

As in the model (Verschaffel, Reybrouck, Janssens, et al., 2010), each item contained a more appropriate an a less appropriate representation of a given sonic fragment, according to a representational criteria (see Section 1.4.4). To put it another way, each sonic fragment was related to 12 representations, a half of them being more appropriate, and a half of them being less appropriate, according to six representational criteria.

Third, the instruments that we devised for the pretest, posttest, and retention test in our pilot study allowed us to ascertain whether they were parallel, what entails that both psychological and statistical criteria must be fulfilled (Chadha, 2009, p. 50). To this respect, the fact that an intervention was carried out between the pretest and the posttest invalidates any estimation, since "when the ability being tested changes markedly in the internal between test administrations, the use of parallel forms is not advisable" (Chadha, 2009, p. 68). Therefore, we focused on the posttest and the retention test, where no intervention happened between them. According to

Chadha (2009, pp. 50–51), our tests are supposed to comply with the psychological criteria, namely having "items concerning the same subject mater", and having "items of the same format". As to statistical criteria, we tested the equality of means and variances by means of the equations (3.1) and (3.2),

$$t = \frac{|M_a - M_b|}{\sqrt{\frac{S_a^2}{N_a} + \frac{S_b^2}{N_b}}} \tag{3.1}$$

$$t = \frac{|S_a - S_b|}{\sqrt{\frac{S_a^2}{N_a} + \frac{S_b^2}{N_b}}} \tag{3.2}$$

taking into account the degrees of freedom (df) $df = Na + Nb - 2$ Our results for the posttest$_a$ and the retention test$_b$ were

Mean $M_a = 9.91; M_b = 10.39$

Item	Criteria	Music parameter
1		Pitch
2	Correctness	Duration
3		Loudness
4		Pitch
5	Completeness	Duration
6		Loudness
7		Pitch
8	Transparency	Duration
9		Loudness
10		Pitch
11	Formality	Duration
12		Loudness
13		Pitch
14	Parsimony	Duration
15		Loudness
16		Pitch
17	Beauty	Duration
18		Loudness

Table 3.4: Pilot study: Set 1.

Standard deviation $S_a = 2.84; S_b = 2.83$

Sample size $N_a = 56; N_b = 56$

and therefore

$$t = \frac{|9.91 - 10.39|}{\sqrt{\frac{2.84^2}{56} + \frac{2.83^2}{56}}} = .9 \tag{3.3}$$

$$t = \frac{|2.84 - 2.83|}{\sqrt{\frac{2.84^2}{56} + \frac{2.83^2}{56}}} = .007 \tag{3.4}$$

for $df = 110$ The above t value for both mean (3.3) and standard deviation (3.4) were less than the table value of t for $df = 110$ ($t_{.05} = 1.984$), then t is no significant, and therefore our posttest and retention test are supposed to be parallel. Nevertheless, the fact that we were unable to include the pretest in our analysis of the pilot study, due to the above reasons, made us to proceed as described below so as to increase the chance that our current three individual tests were parallel.

The procedure consisted of a triple randomization of our original set of pictures by means of R (R Core Team, 2014). As an example, we focus on the pictures we devised so as to measure MRC in combination with the musical parameter 'pitch'. As showed in Table 3.5, 18 items –each one containing two pictures– were provided, rows corresponding to separate tests, and columns corresponding to representational criteria.

1	4	7	10	13	16
2	5	8	11	14	17
3	6	9	12	15	18

Table 3.5: Pilot study: Original items grid for 'pitch'.

In a first step, we randomized columns in order to mix the material from the pilot study pretest, posttest, and retention test (see Table 3.6).

Next, we randomized rows so as to change the order in which the representational criteria were shown (see Table3.7).

Finally, the third randomization was aimed at sorting the couple of pictures of each item, corresponding the value '1' to more appropriate pictures, and the value ‘0’ to less appropriate pictures. This way, we tried to avoid a possible order effect (see Appendix A.6 for an overview).

Fourth, with respect to the sonic fragments, we kept them short and simple, “each with a single sonic parameter that is clearly changing over time (pitch, duration, and loudness), while all other parameters [...] were absent or remained invariant over time” (Verschaffel, Reybrouck, Janssens, et al., 2010, p. 481). We generated these sound fragments by means of LMMS software (Doerffel et al., 2010). As a rule, we used sound samples different to traditional instruments, with an overall mean duration of $10'20'' \pm 2'50''$ (see Appendix A.7 for a description).

Finally, as far as reliability is concerned, our tests yielded a rather low internal consistency (pretest: $\omega = .09$, 95% CI [.01, .44]; posttest: $\omega = .30$, 95% CI [.02, .53]; retention test: $\omega = .32$, 95% CI [.03, .61]). As an additional instrument to validate the tests, we designed a Moodle task aimed at measuring whether “the students actually attended [...] to the visual features of the graphic representations in the same way that we, as researchers, did” (Verschaffel, Reybrouck, Jans, et al., 2010, p. 498).

The instrument relied on that one described in Verschaffel, Reybrouck, Jans, et al. (2010, p. 502), in which the students had to choose “from a list of six representational criteria [...] the criterion addressed in that particular item”. Since the students needed to have been taught precisely contents about representation, it could not be used before the educational intervention

1	4	7	12	14	18
3	5	8	11	13	17
2	6	9	10	15	16

Table 3.6: Current study: First randomization of items grid for ‘pitch’.

12	14	1	4	18	7
3	17	11	8	5	13
6	15	2	9	16	10

Table 3.7: Current study: Second randomization of items grid for ‘pitch’.

ended. The instrument was devised as a multiple choice task, where the students had to select which representational criteria best fitted in with the items that they had just seen in the posttest and the retention test. As to the task settings, Moodle was allowed to shuffle the questions, so as to avoid the students to cheat (see Appendix A.8).

Inter-rater agreement was calculated with the students acting as independent raters ($N = 75$) for the instrument after the posttest and after the retention test, as well as intra-rater agreement between both tests by means of the function `kappam.fleiss` and `iota` in the R package `irr` (Gamer, Lemon, Fellows, & Singh, 2012). With respect to inter-rater agreement, the coefficients proved to be very low for the students allocated to the E group ($\kappa = .008$ after the posttest, $\kappa = .010$ after the retention test), as well as for those belonging to the C group ($\kappa = .008$ after both the posttest and the retention test). As to the intra-rater reliability, the level of agreement was also very low ($\iota = .011$).

3.5.3 The Constructivist On-Line Learning Environment Survey (COLLES)

The COLLES (Taylor & Maor, 2000) was designed so as to measure students' perceptions of the hypermedia learning environment in which they are involved. It allows students to assess both their preferred and actual on-line classroom environments. The instrument consists of 24 Likert-type items, each one with a five-points scale: Almost Never (1), Seldom (2), Sometimes (3), Often (4), Almost Always (5). The questions are organized in six assessment dimensions, namely:

Relevance How relevant is on-line learning to students' practices?

Reflection Does on-line learning stimulate students' critical reflective thinking?

Interactivity To what extent do students engage on-line in rich educative dialogue?

Tutor support How well do tutors enable students to participate in on-line learning?

Peer support Is sensitive and encouraging support provided on-line by fellow students?

Interpretation Do students and tutors make good sense of each other's on-line communications?

We used the available version of the COLLES as released in Moodle 1.9, without any adaptation needed (see Appendix A.9). The only warning was related to the questions 2, 3, and 4, where students were told that "my professional practice" should be understood as "my education". In addition, we dropped the items 25 and 26, which were not relevant to our aims.

With respect to reliability, McDonald's ω was computed for each of the six subscales, with an average good internal consistency (relevance: $\omega = .75$, 95% CI [.62, .84], reflection: $\omega = .57$, 95% CI [.35, .70], interactivity: $\omega = .79$, 95% CI [.66, .86], tutor support: $\omega = .73$, 95% CI [.56, .83], peer support: $\omega = .60$, 95% CI [.43, .70], interpretation: $\omega = .62$, 95% CI [.39, .73]).

3.6 Materials

The high school were this study took place provided the following materials, with the exception of the design tablet.

Netbooks Twenty-four Samsung® 10" netbooks (Model N145 plus) were available for the students to use during the time allocated for the experiment (see Figure 3.2). The netbooks were stored in a cabinet before and after using them so as to keep the batteries charged (see Figure 3.3). They were equipped with Ubuntu 10.4 (Lucid Lynx) operating system, and connection to the high school wireless network was available.

Interactive whiteboard A SMART Board® 77" interactive whiteboard (Model SBM680) was available in the music classroom. A desktop computer equipped with Ubuntu 12.4 (Precise Pangolin) was connected to the device, as well as to a couple of two-way Hi-Fi wood speakers (see Figure 3.4)

Design tablet A Trust® flex ultra-thin design 7.5" tablet with ergonomic wireless pen was used in connection with the classroom desktop computer.

3.7 Procedures

In a generic sense, this study relied heavily on a hypermedia learning environment, namely the high school Moodle virtual classroom. The students were provided with individual netbooks (see Section 3.6) so as to access Moodle in the music classroom. In all cases, the educational setting remained unchanged with respect to the academic routines. It must be said that the

Figure 3.2: Students' netbook.

Figure 3.3: Netbooks' cabinet.

students were used to working with Moodle as a virtual classroom, as well as with individual netbooks, since the beginning of the academic year. As a relevant feature, the actual teaching was done in English –the educational intervention described in this report included–, since the high school which held the study participated in a pilot program of content and language integrated learning (CLIL).

The study started at the beginning of the second term of the academic year, since the students were supposed to need the entire first term to adapt to the educational setting, due to the following reasons. First, with the exception of those students repeating the year, the participants in the study were newcomers to the high school. Second, they would need time to get used to accessing Moodle with their personal user name and password, as well as to using the classroom netbooks. Third, given the CLIL approach in the teaching of music, the students needed some months to acquire the minimum language skills in English so as to allow them to understand the

Figure 3.4: Classroom interactive whiteboard set.

teacher and to minimally express themselves in a foreign language.

In outline, this study proceeded chronologically as follows:

1. Music aptitude measurement

2. Pretest

3. Educational intervention

4. Posttest

5. Retention test

6. COLLES

Next we elaborate on each of these stages.

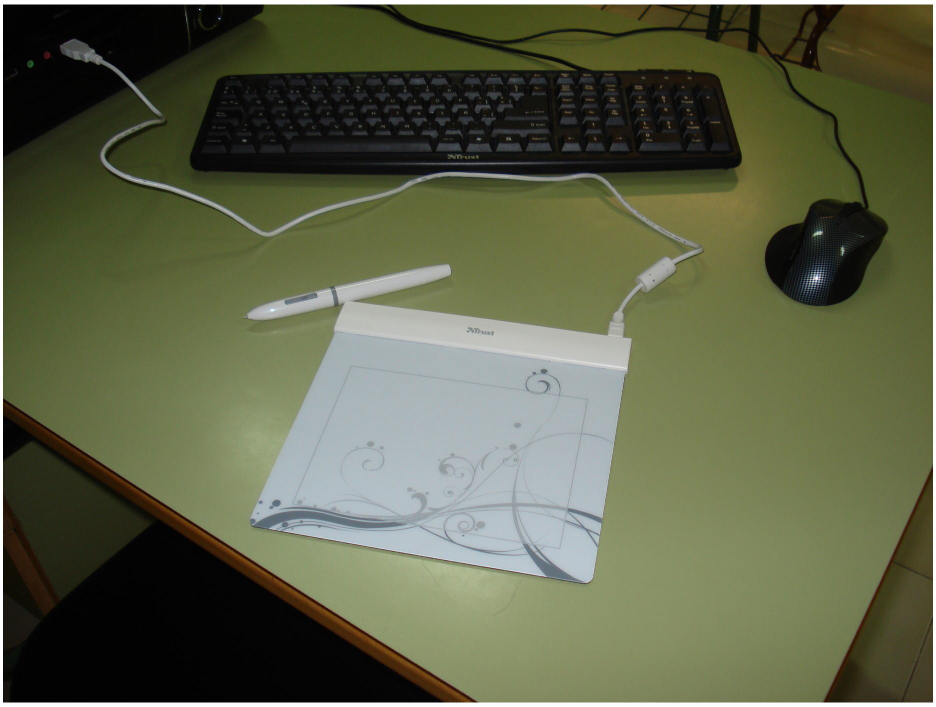

Figure 3.5: Design tablet.

Music aptitude measurement

The students' music aptitude was measured by means of the MAT and the MEQ (see Section 3.5.1 and Appendices A.1 and A.2). They were seated in the classroom as usual according to their school group, and they were provided with individual netbooks. With respect to the MEQ, the teacher would read aloud all the items of the questionnaire, in case any student had problems with reading comprehension. The students were explained how to fill in the questionnaire and then they were invited to click the 'submit all and finish' button when they had finished. This test took one session to be completed. As far as the MAT is concerned, the procedure was similar to the MEQ, with the new feature that the students had to wait until the teacher played the sound fragments, before they chose the best fit. This test took three sessions to be completed, each one for a separate subscale (pitch, duration, and loudness).

Pretest

Once the students completed the MAT and the MEQ, they were ready to take the pretest. The setting was similar to previous tests, with each student having a personal netbook. As a precautionary measure, we prepared a paper-and-pencil version of the pretest, since we had experienced some overloading of the high school wireless network, and that could affect the simultaneous performance of the students. This aid was also very useful in case of momentary malfunction of any of the netbooks.

The pretest consisted of three sections, namely 'pitch', 'duration', and 'loudness', each one containing six items with a more and less appropriate representation of a brief sonic fragment. The Moodle test was set so that the students had to 'submit and finish' each individual section, thus preventing a possible failure of the net, or the possibility for the participants to modify their answers. The teacher-researcher would read aloud the item number and play two times each sonic fragment.

Educational intervention

The educational intervention consisted of eight sessions of 55 minutes each, distributed within four consecutive weeks, according to the weekly timetable scheduled for music in the high school (three sessions per week). Table 3.8 shows the overall calendar of the intervention.

Week/Session	1	2	3	4	5	6	7	8
1	✓	✓	✓					
2				✓				
3					✓	✓		
4							✓	✓

Table 3.8: Educational intervention: Overall calendar.

First week

Sessions one to three were common to both E and C groups. The students were introduced two representational criteria in each session, namely correctness and completeness in session 1, transparency and formality in session 2, and parsimony and beauty in session three. The teacher-researcher explained briefly the basics of the above criteria, and gave the students some practical examples of adequacy and inadequacy among sound and symbol representation by playing short fragments on the piano and drawing simple representations on the interactive whiteboard. Afterwards, couples of volunteers were called to reproduce a similar action, while the rest of the class were allowed to express approval or disapproval with the volunteers' performance. As an example, figure 3.6 shows some of the students' drawings on the interactive whiteboard representing an ascending C major one octave scale.

Each session ended with a summing-up task on the Moodle virtual classroom, in which the students had to complete an easy multiple choice task, so as to answer the question "What did you learn today?" (see Appendices B.2, B.3, and B.4). These tasks had a double purpose: first, to assess their comprehension of the representational criteria; second, to prove their attendance for inclusion/exclusion criteria.

Second week

According to the 2012–13 school calendar in the Balearic Islands, a two-days bank holiday was allocated this week, therefore only one session (Session 4) took place, consisting of a Moodle task. We were able to present separate activities for the E and C groups by means of Moodle 'Groupings'[2]. The procedure was as follows.

The students allocated to the control group were given a multiple choice task (see Appendix B.5). The instructions were like this: "Please listen to this sound fragment. According to the transparency criterion, which picture do you think is better?"[3]. They had 20 minutes to complete the task, and unlimited attempts were allowed, in case they wanted to improve their marks. However, any feedback was provided.

The students allocated to the experimental group were given a lesson[4]

[2]http://docs.moodle.org/19/en/Groupings
[3]The sound fragment can be accessed at http://goo.gl/YBqdbY
[4]http://docs.moodle.org/19/en/Lesson_module

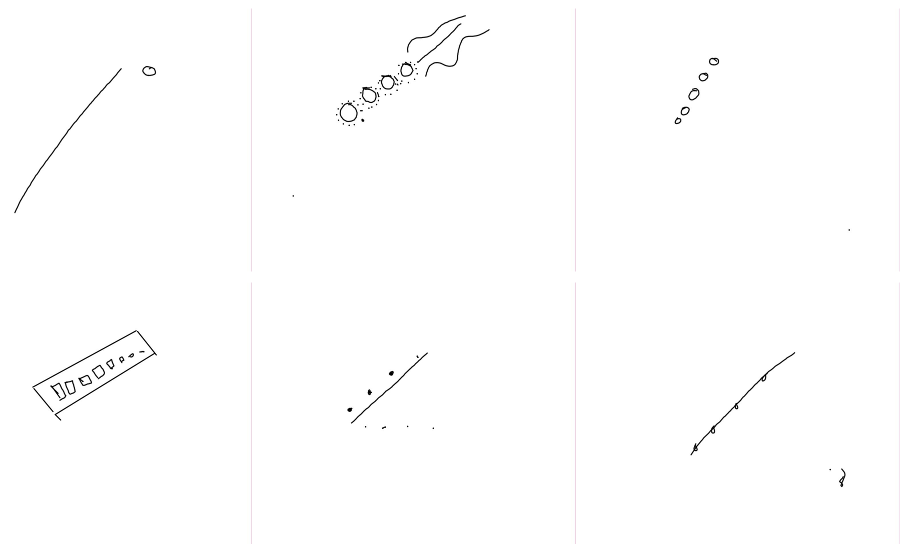

Figure 3.6: Students' representations on the interactive whiteboard.

with an appearance quite similar to the above multiple choice task (see Appendix B.6 for an expanded view), despite existing two main differences. First, a brief explanation of each representational criteria was provided as a reminder. Second, after having chosen a given picture, the students were provided with fixed feedback, which allowed them to continue with the lesson, or made them to go back to the previous choice. Similar to the control group, they had 20 minutes to complete the lesson, and retakes were permitted.

Third week

There was a third bank holiday in addition to the previous two days, therefore only two sessions were possible. Overall, Session 5 was somewhat a recapitulation of the contents already dealt with, and Session 6 was a practical task in which the students were requested to draw a picture according to a given sonic fragment.

Session 5 was different for the students belonging to the E and C groups. The former were given a lesson with a structure of content pages and question pages. Content pages aimed at reminding the students the definitions of the representational criteria, while question pages consisted of multiple choice tasks including fixed scaffolding so as to guide the students' choices (see Appendix B.8 for an expanded view). They had 20 minutes to complete the lesson, and retakes were permitted. As to the latter, the students were given a matching task with the following instructions: "Match the definition with the right criterion. Some words are not needed." As above, they had 20 minutes to complete the task, and unlimited attempts were allowed, in case they wanted to improve their marks. However, any feedback was provided (see Appendix B.7).

Regarding Session 6, all the students were requested to represent a short sonic fragment (see Figure 3.7)[5] by means of a design tablet (see Section 3.6). The procedure was as follows: the design tablet was placed on the teacher table, and the screen where the students could see their drawings was opposed to the sitting position of the rest of the class, so as to no give any clues to the

[5]The sound fragment can be accessed at `http://goo.gl/YBqdbY`

classmates. The sound fragment was regularly played as a loop. The teacher would call individually the students belonging to the control group, and then the students belonging to the experimental group[6]. All of them were allowed to repeat the drawing one time, but only those belonging to the experimental group were given an adaptive feedback, according to their performance. After finishing the drawing, each student completed a multiple choice task (see Appendix B.9). This Moodle task was aimed at the students to self-assessing their own drawings, according to the representational criteria.

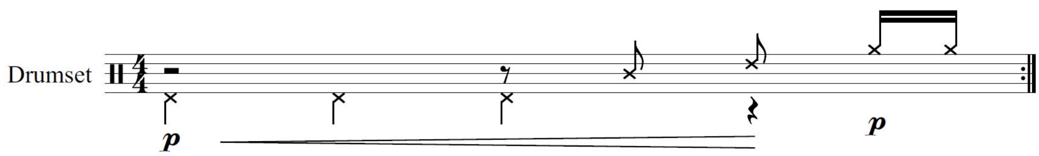

Figure 3.7: Sound fragment.

Fourth week

The last week of the educational intervention consisted of Session 7 and Session 8, the former reviewing concepts about representational criteria, and the latter retaking the drawings from Session 6.

Session 7 was an embedded answers task (Cloze), in which the students had to fill in gaps (words and numbers), and choose the best answer among multiple options. The appearance of the task was exactly the same for both the E and C groups, with the only difference that the students belonging to the E group were provided with fixed scaffolding, consisting of small hints and reminders (see Appendix B.10).

Finally, Session 8 was somewhat a variation of the Moodle task at the end of Session 6, since the students were requested to assess their classmates' drawings. In order to do so in a feasible way, 20 drawings were randomly chosen among those generated in Session 6, so as to avoid the students to get confused or distracted with all the pictures. The instructions were as

[6]This fact remained unknown for the students

follows: “This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.” (see Appendix B.11). As usual, both groups had 20 minutes to complete the task, and unlimited attempts were allowed. The students belonging to the experimental group were provided with fixed scaffolding, unlike those belonging to the control group.

Posttest

The posttest took place once the educational intervention finished, and followed the same procedure as the pretest. Additionally, the students were given a multiple choice task so as to measure their level of agreement when individually relating the items that they had just seen to a given representational criteria. Since the task contained all the items from the previous test, and choosing the right answer could be a difficult issue, no time restraints were imposed. The answer ‘No idea’ was allowed.

Retention test

The students were given a retention test around one month after finishing the educational intervention, with identical procedure to the pretest and the posttest. Similarly to the latter, a multiple choice task in order to measure the students’ level of agreement was performed.

COLLES

After the retention test, and just before ending the school term, the students were invited to participate in a survey (COLLES) about their experience in this lesson. It was made clear to them that this task was not a regular (music) school test, but a survey to know their opinion and therefore to improve our teaching. The setting was similar than previous measurements, with each student completing the task with a personal netbook, and paper-and-pencil versions available in case of technical problems. The teacher-researcher would read aloud each question –and would explain it, if needed– before allowing the students to answer them.

3.8 Data handling

3.8.1 Processing

Since the experimental program relied completely on hypermedia, all data were collected in an electronic way, which entailed the following sources:

- Students' scores for the pretest, posttest, and retention test on Moodle
- Students' scores for the educational intervention on Moodle
- Students' scores for the COLLES on Moodle
- Students' drawings on the interactive whiteboard
- Students' drawings on the design tablet

Raw data stored in the Moodle virtual classroom were exported directly in a spreadsheet format (`.ods`), while the students' drawings were saved in a graphic format (`.jpg`).

3.8.2 Analysis

The statistical approach was chosen taking into account the research hypothesis and questions (see Section 1.5 and Figure 3.8 for an overview), as well as the distribution of the dependent variables. Two remarks must be done about the procedure we followed. First, the dependent variable was computed by summing a bunch of variables with a binomial distribution (see Figure 3.3 for an example), and therefore it was non-normally distributed (see Section 3.1.1).

Second, linear models would not be the most ideal device to analyse longitudinal data consisting of multiple observations on the same individual, since "ignoring correlations between repeated observations may lead to invalid inferences about the regression coefficients" (Sheu, 2000, p. 270). Because of this, we used Generalized Estimating Equations (GEE) "as a means of testing hypotheses regarding the influence of factors on binary and other exponentially [...] distributed response variables collected within subjects across time" (Ballinger, 2004, p. 130). Calculations were performed by means of the function `gglm` in the R package `geepack` (Halekoh, Højsgaard, & Yan, 2006) with the following settings:

Link function Logarithm of the mean, which is the most appropriate when "counted data are being modeled with Poisson regression" (Ballinger, 2004, p. 131).

Distribution Poisson, which is "typically used for count data" (Zuur, Ieno, Walker, Saveliev, & Smith, 2009, p. 198), and "might be used as pseudo distribution if the true distribution is binomial" (Ziegler, 2011, p. 53).

Correlation structure Autoregressive, that "can be used for any data set in which there is a time order" (Zuur et al., 2009, p. 307).

The following is a summarized restatement of the research hypothesis and questions, with the statistical techniques applying.

To evaluate the overall effect of the educational intervention (H1), and its lasting effect (H2), a GEE analysis of variance was performed with group (E vs. C), and time (Pretest vs. Posttest vs. Retention test) as the independent variables, and with the count of more appropriate answers on each separate test as the dependent variable.

As far as H3 is concerned, to evaluate the students' perception of the learning environment, a χ^2 test was performed so as to compare the students' scores on the COLLES in the E group and the C group, since other statistical procedures involving "the mean (and standard deviation) are inappropriate for ordinal data, where the numbers generally represent verbal statements" (Jamieson, 2004, p. 1217). Calculations were performed for each of the six blocks of questions, and for the COLLES as a whole.

With respect to Q1, we analyzed whether the aforementioned general effects of the educational intervention were found to the same extent for different musical experience levels. To this respect, a GEE analysis of variance was performed with group (E vs. C), musical experience (High experienced vs. Medium experienced vs. Low experienced), and time (Pretest vs. Posttest vs. Retention test) as the independent variables, and with the count of more appropriate answers on each separate test as the dependent variable, for each experimental condition. Subsequently, pairwise comparisons were performed between the three music experience levels for each time combination (Pretest vs. Posttest, Pretest vs. Retention test, Posttest vs. Retention test).

As for Q2, so as to evaluate the effect of the educational intervention for the six representational criteria, a GEE analysis of variance was performed with group (E vs. C), representational criterion (Correctness vs. Completeness vs. Transparency vs. Formality vs. Parsimony vs. Beauty), and time (Pretest vs. Posttest vs. Retention test) as the independent variables, and with the count of more appropriate answers on each separate test for each separate criterion as the dependent variable. Subsequently, pairwise comparisons were performed between the six representational criteria for each time

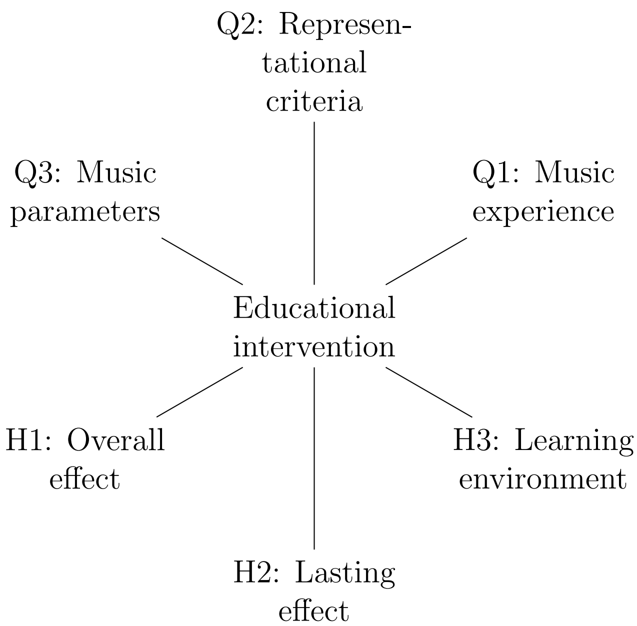

Figure 3.8: Hypotheses and questions overview.

combination (Pretest vs. Posttest, Pretest vs. Retention test, Posttest vs. Retention test).

Finally, in order to evaluate the effect of the experimental program for the three music parameters, as addressed in Q3, a GEE analysis of variance was performed with group (E vs. C), music parameter (Pitch vs. Duration vs. Loudness), and time (Pretest vs. Posttest vs. Retention test) as the independent variables, and with the count of more appropriate answers on each separate test for each separate music parameter as the dependent variable. Subsequently, pairwise comparisons were performed between the three music parameters for each time combination (Pretest vs. Posttest, Pretest vs. Retention test, Posttest vs. Retention test). Additionally, we analyzed whether the students' aural discrimination, as measured by means of MAT, could be influencing the results reported in this section. So as to get a better insight into this, we computed Pearson correlations between the MAT students' scores and the above dependent variable for each test.

3.9 Summary

This study was designed as a replication of a previous pilot study so as to test hypotheses regarding the extent to which an educational intervention would improve the students' MRC in the domain of music, as measured after and before that intervention took place. Despite the educational setting where the study was carried out, stratified random sampling was possible without altering the students' allocation into classes, by means of a hypermedia learning environment. As such, both the instruments and the materials were either administered or presented to students in an electronic format, through a virtual classroom. Despite ethical concerns because of the dual role teacher-researcher, ethical standards were complied with. Finally, the statistical procedures were chosen according to the hypotheses and questions, as well as to the distribution of the dependent variables.

Chapter 4

Data analysis and results

4.1 Introduction

The purpose of this study was to examine the effects of a hypermedia learning environment on middle school students' MRC in the domain of music. Particularly, we aimed at determining whether an educational intervention –namely, the implementation of the aforementioned learning environment– influenced the accuracy with which middle school students ($n = 41$) matched sound (sonic fragments) to symbol (graphic representations). We hypothesized (H_1) that the experimental program would have a positive overall effect on the students' MRC, and that such effect would be lasting. We also predicted that the experimental group students would have a more positive perception of the learning environment. In addition, we inquired into the effectiveness of the educational intervention for participants with different levels of musical experience, as well as into the partial effect for six representational criteria and three music parameters.

This chapter presents the research findings related to the above hypotheses and research questions. As such, it is comprised of two main parts, namely a descriptive analysis and an inferential analysis. The former section includes a description of the sample, and accounts for both the music experience questionnaire, and the distribution of the variables involved in the hypotheses. The latter section addresses the hypotheses and the research questions, according to their order of appearance in Section 1.5 and Section 3.8. The statistical analyses were performed by means of R version 3.1.0 (2014-04-10) – “Spring Dance” (R Core Team, 2014).

4.2 Descriptive analysis

4.2.1 Sample

The analysed sample ($N = 75$) consisted of 36 boys (48%) and 39 girls (52%), who were randomly allocated to the experimental group ($n = 41$) and the control group ($n = 34$). According to the Music Experience Questionnaire (MEQ) scores, they were distributed into three levels of music experience, as shown in Table 4.1 and Figure 4.1.

Music experience	Experimental group		Control group		Total
	Boys	Girls	Boys	Girls	
High	5	2	3	4	14
Medium	8	6	8	4	26
Low	7	13	5	10	35
Total	20	21	16	18	75

Table 4.1: Number of students by gender, treatment, and music experience level.

There were no significant differences between the experimental (E) and the control (C) groups with respect to gender ($\chi^2 = .02, df = 1, p = .882$) and music experience level ($\chi^2 = .22, df = 2, p = .897$).

4.2.2 Music experience questionnaire

The Music experience questionnaire (MEQ) consisted of five sets of closed questions (see Section 3.5.1 and Appendix A.2). Sets 1 and 2, namely ‘Music instruments’ and ‘Music groups’, focused on general skills as demonstrated by instrumental playing. With respect to Set 1, Figure 4.2 is clearly scored to the left, what means that the participants rarely played music instruments, with the outstanding exception of the boys playing stringed instruments (17%). This choice must be understood as boys playing (electric) guitar. A Fisher's Exact Test for Count Data yielded significant differences between boys and girls ($p = .008$).

As to Set 2, the participation in music groups was very low (Figure 4.3), with no significant differences between boys and girls ($p = .755$). It is noteworthy that the 6% of boys admitted to participate in a choral several times a day. To this respect, it must be said that "*Flamenco* song" was accepted as a valid response to this item, and therefore some students who were keen on this musical style marked this answer.

Set 3, on self-definition, was designed to measure self-awareness of musical ability. As a rule, the students scored themselves as having a low music ability. It must be highlighted that the higher marks, irrespective of gender, went to items not entailing the use of music scores, namely 'playing by ear', and 'improvising music'. There were significant differences between boys and

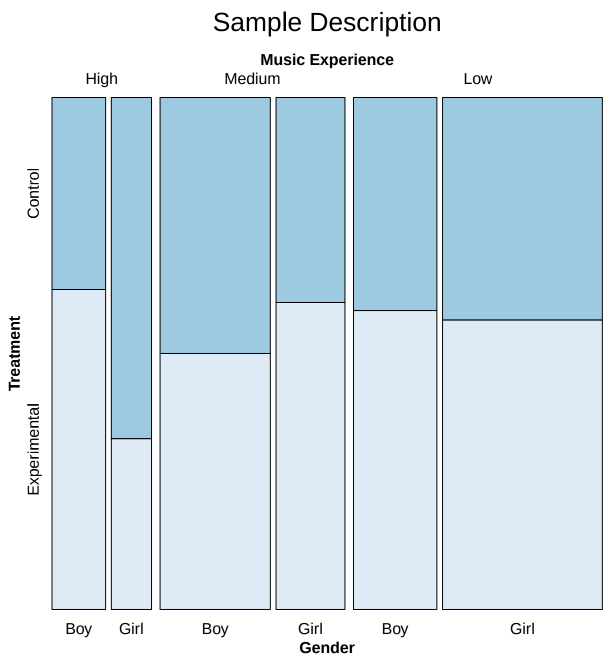

Figure 4.1: Relationship between gender, treatment, and music experience level.

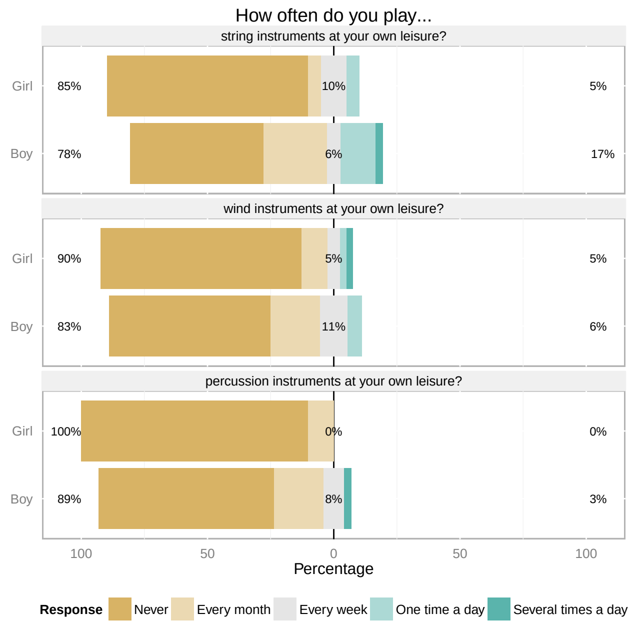

Figure 4.2: Responses on the MEQ' subscale 'Music Instruments'.

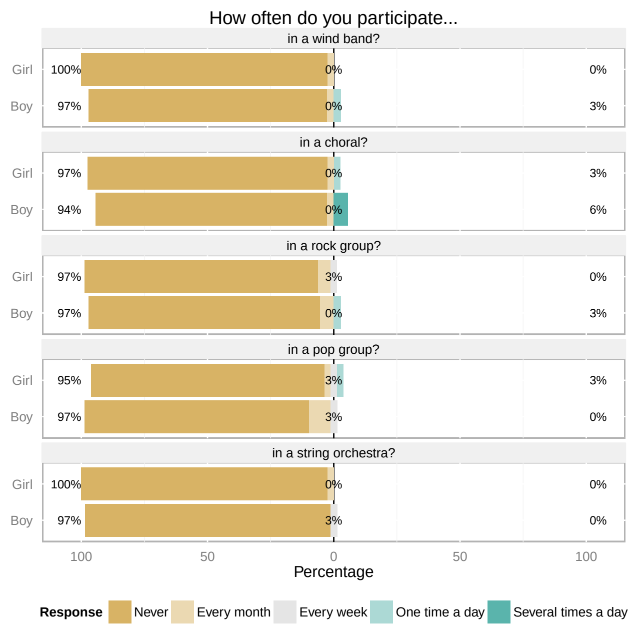

Figure 4.3: Responses on the MEQ' subscale 'Music Groups'.

girls ($\chi^2 = 9.76, df = 4, p = .045$).

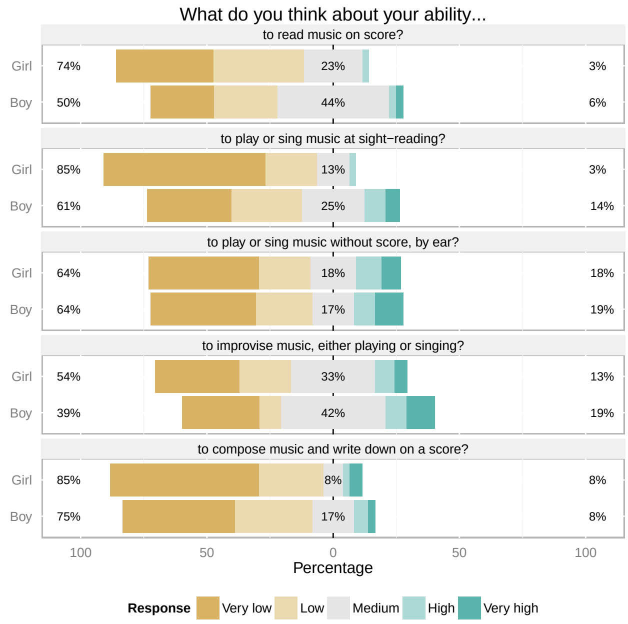

Figure 4.4: Responses on the MEQ' subscale 'Music Skills'.

Set 4 asked for information on formal music training, which proved to be almost lacking, with no significant differences between boys and girls ($p = .360$). Figure 4.5 shows that only a small percentage of girls were attending music lessons when they were asked.

Finally, Set 5 asked about the students' listening habits. Figure 4.6 shows clearly a preference for modern music, namely pop, rock, and techno, as one could expect with teenagers. There were significant differences between boys and girls ($\chi^2 = 10.02, df = 4, p = .040$).

4.2.3 Drawing task

During the educational intervention (see Section 3.7), the students performed a two-fold task in which they were requested to represent a sound fragment (Session 6) and subsequently to evaluate 20 drawings randomly selected from their classmates' representations (Session 8). According to diSessa's frame-

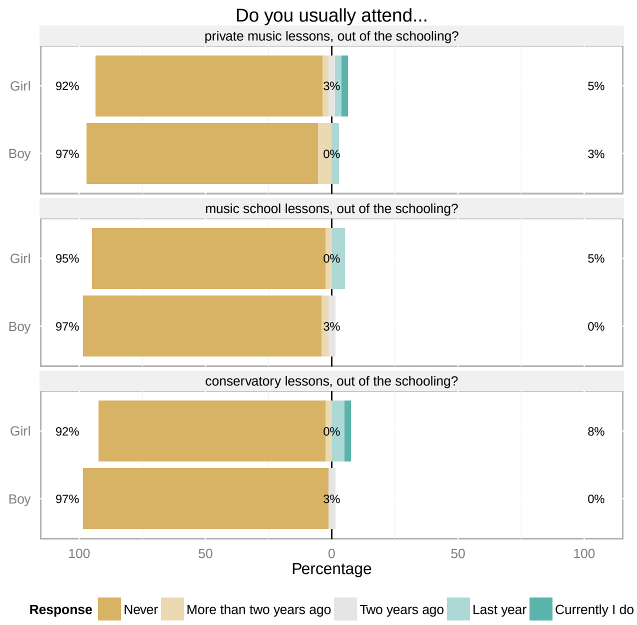

Figure 4.5: Responses on the MEQ' subscale 'Music Training'.

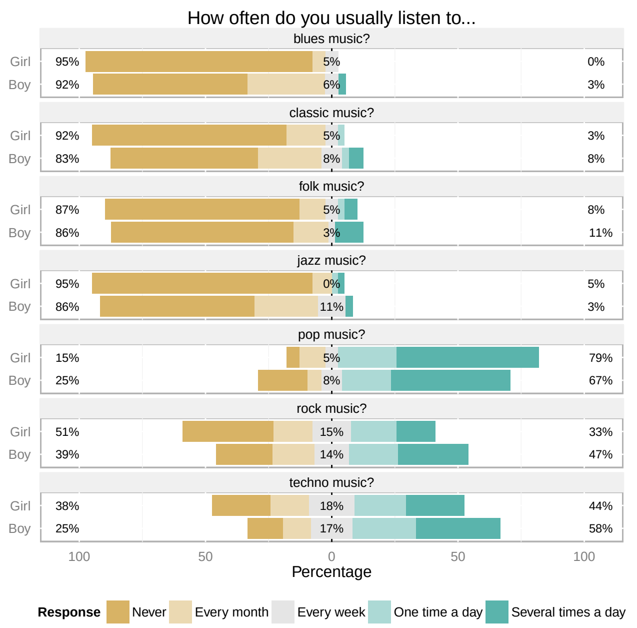

Figure 4.6: Responses on the MEQ' subscale 'Listening Habits'.

work (diSessa, 2002, p. 107), the former task is linked to *constructive resources*, while the latter one is related to *critical capabilities* (see Section 1.3 for a description).

As an example, Figure 4.7 shows some of the students' drawings representing the sound fragment (see Appendix B.11 for the complete set).

Experimental group	Control group

Figure 4.7: Some students' representations on the design tablet.

Some common traits can be drawn from these representations. First, the students used mainly a regular black stroke, despite having been taught how to change both the colour and the stroke shape on the drawing tablet. Second, the unfolding of the sound fragment was mainly represented in a left-to-right horizontal axis. Third, the most of the drawings followed the starting point of the sound fragment, with crotchets at the beginning and semiquavers at the end (see Figure 3.7), and only a few started by representing semiquavers in first place. Overall, there were no self-explanatory differences between the E group and the C group as far constructive resources is concerned.

Regarding critical capabilities, an item analysis was performed so as to obtain the *facility index* of the selected 20 drawings according to the treatment. This coefficient ranges from 0 to 1, so "[t]he larger the value of the index is, the *easier* the item" (Ebel & Frisbie, 1991, p. 228). Figure 4.8 shows that the experimental group outperformed the control group in all cases, what means that the students allocated to the former group found easier to answer the multiple choice test than the students allocated to the latter group. In addition, the distance between groups' indices remained quite parallel, as the linear regression line indicates.

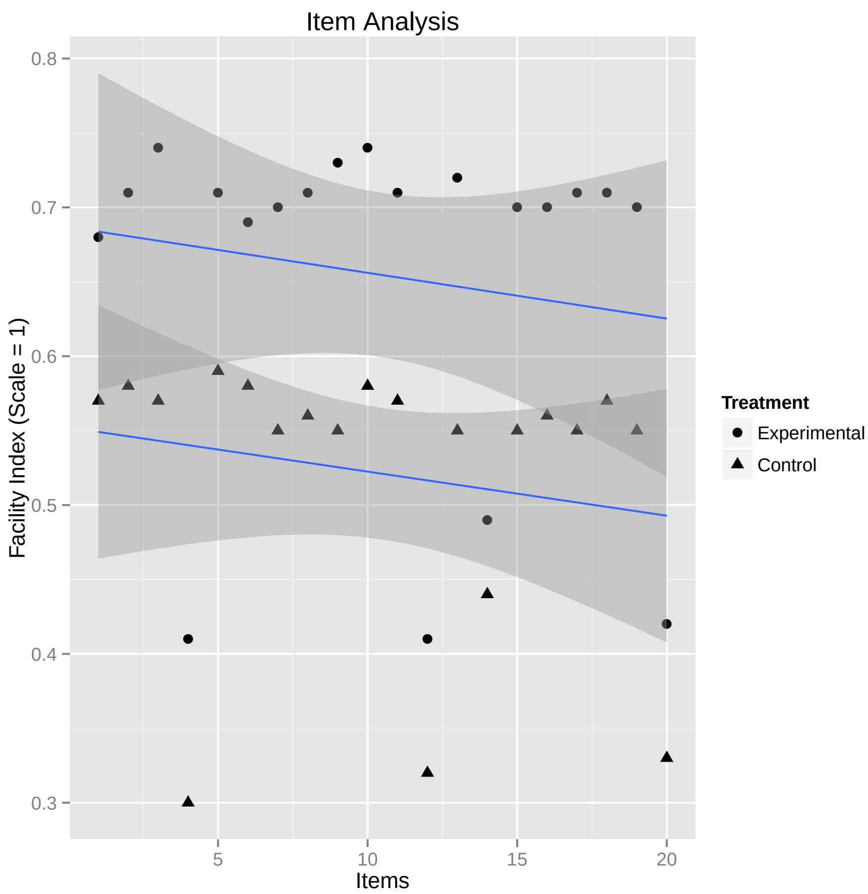

Figure 4.8: Item analysis (Facility index).

4.2.4 Dependent variables

We have referred elsewhere to how the dependent variables were distributed (see Section 3.1.1 and Section 3.8). As a prerequisite before dealing with any statistical analysis, we performed normality tests in order to confirm whether they followed a gaussian distribution. Given our sample size ($N > 30$), we chose the Lilliefors (Kolmogorov-Smirnov) normality test, which revealed that the count of more appropriate answers on each separate test was non-normally distributed ($D = .12, p = .000$).

A Poisson regression was used in order to model this variable by means of the function `glm`. Deviance residuals were normally distributed ($D = .25, p = .401$), which showed that the model was likely to be properly specified. In turn, we used the residual deviance to perform a goodness-of-fit test for the overall model (see Appendix C.1 for the R output). We concluded that the model fitted reasonably well because the goodness-of-fit χ^2 test was not statistically significant ($res.deviance = 75.64, df = 219, p = 1$).

A further analysis on this variable revealed the presence of outliers spread on the three tests in both the E group and the C group (see Figure 4.9). According to our previous statement about respect for students' individual differences and inclusive education (see Section 1.1), none of them were removed from the sample.

4.3 Inferential analysis

4.3.1 Overall and lasting effect

Our first hypothesis (H_1) was that the educational intervention would have a positive overall effect on the students' MRC. We predicted a significant increase in the number of more appropriate answers from pretest to posttest for the E group, who received an educational intervention. For the C group, who did not receive this intervention, no significant increase from pretest to posttest was expected. The second hypothesis was that the positive effect of the E program would be lasting. As such, we predicted that the expected significant difference in the number of more appropriate answers in favour of the E group would not disappear in a retention test.

With respect to Hypothesis 1, the GEE analysis revealed significant differences between the pretest and the posttest, irrespective of the treatment (Wald $\chi^2(2) = 29.588, p = .000$). That result means that both the E group and the C group benefited from the educational intervention, what is at odds with our prediction of obtaining worse scores in the C group. Therefore our Hypothesis 1 was only partially supported.

As to Hypothesis 2, Figure 4.10 presents the mean scores and the 95%

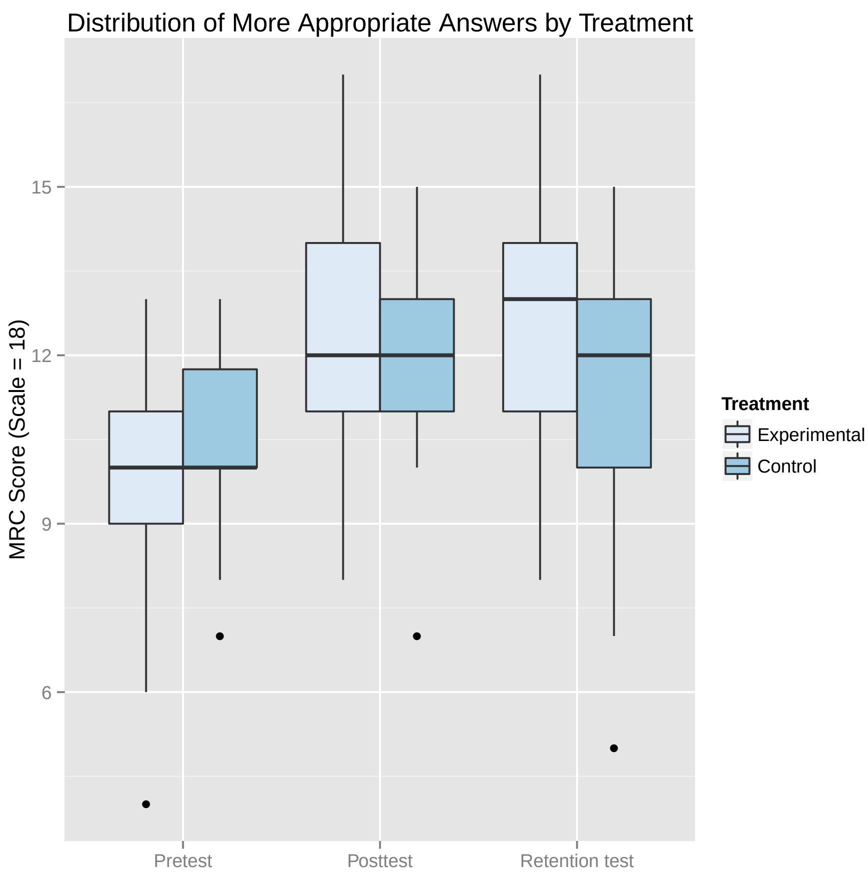

Figure 4.9: Distribution of the count of more appropriate answers on the three test moments by treatment. Outliers are included.

confidence intervals of the students from the E group and the C group on the three tests. Although the C group yielded slightly better results than the E group in the pretest, the latter outperformed the former during the posttest, and this difference in favour of the E group continued to exist on the retention test, while the C group scored lower (see Table 4.2). Therefore Hypothesis 2 was accepted.

Taking everything into account, the most remarkable outcome was the overall effect between the pretest and the retention test (Wald $\chi^2(2) = 5.025, p = .025$), which proved to be significant because of the treatment. Such a result suggests that the intervention would be effective, since it combines the positive effect predicted in Hypothesis 1, and the lasting effect expected in Hypothesis 2 (see Appendix C.2.1 for the R output).

Treatment	Time	M	NM	SD	SE	CI
Experimental ($n = 41$)	Pretest	10.00	9.85	2.45	.38	.77
	Posttest	12.51	12.36	2.50	.39	.79
	Retention test	12.44	12.29	2.61	.41	.82
Control ($n = 34$)	Pretest	10.41	10.59	1.71	.29	.60
	Posttest	12.15	12.33	2.05	.35	.71
	Retention test	11.41	11.59	2.75	.47	.96

Table 4.2: Summary of overall data: Mean (M), normed mean (NM), standard deviation (SD), standard error of the mean (SE), and 95% confidence interval (CI) 95%.

4.3.2 Students' perception of the learning environment

As far as Hypothesis 3 is concerned, we predicted that the students allocated to the E group would assess the learning environment in a more positive way than the students allocated to the C group, as evidenced by their responses to a Constructivist On-Line Learning Environment Survey (COLLES). The instrument consisted of six blocks, namely Relevance, Reflection, Interactivity, Tutor support, Peer support, and Interpretation. Each block comprised four Likert-type questions (see Section 3.5.3 and Appendix A.9 for an overview).

Block 1 asked the students about the relevance of online learning to their practices. Since we used a version of the COLLES as released in Moodle 1.9, and the items could not be adapted to our particular educational setting, the students were told that 'my professional practice', as stated in this section, stood for 'my education'. Figure 4.11 shows that the contents of the unit hardly interested the students (32% and 21% of the students belonging to the E group and C group, respectively, had an opinion more positive than neutral). It is noteworthy that more than a half of the E group students (54%) considered that they had learned how to improve their education. The

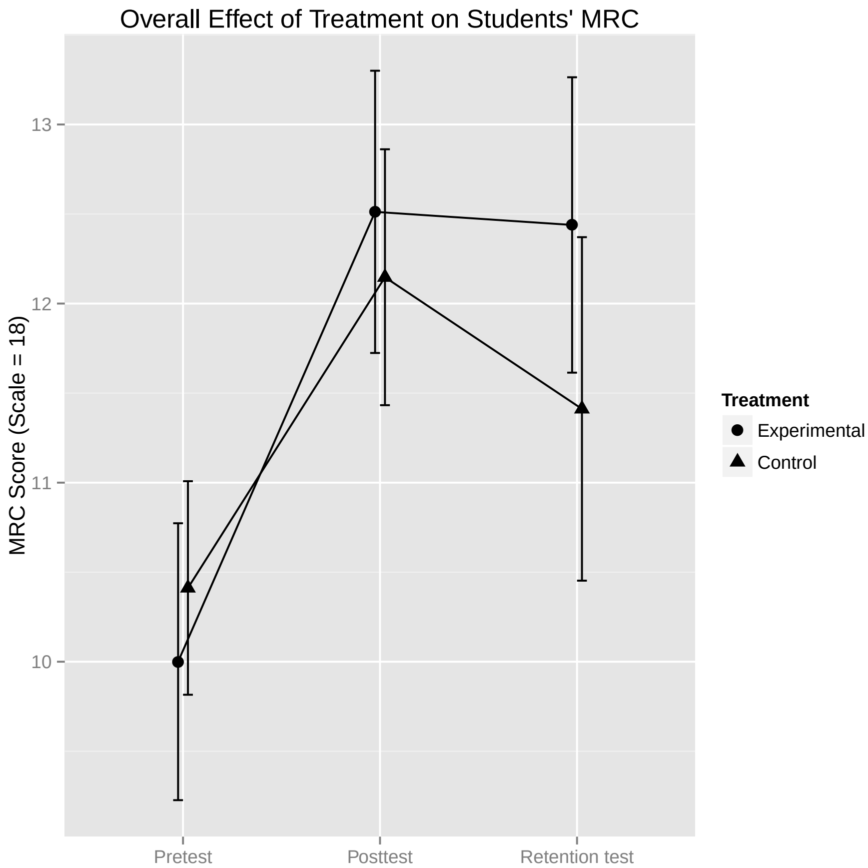

Figure 4.10: Mean scores and 95% confidence interval on the three tests by treatment.

E group scored slightly better than the C group, but significant differences between them were not found ($\chi^2 = 2.64, df = 4, p = .620$).

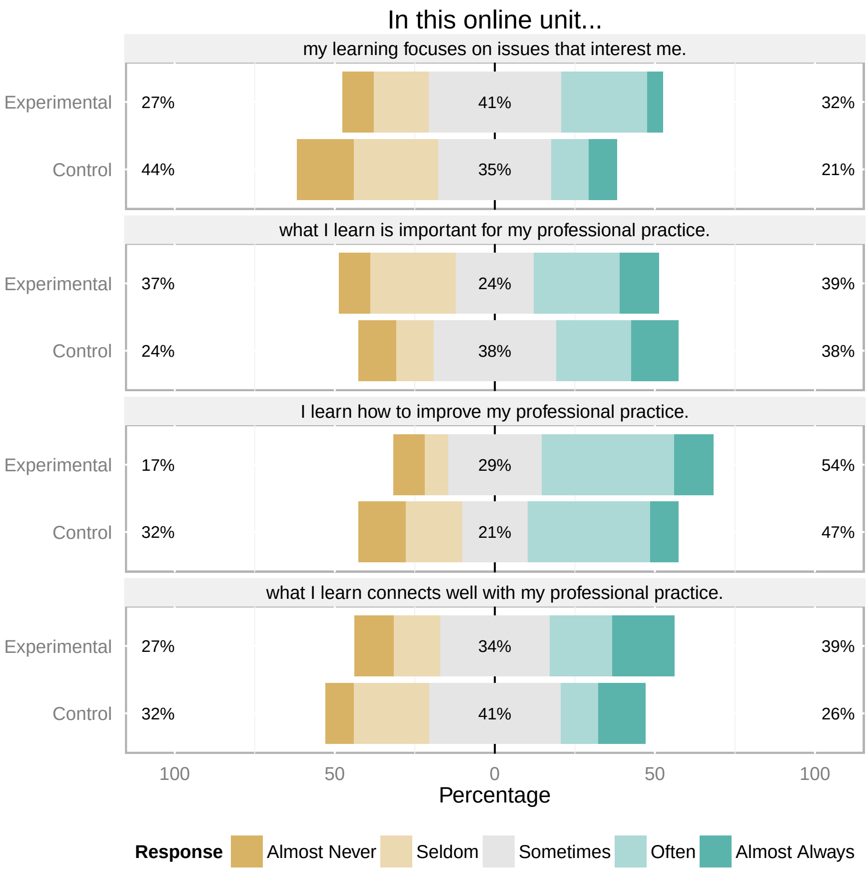

Figure 4.11: Responses on the COLLES' subscale 'Relevance'.

Block 2 accounted for whether online learning stimulated students' critical reflective thinking (see Figure 4.12). Two outstanding results from the C group students deserve attention: first, a half of them admitted scarcely thinking critically about their learning. Second, this percentage even increased to more than two thirds of them (68%) when thinking about other students' ideas. The E group students scored better as to thinking critically about their own ideas (44%), while both groups scored similar with respect to thinking critically about ideas in the readings. Overall, there were significant differences between the E group and the C group ($\chi^2 = 14.24, df = 4, p = .007$).

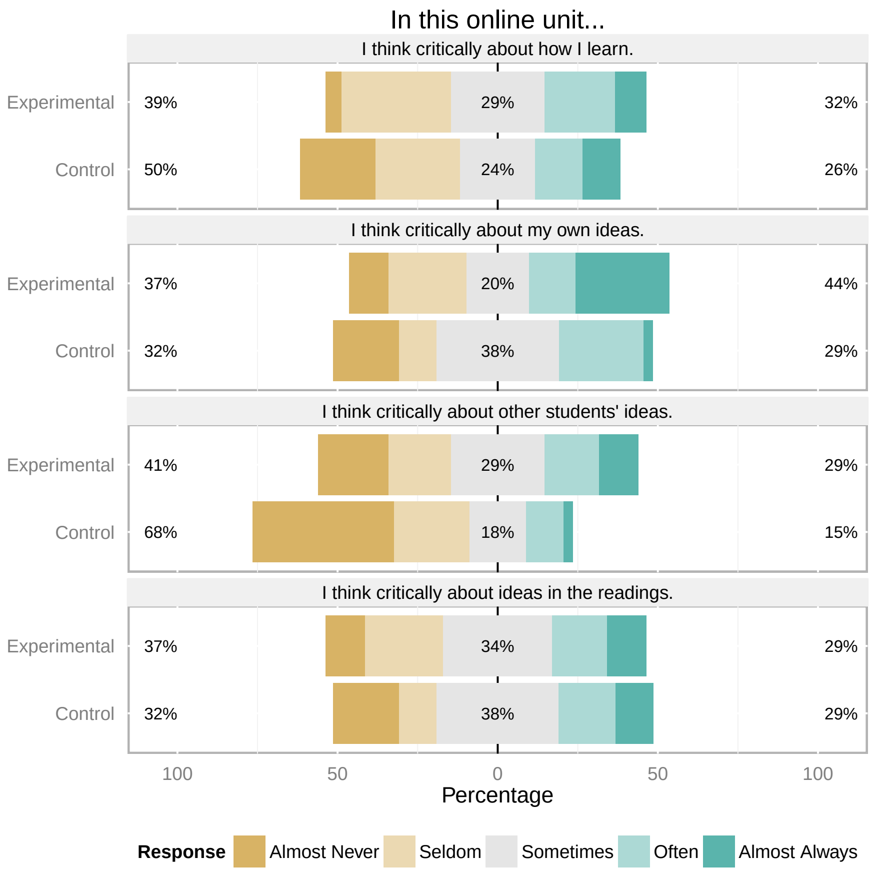

Figure 4.12: Responses on the COLLES' subscale 'Reflective Thinking'.

Block 3 dealt with the students' exchange of ideas by means of an online learning environment (see Figure 4.13). Despite the E group students scored slightly better than the C group students, the percentages of exchange were rather low, as one could expect, since the Moodle unit was not designed to enhance such exchange. There were no significant differences between the treatment groups ($\chi^2 = 5.73, df = 4, p = .220$).

Block 4 asked the students about the role of the tutor (teacher) to enable students to participate in online learning. Broadly speaking, that role was widely acknowledged, as shown in Figure 4.14. Overall, there were significant differences between the E group and the C group ($\chi^2 = 10.78, df = 4, p = .029$).

Block 5 accounted for the role of fellow students to encourage and support their peers in online learning. Figure 4.15 shows that the scores are low, on the whole, which is related to the above results for Block 3. As stated above, this online unit was not designed to enhance the students' exchange of information, what entails that there was no way for the students to encourage, praise, or value each other. There were no significant differences between the treatment groups ($\chi^2 = 4.42, df = 4, p = .352$)

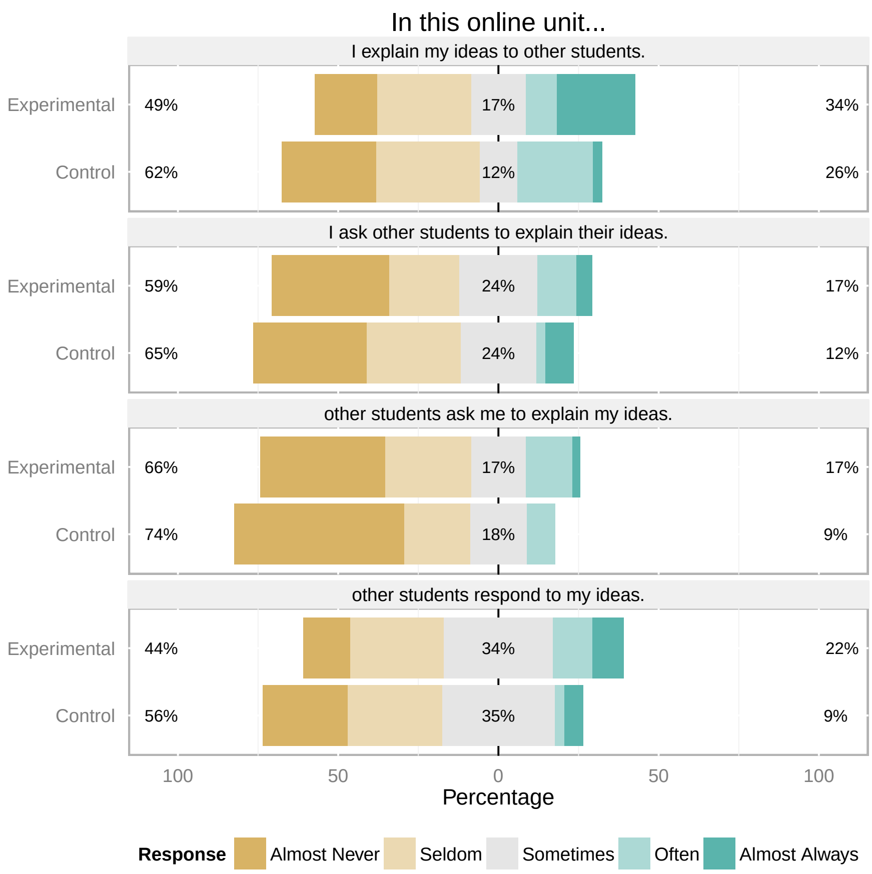

Figure 4.13: Responses on the COLLES' subscale 'Interactivity'.

Finally, block 6 dealt with making sense of the students and teacher online communications. Figure 4.16 shows that scores for items 1 and 3 are better than those for items 2 and 4. These results are foreseeable, since the former are related to what the students experience –and therefore they can opine about it–, while the latter are related to what others think about one's messages –and that is hard to know, and therefore to answer. It is noteworthy that about two third parts of both the C group (65%) and the E group (61%) admitted making good sense of the teacher's messages. There were no significant differences between the treatment groups ($\chi^2 = 2.24, df = 4, p = .691$).

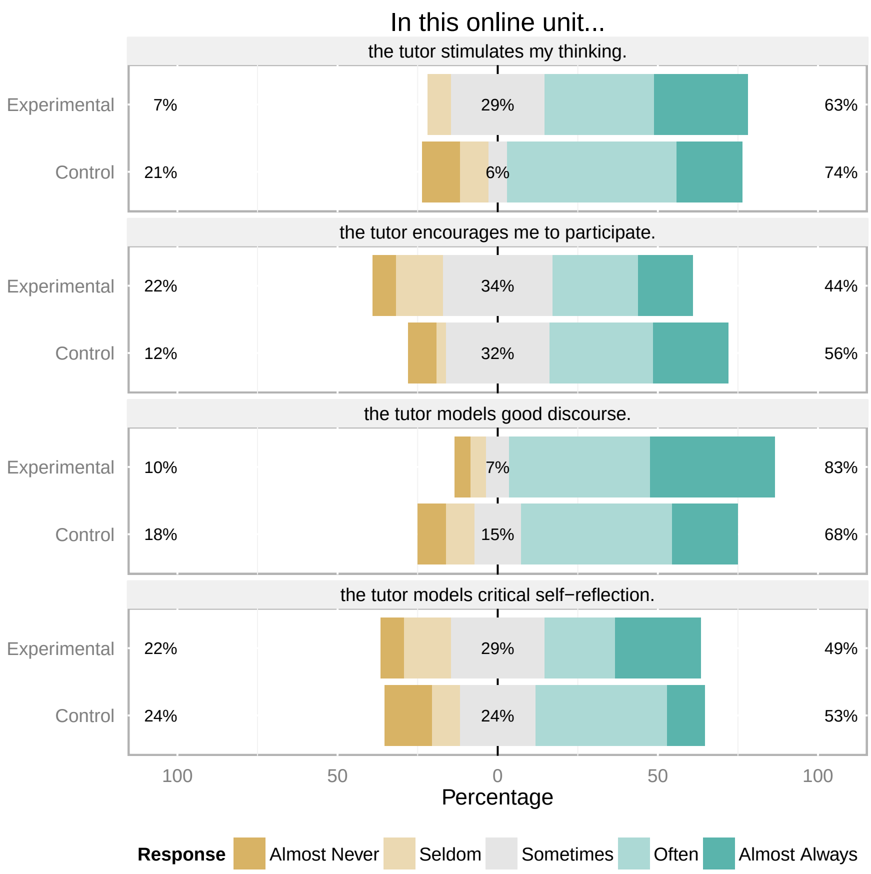

Figure 4.14: Responses on the COLLES' subscale 'Tutor Support'.

Besides each separate block, we also computed an overall effect of the treatment on the COLLES as a whole, which yielded a significant difference between the E group and the C group ($\chi^2 = 16.45, df = 4, p = .002$). Therefore Hypothesis 3 was supported.

4.3.3 Influence of music experience

In order to answer Question 1, we analyzed whether the aforementioned overall effect of the educational intervention was found to the same extent for the different music experience levels. To make this analysis possible, every

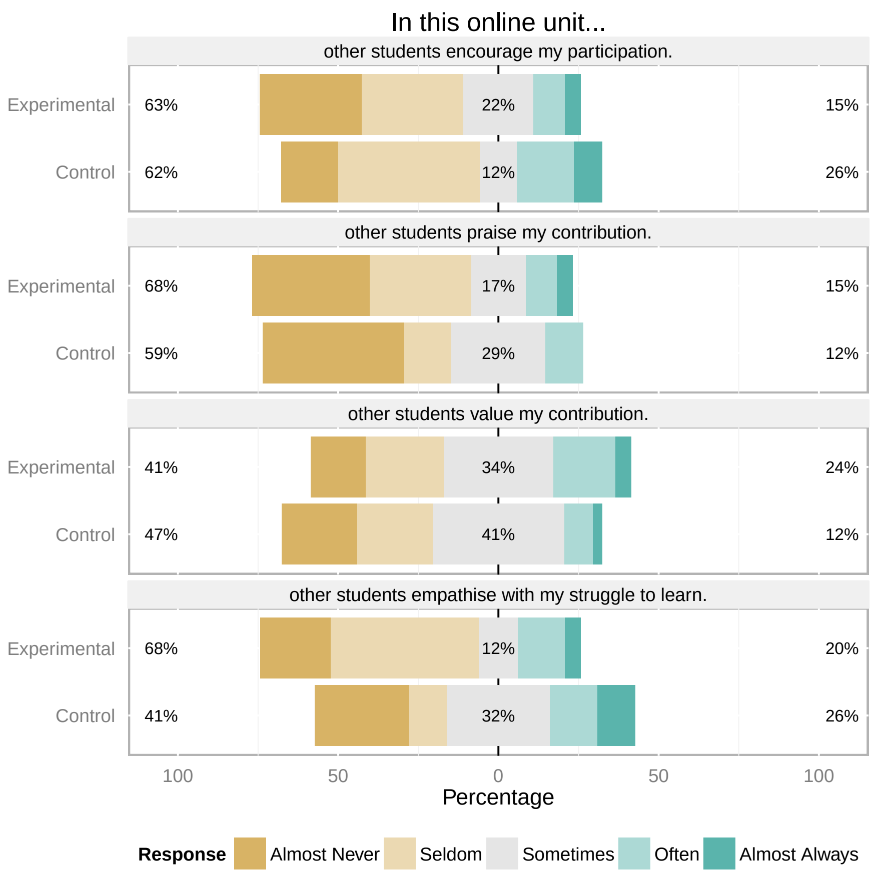

Figure 4.15: Responses on the COLLES' subscale 'Peer Support'.

student from the E group and the C group was put into a 'high-experienced', 'medium-experienced', or 'low-experienced' group based on their scores on the MEQ (see Section 3.2 for a description of how the students were allocated to each level, and Section 3.5.1 for a description of the instrument).

A GEE analysis with the factors treatment (E vs. C), time (Pretest vs. Posttest vs. Retention test), and music experience (High experienced vs. Medium experienced vs. Low experienced) treated as independent variables, and the number of more appropriate answers as the dependent variable revealed no significant triple interaction. The only significant outcome attributed to the treatment was the improvement between the pretest and

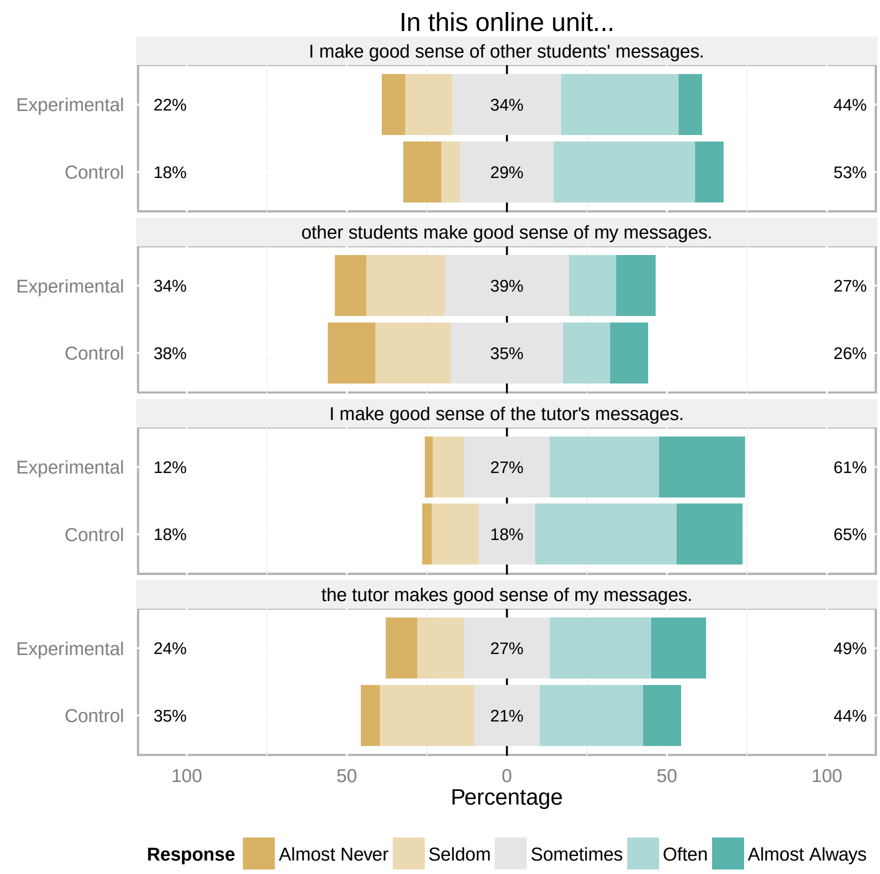

Figure 4.16: Responses on the COLLES' subscale 'Interpretation'.

the posttest for the low-experienced students (Wald $\chi^2 = 4.34, p = .037$). Significant differences were found between the pretest and the retention test, irrespective of the treatment, for the high-experienced students (Wald $\chi^2 = 7.330, p = .007$), as well as the medium-experienced students (Wald $\chi^2 = 4.42, p = .035$), and the low experienced students (Wald $\chi^2 = 14.61, p = .000$). This result suggests that all three levels contributed to the aforementioned treatment x test interaction effect as presented in Figure 4.10. In other words, the educational intervention resulted not only in a significant increase in the MRC of the high-experienced and medium-experienced students, but also of those of low experience (see Figure 4.17 and Table 4.3).

In addition, pairwise comparisons between levels of music expertise revealed significant differences between the high-experienced students and the low-experienced students, irrespective of the treatment, between the pretest and the posttest (Wald $\chi^2 = 4.099, p = .043$), and between the posttest and the retention test (Wald $\chi^2 = 6.023, p = .014$). The complete R output is shown in Appendix C.2.2.

4.3.4 Partial effects for each representational criterion

As to Question 2, we explored the extent to which the aforementioned overall effect of the educational intervention was found to the same degree for the different representational criteria. A GEE analysis with the factors treatment (E vs. C), time (Pretest vs. Posttest vs. Retention test), and representational criteria (Correctness vs. Completeness vs. Transparency vs. Formality vs. Parsimony vs. Beauty) as independent variables, and the number of more appropriate answers as the dependent variable revealed that the only significant outcome because of the treatment was the difference between the pretest and the retention test for the criteria 'Formality' (Wald $\chi^2 = 5.16, p = .023$) and 'Parsimony' (Wald $\chi^2 = 6.14, p = .013$). With respect to the rest of criteria, both treatment groups followed a similar pattern, with scores moving quite parallel, therefore any effect may be attributed to the scaffolding that the E group students received (see Table 4.4 and Figure 4.18).

Additionally, pairwise comparisons showed widespread significant differ-

Treatment	Music experience	Time	M	NM	SD	SE	CI
Experimental	High ($n = 7$)	Pretest	10.43	10.31	1.56	.59	1.44
		Posttest	11.57	11.45	2.33	.88	2.15
		R. test	12.86	12.74	2.49	.94	2.31
	Medium ($n = 14$)	Pretest	10.36	10.17	2.52	.67	1.46
		Posttest	12.43	12.24	2.75	.73	1.59
		R. test	12.29	12.10	2.82	.75	1.63
	Low ($n = 20$)	Pretest	9.60	9.47	2.65	.59	1.24
		Posttest	12.90	12.77	2.35	.52	1.10
		R. test	12.40	12.27	2.62	.59	1.23
Control	High ($n = 7$)	Pretest	10.29	10.55	.60	.23	.55
		Posttest	11.57	11.84	2.63	.99	2.43
		R. test	11.86	12.12	2.05	.78	1.90
	Medium ($n = 12$)	Pretest	10.25	10.53	1.74	.50	1.11
		Posttest	12.67	12.95	2.04	.59	1.30
		R. test	10.75	11.03	2.03	.59	1.29
	Low ($n = 15$)	Pretest	10.60	10.66	2.06	.53	1.14
		Posttest	12.00	12.06	1.73	.45	.96
		R. test	11.73	11.79	3.45	.89	1.91

Table 4.3: Summary of partial data for each music experience level: Mean (M), normed mean (NM), standard deviation (SD), standard error of the mean (SE), and confidence interval (CI) 95%.

ences between the six representational criteria, irrespective of the treatment, with the only exception of the couple 'Correctness-Beauty'. Several significant triple interactions were also found (see Table 4.5 (*)). As a rule, differences were present between all measurements, with only a few exceptions. The complete R output is shown in Appendix C.2.3.

4.3.5 Partial effects for each musical parameter

Finally, we addressed Question 3 about the partial effect of the educational intervention for the three music parameters. A GEE analysis with the factors treatment (E vs. C), time (Pretest vs. Posttest vs. Retention test), and music parameter (Pitch vs. Duration vs. Loudness) taken as independent variables, and the number of more appropriate answers as the dependent variable revealed no significant triple interaction. Significant differences were found for the music parameter 'Pitch', because of the treatment, between the pretest and the posttest (Wald $\chi^2 = 4.158, p = .041$), and between the pretest and the retention test (Wald $\chi^2 = 6.134, p = .013$). As to 'Duration', despite the C group yielded slightly better results than the E group in the pretest, the latter outperformed the former during the posttest, and this difference in favour of the E group even increased on the retention test, while the C group scored lower. Finally, the scores for 'Loudness' were quite parallel for both treatment groups (see Table 4.6 and Figure 4.19).

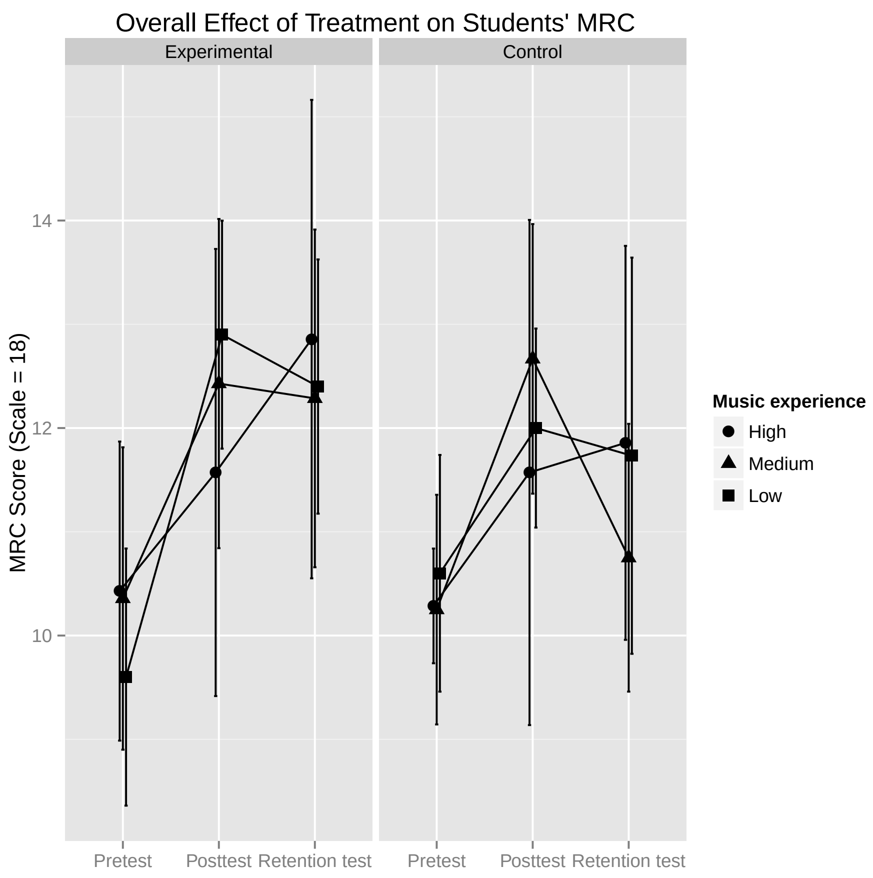

Figure 4.17: Mean scores and 95% confidence interval for the three experience levels on the three test moments by treatment.

In addition, pairwise comparisons between the music parameters revealed significant differences between 'Pitch' and 'Duration', irrespective of the treatment, between the pretest and the posttest (Wald $\chi^2 = 26.395, p = .000$), and between the posttest and the retention test (Wald $\chi^2 = 13.764, p = .000$); as well as between 'Pitch' and 'Loudness', irrespective of the treatment, between the pretest and the posttest (Wald $\chi^2 = 5.191, p = .023$). The complete R output is shown in Appendix C.2.4.

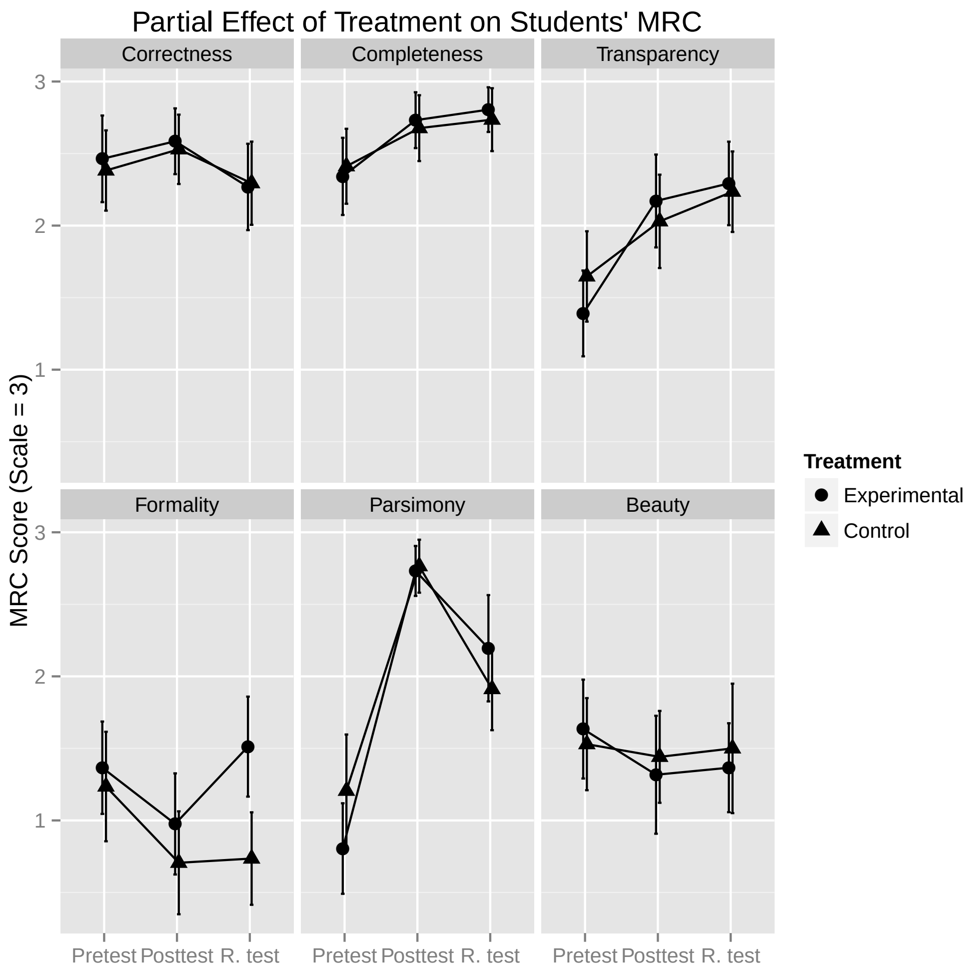

Figure 4.18: Mean scores and 95% confidence interval for the six representational criteria on the three test moments by treatment.

Finally, we calculated Pearson correlations between the Music Aptitude Test (MAT) students' scores and the number of more appropriate answers related to each music parameter for each test. Results revealed no strong association between these variables, as shown in Figures 4.20, 4.21, and 4.22. Even in the few cases where that association was significant, the ρ value was rather small so as to explain the results on the tests because of the students' aural discrimination, as measured by means of MAT (see Table 4.7).

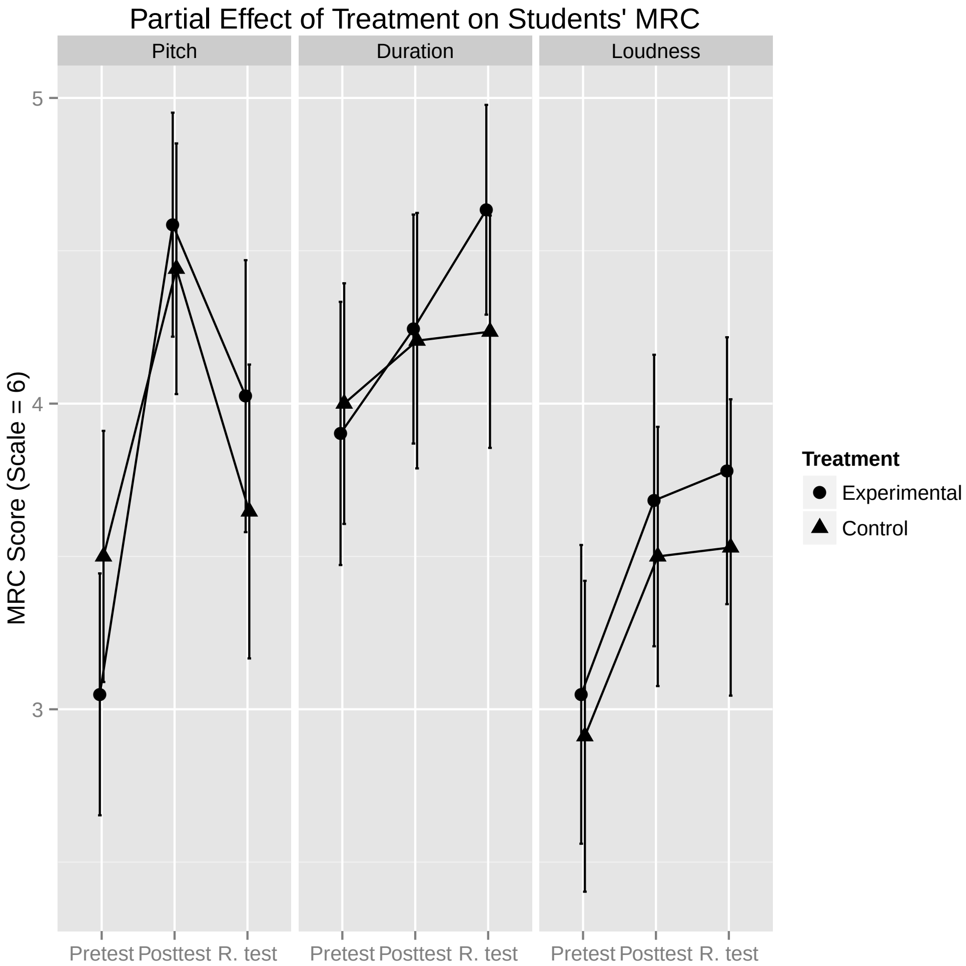

Figure 4.19: Mean scores and 95% confidence interval for the three music parameters on the three test moments by treatment.

4.4 Summary

This section showed the extent to which an educational intervention influenced the accuracy with which middle school students ($n = 41$) matched sounds (sonic fragments) to symbols (graphic representations). We hypothesized that the experimental program would have a positive overall effect on the students' MRC, which was partially supported, since such positive effect happened irrespective of the treatment. We also predicted a lasting effect of the intervention for the students who received scaffolding during the inter-

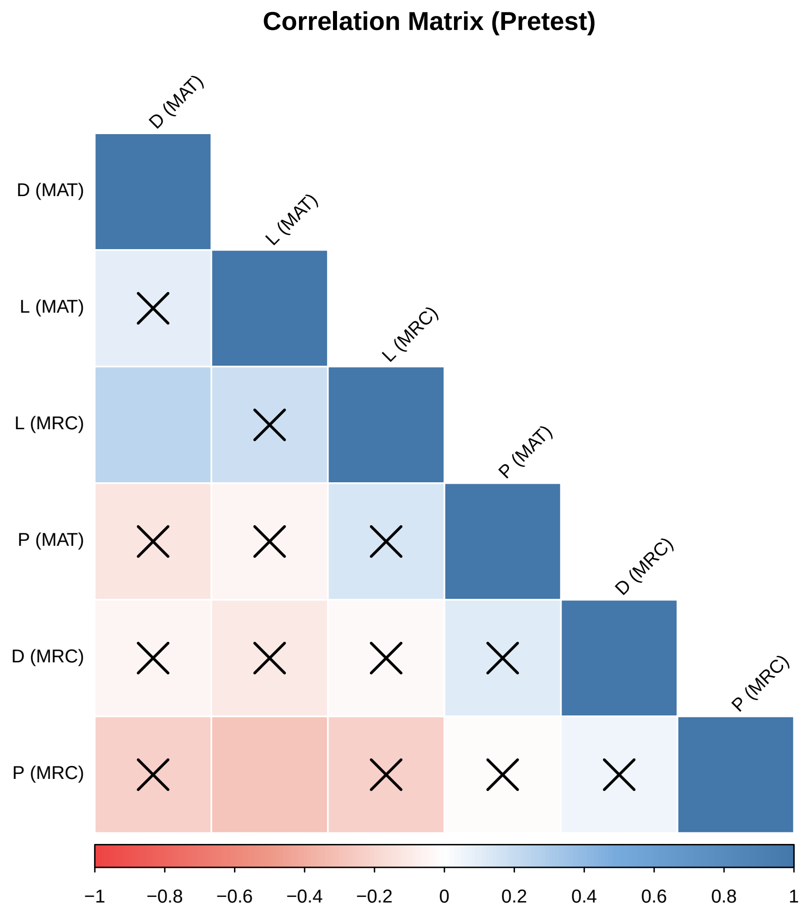

Figure 4.20: Correlation matrix between the MAT students' scores and the MRC measurements on the pretest (P = Pitch; D = Duration; L = Loudness). A cross means no significance.

vention, and that finding was confirmed. The most remarkable outcome was the overall effect of the experimental program as a whole, which proved to be significant as a consequence of the treatment.

As to the students' perception of the learning environment, the students allocated to the experimental condition overall scored their experience with the lesson in a more positive way, despite this trend was not confirmed for all the subscales of the survey. In addition, we inquired into the effectiveness of the treatment for participants with different levels of musical experience, as

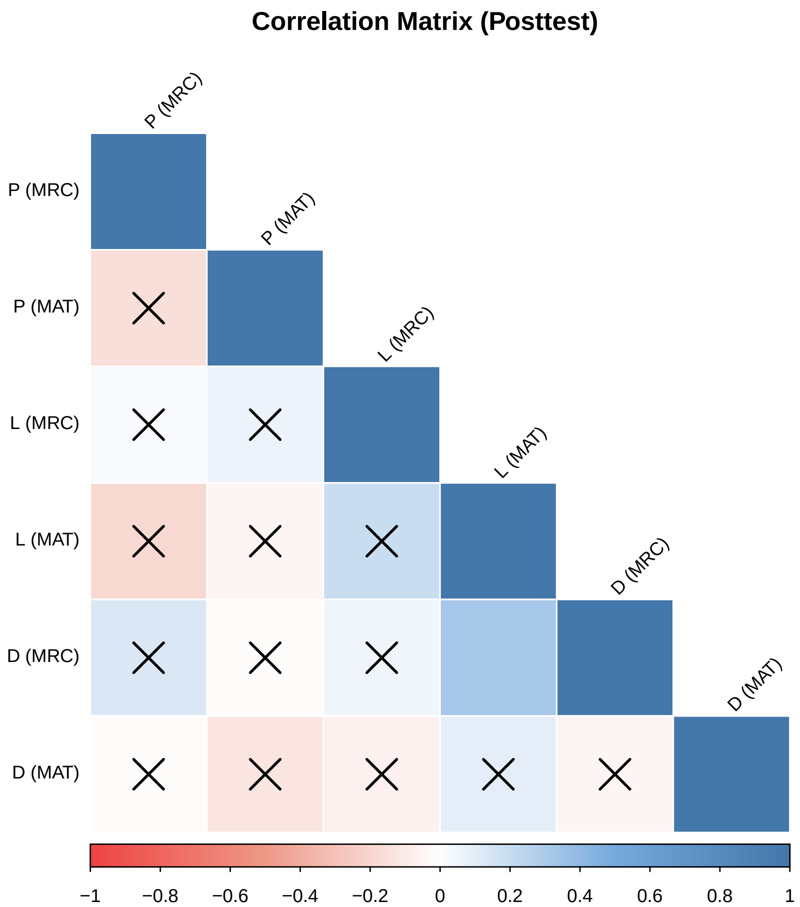

Figure 4.21: Correlation matrix between the MAT students' scores and the MRC measurements on the posttest (P = Pitch; D = Duration; L = Loudness). A cross means no significance.

well as into the partial effect for six representational criteria and three music parameters. There are no clear-cut answers for these questions, since results show that every partial construct, namely music experience, representational criterion, or music parameter contributes to some extent to the overall effect as hypothesized.

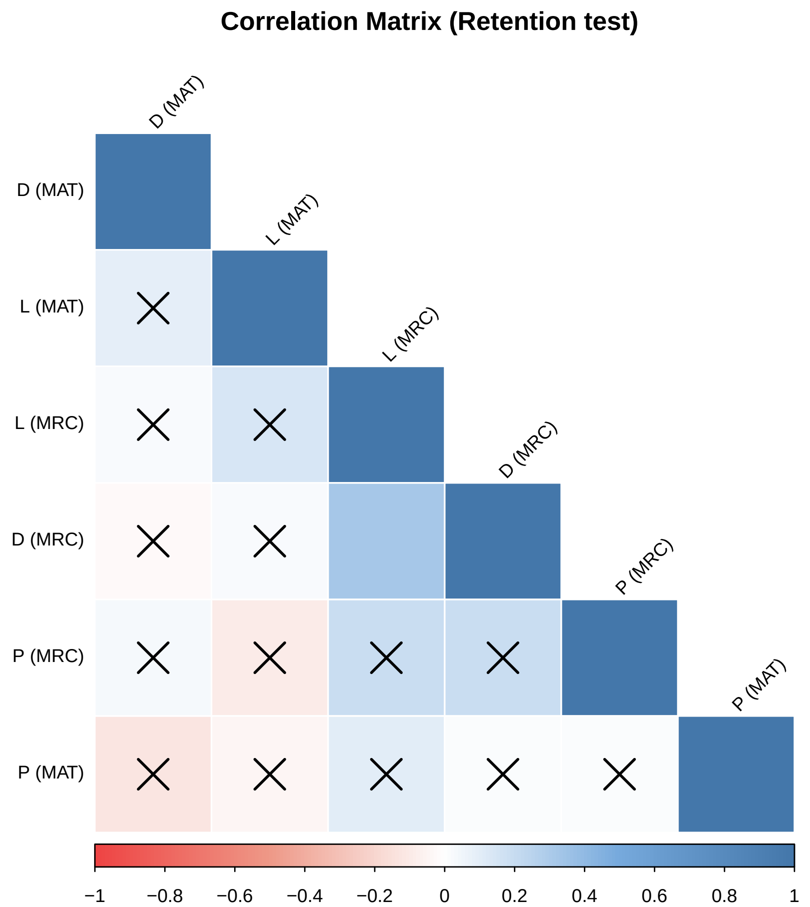

Figure 4.22: Correlation matrix between the MAT students' scores and the MRC measurements on the retention test (P = Pitch; D = Duration; L = Loudness). A cross means no significance.

Treatment	Criteria	Time	M	NM	SD	SE	CI
Experimental ($n = 41$)	Correctness	Pretest	2.46	1.94	.95	.15	.30
		Posttest	2.59	2.06	.72	.11	.23
		R. test	2.27	1.75	.95	.15	.30
	Completeness	Pretest	2.34	1.63	.85	.13	.27
		Posttest	2.73	2.02	.61	.10	.19
		R. test	2.80	2.10	.49	.08	.16
	Transparency	Pretest	1.39	1.36	.94	.15	.30
		Posttest	2.17	2.14	1.02	.16	.32
		R. test	2.29	2.26	.92	.14	.29
	Formality	Pretest	1.37	2.00	1.02	.16	.32
		Posttest	.98	1.61	1.11	.17	.35
		R. test	1.51	2.14	1.10	.17	.35
	Parsimony	Pretest	.80	.81	1.00	.16	.31
		Posttest	2.73	2.74	.55	.09	.17
		R. test	2.20	2.20	1.17	.18	.37
	Beauty	Pretest	1.63	2.11	1.09	.17	.34
		Posttest	1.32	1.80	1.30	.20	.41
		R. test	1.37	1.84	.98	.15	.31
Control ($n = 34$)	Correctness	Pretest	2.38	1.90	.80	.14	.28
		Posttest	2.53	2.04	.69	.12	.24
		R. test	2.29	1.81	.83	.14	.29
	Completeness	Pretest	2.41	1.72	.75	.13	.26
		Posttest	2.68	1.99	.66	.11	.23
		R. test	2.74	2.04	.63	.11	.22
	Transparency	Pretest	1.65	1.59	.90	.15	.31
		Posttest	2.03	1.98	.93	.16	.32
		R. test	2.24	2.18	.80	.14	.28
	Formality	Pretest	1.24	2.26	1.09	.19	.38
		Posttest	.71	1.73	1.02	.18	.36
		R. test	.74	1.76	.92	.16	.32
	Parsimony	Pretest	1.21	1.16	1.12	.19	.39
		Posttest	2.76	2.72	.53	.09	.18
		R. test	1.91	1.87	.82	.14	.29
	Beauty	Pretest	1.53	1.96	.92	.16	.32
		Posttest	1.44	1.87	.91	.16	.32
		R. test	1.50	1.93	1.29	.22	.45

Table 4.4: Summary of partial data for each representational criterion: Mean (M), normed mean (NM), standard deviation (SD), standard error of the mean (SE), and confidence interval (CI) 95%.

	COM		TRA		FOR		PAR		BEA	
	Wald χ^2	p	Wald χ^2	p	Wald χ^2	p	Wald χ^2	p	Wald χ^2	p
COR ($df - 1 = 5$)			15.337	.000	4.385	.036	52.061	.000		
	11.077	.001	23.556	.000	* 4.852	.028	* 6.214	.013		
	5.204	.023	4.444	.035	19.460	.000				
COM ($df - 1 = 4$)			8.463	.004	7.823	.005	39.688	.000	6.174	.013
			9.411	.002			* 4.261	.039	6.960	.008
					11.665	.001	9.850	.002		
TRA ($df - 1 = 3$)					15.075	.000	16.676	.000	13.016	.000
					5.470	.019	7.946	.005	26.466	.000
					8.944	.003	10.655	.001		
FOR ($df - 1 = 2$)							47.827	.000		
							21.116	.000	* 5.049	.025
							18.173	.000		
PAR ($df - 1 = 1$)									40.879	.000
									* 5.547	.019

Table 4.5: Pairwise significant effects between tests: Pretest and Posttest (top), Posttest and Retention test (middle), and Pretest and Retention test (bottom). Criteria: Correctness (COR), Completeness (COM), Transparency (TRA), Formality (FOR), Parsimony (PAR), Beauty (BEA).

Treatment	Parameter	Time	M	NM	SD	SE	CI
Experimental ($n = 41$)	Pitch	Pretest	3.05	3.00	1.25	.20	.40
		Posttest	4.59	4.53	1.16	.18	.37
		R. test	4.02	3.97	1.41	.22	.44
	Duration	Pretest	3.90	3.48	1.36	.21	.43
		Posttest	4.24	3.82	1.19	.19	.37
		R. test	4.63	4.21	1.09	.17	.34
	Loudness	Pretest	3.05	3.38	1.55	.24	.49
		Posttest	3.68	4.01	1.51	.24	.48
		R. test	3.78	4.11	1.38	.22	.44
Control ($n = 34$)	Pitch	Pretest	3.50	3.47	1.18	.20	.41
		Posttest	4.44	4.41	1.18	.20	.41
		R. test	3.65	3.62	1.38	.24	.48
	Duration	Pretest	4.00	3.69	1.13	.19	.39
		Posttest	4.21	3.89	1.20	.21	.42
		R. test	4.24	3.92	1.09	.19	.38
	Loudness	Pretest	2.91	3.43	1.46	.25	.51
		Posttest	3.50	4.02	1.22	.21	.42
		R. test	3.53	4.05	1.39	.24	.48

Table 4.6: Summary of partial data for each musical parameter: Mean (M), normed mean (NM), standard deviation (SD), standard error of the mean (SE), and confidence interval (CI) 95%.

Test	MAT	MRC	ρ	p
Pretest	L	P	-.29	.0125
	D	L	.24	.04
Posttest	L	D	.33	.004
Retention test	D	L	.32	.005

Table 4.7: Significant correlations between the MAT students' scores and the MRC measurements (P = Pitch; D = Duration; L = Loudness).

Chapter 5

Discussion and conclusions

5.1 Summary of findings

The purpose of this study was to examine the effects of a hypermedia learning environment on middle school students' MRC in the domain of music. Particularly, we aimed at determining whether an educational intervention –namely, the implementation of the aforementioned learning environment– influenced the accuracy with which middle school students ($n = 41$) matched sound (sonic fragments) to symbol (graphic representations).

We hypothesized (H_1) that the experimental program would have a positive overall effect on the students' MRC, which was partially supported, since such positive effect happened irrespective of the treatment. We also predicted a lasting effect of the intervention for the students who received scaffolding during the intervention, and that finding was confirmed. The most remarkable outcome was the overall effect of the educational intervention as a whole, which proved to be significant as a consequence of the scaffolding. As to the students' perception of the learning environment, those allocated to the experimental condition overall scored their experience with the lesson in a more positive way, despite this trend was not confirmed for all the subscales of the survey.

In addition, we inquired into the effectiveness of the treatment for participants with different levels of musical experience, resulting that not only the high-experienced students, but also those of medium and low experience benefited from the educational intervention. As to the partial effect for the six representational criteria involved in the study, a significant overall effect because of the intervention was found for two non-epistemic criteria, namely formality and parsimony. Finally, regarding the partial effect for the three music parameters studied, a significant overall effect because of the treatment was found for pitch.

5.2 Interpretation of findings

As far as can be ascertained, no previous study has addressed the effects of an educational intervention on students' MRC, with the only exception of our pilot study (Gil et al., in press). Therefore, our study findings will be related mainly to this previous study.

5.2.1 Overall and lasting effect

First, with respect to the effect of the treatment on the students' MRC, our current results improve to a great extent those obtained in the pilot study. Particularly, both treatment groups got better as a consequence of the intervention, albeit it is at odds with the pilot study, in which the "overall gain was to a great extent due to a decrease in the score of the C group at posttest, while the gain in the E group was rather small." In any case, our findings are in line with Verschaffel, Reybrouck, Jans, et al. (2010, p. 495), since our students "demonstrated evidence of MRC in relation to representation of sound fragments, analogous to diSessa's (2002) students working on mathematics- and science- related representations."

Second, the lasting effect of our current intervention was more prominent for the E group, whose scores remained quite stable, than for the C group, whose scores slightly got worse. This pattern highlights the usefulness of the scaffolding that was provided to the students allocated to the E group, which contributed to this mentioned lasting effect. Once again, this finding is contrary to the one in the pilot study, in which both treatment groups showed a similar retention pattern, even slightly outperforming the scores in the posttest.

Taking the treatment and the lasting effect as an overall measure of our educational intervention, two main conclusions arise: a) despite not existing a significant difference between the treatment groups in the posttest, there is a undeniable instructional value of our current outcome, since our mission as teachers is to make all the students to improve, irrespective of their allocation; and b) a significant difference because of treatment was found between the pretest and the retention test, what supports the effectiveness of the intervention insofar as the students' acquired knowledge was retained. To this respect, Mayer (2002, p. 226) considers retention as one of "the most important educational goals".

5.2.2 Effect of the learning environment

Discussing our findings related to how the students experienced the learning environment while the intervention took place does not admit a comparison with the pilot study, since this issue was not addressed. However, the available literature on learning environments allows us to derive some conclusions. Two main outcomes due to the treatment deserve attention: a) the online learning environment significantly stimulated the experimental students' critical reflective thinking; and b) the role of the teacher to enable the students to participate in online learning was signifficantly acknowledged by the E group. These findings are in line with Fraser (1996, p. 679) when he argues that "[t]he environment [. . .] of a classroom is believed to exert a powerful influence on student behavior, attitudes, and achievement." Similarly, our results illustrate the statement that "[h]ypermedia environments have the potential to be powerful learning tools for fostering students' learning" (R. Azevedo & Cromley, 2004, p. 523).

With respect to the enhancement of the students' critical reflective thinking, de Corte, Verschaffel, and Masui (2004, p. 370) pointed that "[l]earning environments should foster the development of self-regulation strategies in students." In the precise case of hypermedia environments, students' regulation of their learning becomes a requisite, since they are supposed to decide "what and how to learn, how much time to spend on a task" (Lajoie, 2005, p. 546), "when to abandon or modify plans and strategies, and when to increase effort." (R. Azevedo & Cromley, 2004, p. 524) Despite reflective thinking is not a sufficient condition for self-regulated learning, it is clearly a necessary condition. Therefore we must consider such influence as derived from our results, insofar the students allocated to the E group were provided with scaffolding, what allowed them to retake the tasks so as to get a better mark and to some extent to decide when to drop it.

Regarding the positive role of the teacher, it seems that the members of the E group acknowledged that "computers make it possible to give more personal attention to individual students, without which the coaching and scaffolding of apprenticeship-style learning are impossible." (Collins, Brown, & Newman, 1989, p. 491) In addition to (fixed) scaffolding, as provided by the teacher through a hypermedia environment, our findings would also be supporting that "adaptive scaffolding is effective mainly because human tutors have the ability to continuously monitor and diagnose the student's emerging understanding and provide timely scaffolding during learning." (R. Azevedo, Cromley, et al., 2005, p. 387). Although such (adaptive) scaffolding was scarcely provided during the intervention (Session 8), it could be contributing to explain the students' positive perception of the teacher as a mediator to enable them to participate in online learning.

5.2.3 Effect of music experience

As to the influence of the students' music experience on the results, while in the pilot study the scores of the low-experienced students influenced to a great extent the significant decrease in more appropriate answers between the pretest and the posttest, our current findings show just the opposite[1], with the low-experienced students significantly improving due to the treatment between the pretest and the posttest. In turn, a decrease similar to the

[1] To a better comparison between the pilot study and the current one, it must be said that there were no high-experienced students in the pilot study.

aforementioned took place for the medium-experienced students between the posttest and the retention test.

Overall, our results are far from being what one could expect, that is, the students' scores progressively higher as their level of music experience increase (see Verschaffel, de Corte, et al. (1999, p. 220) for a reference study showing such effect in other research domain). Instead, two main patterns emerge from our study: a) all the students, irrespective of their music-experience level and their allocation to the treatment, improved after the intervention, with the high-experienced students being outperformed by the other two levels; and b) the high-experienced students continued improving in the retention test, while the medium and low-experienced students reverted to lower scores (see Figure 4.17).

Discussing this issue makes necessary for us to consider the suitability of our measure instrument (MEQ) as well as the measured construct (music experience). As to the former, we obtained a quite good internal consistency (see Section 3.5.1), despite not being a published standardized test. To this respect, Ebel and Frisbie (1991, p. 86) points that "teacher-prepared tests tend to produce scores with reliability coefficients around 0.50", and we obtained values ranging from .57 to .81. Therefore, the MEQ scores are likely to be reliable. Regarding the latter, our approach is close to the one defended by Demorest (2011, p. 201):

> Many studies that compare trained and untrained listeners use the terms musician and nonmusician to describe the two samples. [...] It may be time to acknowledge that, in any study involving human beings, all of the participants are musical; they just possess differing levels of musical training. Perhaps it would be more accurate to use the terms trained and untrained to describe our groups.

Why, then, did we formulate the construct 'music experience', instead of using 'musical training', as quoted? Our dual role as teacher and researcher allowed us to be aware of the average household background of our students, and therefore we agreed with Upitis (1992/2010, p. 52) that ...

> ... most of the children would never have the opportunity to take pri-

> vate lessons outside of school, so it seemed that spending a good deal of effort understanding the effects of music training on children's notational systems was out of place when almost none of the children I was dealing with would ever have the opportunity to have such instruction. In other words, I felt that the research emphasizing music training was in some sense elitist.

Rather than joining to controversial debates, such as testing of musical intelligence (Boyle, 1992; Edwards et al., 2000; Hallam, 2010; Hallam & Prince, 2003; Haroutounian, 2000; Murphy, 1999; Serafine, 1983), or whether musicians benefit from their musical training over nonmusicians when required to participate in certain musical tasks (Bigand & Poulin-Charronnat, 2006; Davidson & Scripp, 1988; Demorest, 2011; Eitan & Granot, 2006; Küssner & Leech-Wilkinson, 2013; Lidji, Kolinsky, Lochy, & Morais, 2007; C. K. Madsen & K. Madsen, 2002; Morrongiello, 1989; Peretz, 2006), or the classic nature-nurture debate (Hallam & Prince, 2003; Murphy, 1999; Peretz, 2006), it was our contention that a proper operationalization of our construct was needed.

Taking into account that Hankinson et al. (1999) consider that it is "highly debatable whether [playing a musical instrument] is a suitable selection criteria for musical ability", and being aware of the nuances between constructs such as 'musical ability', 'musical achievement', 'musical aptitude', 'musical capacity', 'musical talent', and 'musicality' (Radocy & Boyle, 1979/2012, 431—433), we formulated the construct 'music experience' so as to obtain a more detailed picture of our students' musical behaviour, richer than considering their instrumental skills and their formal/informal training. This decision justifies our design of the MEQ as we detailed elsewhere (see Section 3.5.1).

We have just given reasons that support the suitability of our measure instrument (MEQ) as well as the measured construct (music experience). However, our findings still await explanation. A further look at Figure 4.17 allows us to glimpse that the low and medium-experienced students benefited the most from the intervention, but after a period of time they were outperformed by the high-experienced students. This leads us to the so-called *wipe-out* phenomenon, as described by Bamberger (1982, p. 205):

> The wipe-out phenomenon means once you internalize the coherence of some phenomena in terms of the conventions or a formal symbol system associated with a domain, the way you thought and how you saw the phenomena before is wiped out.

The students other than high-experienced are indeed likely to have been exposed to standard music notation to a lesser extent. Therefore, they could be able to depict "a richer range of sound dimensions in their representations." (Tan & Kelly, 2004, p. 207), while their high-experienced classmates "are systematically inattentive to those features that do not match their internalized expectations." (Bamberger, 1982, p. 224). This is in line with Davidson, Scripp, and Welsh (1988, p. 68), when they argue that "it appears that knowledge of musical practice, gained primarily through study of an instrument using conventional notation, produces a surprisingly limited understanding of musical representation."

Why, then, the low and medium-experienced students obtained lower scores in the retention test? A feasible explanation would point that the high-experienced students really learned something during the intervention, but they were unable to cope with the representations since their musical thinking was 'shaped' by the standard music notation (Barrett, 2005, p. 119). Thus, they started to make sense of the intervention after finishing the posttest, perhaps moved by the (not entirely satisfactory) marks they scored, what would explain their improvement in the retention test.

On the other hand, the low and medium-experienced students, despite being less attentive to the treatment, would have benefited from their 'freshness' and proceeded in an intuitive way to deal with representations, without the constraints of having "thoroughly internalized conventional symbolic expressions associated with a professional community of users" (Bamberger, 1996, p. 35). During the period of time before the retention test, the effects of the weaker learning would have disappeared, and therefore they scored lower than their high-experienced classmates.

5.2.4 Partial effects

First, with respect to the partial effect for the six representational criteria involved in the study, what emerges from our findings is that the students, irrespective of the treatment, overall scored higher for the so-called 'epistemic criteria', namely correctness, completeness, and transparency, than for the 'non-epistemic criteria', namely formality, parsimony, and beauty (see Figure 4.18). This outcome is partially in line with our pilot study, in which the students obtained better results for correctness and completeness, and also with Verschaffel, Reybrouck, Degraeuwe, et al. (2013, p. 707), who "found partial confirmation for the general hypothesis [...] that, with age and experience, children would put 'epistemic' criteria of correctness, transparency and formality higher, and 'aesthetic' criteria lower in their personal rankings".

In addition, we found a widespread absence of significance because of the treatment, while in the pilot study "[t]he data showed that the intervention was effective for correctness, completeness and transparency criteria". As to the rest of criteria, the scoring pattern was quite unpredictable, with unexpected gains and losses, what coincides with the pilot study. This outcome seems to corroborate what reported by Verschaffel, Reybrouck, Jans, et al. (2010, p. 497):

> ...it is impossible to give an absolute value to beauty, formality, and parsimony. [...] So, for the three non-epistemic criteria, the contextual circumstances seem to be decisive for which feature is most appropriate, and the same conclusion may apply, albeit to a less extent, for the three epistemic criteria of correctness, completeness, and transparency.

We have no convincing explanation for this failure of the treatment, even with the most obvious criteria, such as correctness and completeness. Perhaps the students got confused with the scope of every criterion, and that confusion become higher once the intervention finished. To this respect, the reminder tasks (see Appendices B.8, B.7, and B.10) were not so effective as expected in order to keep the students' attention focused on semantics.

Second, as far as the partial effect for the three music parameters is concerned, Verschaffel, Reybrouck, Jans, et al. (2010, p. 489) reminds us that "[t]he available literature did not suggest any particular hypothesis concerning the impact of the sonic parameter on the percentage of children's normatively accurate choices". Such a statement applies to our pilot study, since we did not address this issue, and therefore no hypothesis was formulated to this respect. Taking everything into account, our results corroborate those obtained by Verschaffel, Reybrouck, Jans, et al. (2010, p. 489) with respect to the absence of effect of sonic parameter on the students' scores.

Regarding the significant differences found for the music parameter 'pitch', as well as the higher scores with respect to 'duration' and 'loudness', these findings seem to be in line with Davidson and Scripp (1988, p. 197) when they argue that "musical pitch emerges as the primary component of children's musical cognitive development by the age of seven." A feasible explanation for our students aged 11-12 is that "pitch development in notation and performance increasingly correlates with age, whereas correlations are decreasing with respect to rhythm." (Davidson & Scripp, 1988, p. 217).

5.2.5 Other findings

Finally, despite not being neither a hypothesis nor a research question, we mentioned in the descriptive analysis (see Section 4.2) that there were no self-explanatory differences between the E group and the C group as far constructive resources was concerned when we requested the students to represent a sound fragment by means of a design tablet (see Section 3.7 for an overview of the task). In other words, the educational intervention that was about to finish seemed to have no influence over the students' strategies for generating representations, which remained quite simple irrespective of the treatment.

Taking into account the age range of our sample (11-12 years old), some authors have described an age-related decline in drawing at age 10-11, that could explain our findings. Particularly, Serafine (1988, p. 225) suggests that "[i]t is possible that decrements in some areas of music cognition are necessary for other gains to be made." Similarly, Winner (2006, p. 880) argues that "[c]hildren draw less frequently as they grow older [...] and drawings become conventional and lose their playfulness by age 9 or 10." In this line, Rose, Jolley, and Burkitt (2006, p. 347)highlights that "teachers, parents and children cite a number of factors with lack of time and increasing interest in other activities being most characteristic."

Apart from the aforementioned age-related decline, Upitis (1992/2010, p. 54) mentions that "[w]hen considering children's music notations, one should also bear in mind that children do not necessarily notate everything that they know about a given melody or rhythm." To this respect, as Verschaffel, Reybrouck, Jans, et al. (2010, p. 498) pointed and we argued in the pilot study,"we do not have conclusive confirmation that the students actually attended to the salient parameters of the sonic fragments [...] in the same way that we, as researchers, did." Maybe this limitation, or a combination of the above phenomena could explain the nature of our students' representations.

5.3 Limitations of the study

Remarks on the reliability of the measurement instruments and ethical compliance have been conveniently addressed elsewhere (see Sections 3.5 and 3.4). So as to get a better insight into the study boundaries, what follows focusses on the validity of our experiment, understood as "the approximate truth of an inference. When we say something is valid, we make a judgement about the extent to which relevant evidence supports that inference as being true or correct." (Shadish et al., 2002, p. 34)

5.3.1 Internal validity

Given the educational setting where this study took place, with odd variables probably intervening, threats to internal validity (Shadish et al., 2002, p. 55) such as history or maturation could have occurred during the experiment. In addition, the exposure to a test could affect the scores on subsequent exposures to that test, which might be confused with a treatment effect. To this respect, we designed parallel tests so as to minimize this testing threat, although it remains unclear whether the treatment effect can be ruled out. Regarding the attrition threat, a loss of respondents to measurement happened during the experimental program (see Section 3.2), which might be responsible of artefactual effects. Finally, despite the random assignment could have reduced other threats to internal validity (Shadish et al., 2002, p. 61), we could not say that this experiment was internally valid, since validity is a property of inferences, not a property of designs or methods (Shadish et al., 2002, p. 34).

5.3.2 External validity

As Shadish et al. (2002, p. 248) remind us, "random assignment is not random sampling", despite the two procedures sharing the idea of "randomness". Therefore, since our study was restricted to the first year students enrolled in a concrete secondary school, random sampling was unfeasible. Otherwise, we should have randomly selected our sample from an hypothetical overall population, according to certain threshold, namely "first year students from the: entire city/island/archipelago…". This drawback obviously threatens the external validity of the experiment (Shadish et al., 2002, p. 87), since the effect found in the mentioned high school may not hold in other settings with other students participating.

5.3.3 Statistical conclusion validity

Two major remarks must be made regarding whether inferences about covariation between our variables might be incorrect (Shadish et al., 2002, p. 45). First, all the variables measuring MRC were dichotomous, what might have weaken their relationship with another variables, due to its reduced range. In order to minimize this threat, such variables were not analysed in isolation, but jointly with related variables, what increased the range (see Section 3.1.1). Second, guidance on sample size by the Central Office for Research Ethics Committees (Cunningham & McCrum-Gardner, 2007, p. 132;

McCrum-Gardner, 2010, p. 10) requires that "the number should be sufficient to achieve worthwhile results, but should not be so high as to involve unnecessary recruitment and burdens for participants". By means of a pilot study (Gil et al., in press), we calculated the effect size of an intervention similar to which took place in this study. After these data, we estimated an improvement of the results in the current study (see Section 3.2.2), what allowed us to get a sample size "big enough" that an effect of such magnitude as to be of scientific significance would also be statistically significant (Lenth, 2001, p. 187). Although the number of students at our disposal exceeded the sample size, we decided not to reject any of them, as a precaution against attrition. Indeed, the analysed overall sample after loss to follow up was slightly bigger that the calculated sample size.

5.3.4 Construct validity

The educational setting where the experiment was carried out could have led us to incorrect inferences about the constructs that characterize the study (Shadish et al., 2002, p. 73). First, the participants' responses could have reflected not just the educational intervention, but also their perceptions of the experimental situation. Second, the experimenter could have influenced the participants' responses by conveying expectations about desirable responses, due to his dual role as teacher and researcher (see Section 3.4). A further threat is related to the performance of the students allocated to the control condition, who were deprived of scaffolding during the educational intervention, contrary to their classmates allocated to the experimental group. Therefore, compensatory marks were provided in their school report, since the experimental program was presented to them as a part of the school curriculum (see Section 3.7). This procedure could entail two threats, namely (a) participants not receiving treatment may be motivated to show they can do as well as those receiving treatment; and (b) participants not receiving a desirable treatment may be so resentful or demoralized that they may respond more negatively than otherwise. So as to minimize these threats, the students were not informed about their allocation to the experimental condition. However, their inquisitive interest might led them to compare one another, if differences in marks aroused their suspicions.

5.4 Implications of the study

5.4.1 Theoretical implications

This study was somewhat a replication of a previous pilot study with important nuances as to the design of the learning environment, and partially relied on Verschaffel, Reybrouck, Jans, et al. (2010), with the students being requested to "pick out one from among two possible representations" (p. 499) for a given sonic fragment. As such, we focussed on the students' critical capabilities, albeit our educational intervention allowed us to explore also their constructive resources (see Section 1.3 for an overview on diSessa's theoretical framework). Hence some theoretical implications emerge, mainly centred on children's graphical representation of music, but also including a glance of ecological perception, in view of further research.

Previous studies on children's graphical representation of music have provided evidence for two main claims, namely the broad range of representational strategies that children employ (Barrett, 2001, p. 34; Barrett, 2005, p. 127; Elkoshi, 2004a, p. 77; Upitis, 1990, p. 89; Upitis, 1993, p. 52), and the influence of musical tasks on those strategies, which do not seem to follow a developmental path (Barrett, 2000, p. 45; Barrett, 2002, p. 56; Barrett, 2005, p. 130; Reybrouck et al., 2009, p. 204). Next we elaborate on these two claims.

First, taking the students' self-generated pictures that we collected in Session 6 as a snapshot of their drawing skills, the fact is that they did not display a broad palette of representational strategies. As a rule, they used lines, circles, asterisks, and crosses, as well as changes in "length, width, color, and slant of line segments for representational purposes." (diSessa, 2004, p. 312) Students seemed to be also sensitive to general principles, such as "'coming after' in paper space can substitute for 'do it again' in action space." (Bamberger, 2013, p. 56), which leads us to the SMARC[2] effect (Rusconi, Kwan, Giordano, Umiltà, & Butterworth, 2006, p. 125).

Eitan and Timmers (2010, p. 405) reminds us that "[d]iscourse concerning auditory phenomena, and music specifically, relies heavily on terms derived from non-auditory realms of experience". To this respect, a "variety of languages [. . .] associate pitch polarities [. . .] with the vertical spatial plane" (Eitan, 2013, p. 168), what has been confirmed in a number of experiments (Walker, 1985, p. 232; Küssner & Leech-Wilkinson, 2013, p. 15). This supposedly universal "representational fact" was only partially confirmed in our students' drawings, where the cross-domain associations 'pitch–vertical axis', 'duration–horizontal axis', and 'loudness–size' were not always found. This is in line with diSessa and B. L. Sherin (2000, p. 390) when he argues that "there may be something like a universal inclination toward using up to represent more. However, this does not at all mean that children are not easily capable of doing the reverse."

Second, regarding the influence of the musical task on the students' representations, it seems that using a drawing tablet instead of paper and pencil constrained the students' graphical choices, which proved to be somewhat conservative, as already mentioned. Positive effects were also found, as we will discuss in Section 5.4.2. With respect to whether the students "move back and forth between notational strategies rather than moving progressively through hierarchically distinct stages" (Barrett, 2005, p. 130), we were not able to address this claim, since our study focussed on same-age students during a limited period of time, and therefore there was not opportunity to analyse their representations from a developmental approach.

As to ecological perception is concerned, this study humbly tried to contribute to narrow the so-called theory-practice gap (de Corte, 2000) by addressing some claims repeatedly put forward in previous research, as in Reybrouck (2005b). Since our theoretical framework partially rested on this ground (see Section 1.4.2 for an overview), we raise next some issues that could help to reduce the aforementioned gap in the future, namely how music users make sense of their sounding environment by means of cognitive maps,

[2] Spatial–Musical Association of Response Codes

and the extent to which cognitive economy is a determining factor in this musical behaviour.

In the first place, two influential theories deserve our attention, namely Dewey's description of "having an experience", and Gibson's conception of "perceptual systems":

> ... art, in its form, unites the very same relation of doing and undergoing, outgoing and incoming energy, that makes an experience to be an experience. [...] The doing or making is artistic when the perceived result is of such a nature that its qualities as perceived have controlled the question of production. The act of producing that is directed by intent to produce something that is enjoyed in the immediate experience of perceiving has qualities that a spontaneous or uncontrolled activity does not have. The artist embodies in himself the attitude of the perceiver while he works. (Dewey, 1934/2005, p. 50)

> We shall have to conceive the external senses in a new way, as active rather than passive, as systems rather than channels, and as interrelated than mutually exclusive. If they function to pick up information, not simply to arouse sensations, this function should be denoted by a different term. They will here be called perceptual systems. (J. J. Gibson, 1966, p. 47)

Both theories are at the very core of a new approach to music cognition, which conceives of "music users" as organisms or devices who interact with a sounding environment (Reybrouck, 2005a, p. 247; Reybrouck, 2005b). As such, dealing with music –in other words, coping with the sonic world– becomes a constructive process of sense-making (Reybrouck, 2006b, p. 62; Reybrouck, 2005a, p. 234; Reybrouck, 2004, p. 411; Reybrouck, 2006a, p. 43; Reybrouck, 2012, p. 402; Reybrouck, 2002, p. 2; Reybrouck, 2010, p. 191), what stresses listening as an active experience (Reybrouck, 2001, p. 613; Michaels & Carello, 1981, p. 15; Reybrouck, 2003, p. 298; E. J. Gibson & Pick, 2000, p. 15; Godøy, 1999, p. 96), even a "performance" (Bamberger, 2013, p. 171; Bamberger, 1991b, p. 8).

Since music users are subjects who deal with music by means of "traditional musical behaviours [. . .], as well as more general 'perceptual' and 'behavioural' categories" (Reybrouck, 2005b), it would not make sense any more to study the influence of isolated subject variables –such as aural perception, or musical training– on children's MRC, but to take into account all of the constructs involved, with their particular nuances. That is, children's listening, performing, improvising and composing skills should be conveniently measured, as well as other categories, "such as exploring, selecting and focussing of attention [. . .], and actions, interactions and transactions with the (sonic) world" (Reybrouck, 2005b). Although our MEQ is in line with this approach (see Section 3.5.1 for a description), more research is needed so as to refine this instrument.

In the second place, making-sense of the sonic world leads us to the concept of cognitive map, understood as "the mental structuring process that leads to the creation of an overall mental image or representation of the space and layout of a setting." (Reybrouck, 2008, p. 82) In this context, the music user is conceived as a navigator (Reybrouck, 2003, p. 299) who extracts salient features or 'cues' from the environment and put them together in some coherent way (Reybrouck, 2010, p. 193), what is similar to the concept of *map maker*, who "differentiate parts, name, test and make certain so as to say what they perceive" (Bamberger, 2013, p. 51).

Such an approach relies on both active listening and cue abstraction (Deliège, 1996, 2001, 2007; Deliège & Mélen, 1997), which are mediated by means of the principle of cognitive economy (Reybrouck, 2010, p. 192; Reybrouck, 2004, p. 412; Reybrouck, 2005a, p. 256). As J. J. Gibson (1966, p. 286) put it, " the information registered about objects and events becomes only what is needed, not all that could be obtained." Therefore, for children to be capable of making sense of their sonic environment, sounding material should be selected in order to allow them to extract salient features without overloading memory, what would exclude, in a first stage, the 'classical' repertoire of the Western tradition.

5.4.2 Methodological implications

The experimental approach followed in the present study allowed us to investigate the influence of a hypermedia learning environment on middle school students' MRC. Technology enhancement was of great benefit to the study, as we mentioned elsewhere (see Section 1.6). First, it allowed us to randomize our sample without altering the natural allocation of the students to the high school classrooms, what would have been extremely difficult, if not impossible, to perform (de Corte, Verschaffel, & Masui, 2004, p. 379). Second, we used a design tablet instead of paper and pencil for the students to draw, what has been acknowledged as an "appropriate tool to provide data that can be analysed both qualitatively and quantitatively." (Küssner, 2013, p. 3) Third, "[t]echnology has motivational benefits as a 'hook' that gets students to participate. " (Blumenfeld et al., 2002, p. 484) This is in line with the statement that "classroom contexts and instructional practices affect the degree to which students simply participate or are willing to invest in learning and understanding." (Blumenfeld et al., 2002, p. 476) To this respect, Collins, Brown, and Newman (1989, p. 489) point out "the importance of creating learning environments in which students perform tasks because they are intrinsically related to an interesting or at least coherent goal, rather than for some extrinsic reason, like getting a good grade or pleasing the teacher." Engaging the students by means of technology, as Arriaga and Madariaga (2014, p. 384) suggest, could be beneficial in order to avoid that drawing in response to music loses its appeal for students, as warned by Upitis (1992/2010, p. 116).

Our approach, however, entailed some limitations, as already mentioned (see Section 5.3), several of which are particularly important in consideration of further research. First, children's verbal explanations of their drawings are "[a] further class of constructive resources" (diSessa, 2004, p. 312). Since "speech has an explanatory function with respect to the drawing" (van Oers, 1997, p. 242), language is a helpful tool to help teachers and researchers to interpret children's drawings (Hair, 1993, p. 47; Elkoshi, 2004a, p. 79). To this respect, we did not collect any verbal reaction from our students, neither requested we them to describe or explain their drawings in writing. The main reason for that decision was that the actual teaching was in English (see Section 3.7) and we did not consider the students proficient enough to do this task. Future experiments should address this issue, as previous studies have claimed and we argue in Section 5.5. Second, “[b]ecause of the aims and scope of this study, it was not possible to borrow existent instruments with well-documented and widely acknowledged psychometric qualities.” (Verschaffel, de Corte, et al., 1999, p. 224) Instead, we designed instruments in order to measure the students music experience as well as their MRC (see Section 3.5), whose internal consistency did not reach the level of standardized tests. Admittedly, “[r]eliability is not simply an intrinsic trait of a test; its value depends on the nature of the group tested, the test content, and the conditions of testing.” In order to increase the chance to obtain a better internal consistency in future research, true-false tests –as the one designed to measure the students MRC– should be replaced by multiple choice tasks, as Ebel and Frisbie (1991, p. 91) suggest. That would mean that students should pick out one from among more than two possible representations. Third, the educational setting where this study was carried out was rather different to the ones described in diSessa and associates’ successful experiments, characterized by small classes (diSessa, 2004, p. 308), talented students (diSessa, 2002, p. 110), and volunteer and paid participants (diSessa & B. L. Sherin, 2000, p. 394).

As already explained (see Section 3.2.1) our study took place in a state high school with all the enrolled first year students participating ($N = 100$), what included a number of special education needs (SEN) students. Such a scenario clearly influenced our results to fall, albeit we advocate replicating experiments similar to our study in real educational settings, so as to contribute to narrow the theory-practice gap, as stated earlier (see Section 5.4.1). Fourth, as Verschaffel, Reybrouck, Jans, et al. (2010, p. 498) warned and Gil et al. (in press) insisted, “we do not have extensive confirmation that the children actually attended to the sonic features of the sound fragments and the visual features of the graphic representations the same way we as researchers did.” This is especially significant, since the agreement between raters when evaluating the drawings in the posttest and the retention test was rather low (see Section 3.5.2). Therefore, alternative representations and/or sonic fragments should be designed in future studies. Finally, despite our study was characterized by a high degree of ecological validity –because of the real educational setting in which it took place–, a criticism could be raised "in the sense that the material and the response mode were quite unlike what people normally encounter in their everyday sonic experiences." (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 708) To this respect, although using artificially generated stimuli held some benefits, such as precise control over duration, frequency, and intensity, "such sounds [were] far removed from those used in musical contexts" (Schutz, 2008, p. 87), so it would be advisable to use sound fragments closer to the reality of students.

5.4.3 Educational implications

In considering implications for music education, what emerges from our findings is that children's self-generated representations of sound should be regarded as an integral part of the school curriculum, instead of focussing on standard music notation (SMN). That would provide a chance for students in general –and SEN students in particular– to increase their self-efficacy beliefs, and therefore to benefit from education in general, since transfer across multiple domains would be enhanced. Next we elaborate on these claims.

First, McPherson and O'Neill (2010, p. 133) highlighted two public misconceptions about the place of music in education, namely that "arts subjects have historically been valued for recreation and cultural development", and that "music is not a routine capacity but rather requires a special gift." As a consequence, 'academic subjects' such as mathematics or sciences are commonly regarded essential for instruction, while music is probably judged dispensable. In addition, many students are likely to exclude themselves from participating in musical activities, since they only consider 'truly musicians' those classmates enrolled in music lessons apart from formal schooling. These behavioural patterns make sense in the light of some evidences, such as the aforementioned children's age-related decline in drawing around when they start high school (see Section 5.2.5), or the fact that "as boys and girls get older their ability self-perceptions exert a greater influence on whether they continue to value certain subjects at school." (McPherson & O'Neill, 2010, p. 104) To this respect, our findings showed that the contents of the intervention hardly interested the students, what is in line with the above described students' lack of interest in music in general and in representation in particular (see Section 4.3.2).

Second, in the context of learning science, diSessa and B. L. Sherin (2000, p. 391) advocated including representation as part of instruction, since "contemporary approaches to instruction have moved away from memorizing and reproducing techniques of professional science toward activities that more resemble participating in science". In a subsequent article diSessa (2004, p. 326) argued that "bringing metarepresentation into the science curriculum is both possible and important. Scientists are designers of representation, so representation is a legitimate aspect of learning science." By the same token, the same holds true for learning music, since contemporary approaches to instruction are also being felt in music education –this study is a live example–, and we can conceive of musicians as 'designers of representation'. Therefore, there is no reason to not include (meta) representation in the music curriculum in order to benefit from transfer chances across domains. This would contribute to dispel doubts regarding what the role of music in education should be (Paynter, 2008, p. 4), and is in line with promoting transversal key competences for student-centred learning, as we stated at the beginning (see Section 1.1).

Third, once acknowledged the importance of representation into the music curriculum, a question arise regarding what kind of representations should be taught in school. On the one hand, authors have advised to use "undirected graphic representations" (Tan & Kelly, 2004, p. 208), to allow children to "develop their own notational systems" (Upitis, 1992/2010, p. 10), as well as to "liberate the creative activity from too much attention to restricting calligraphic laws of standard notation" (Elkoshi, 2002, p. 210). On the other hand, the standard music notation (SMN) has been widely criticized for "presenting a perceptually confusing, inaccurate, learning situation to children"

(Walker, 1981b, p. 110) which "may have contributed to a mismeasurement of rhythmic perception." (Davidson & Colley, 1987, p. 109) To this respect, Bamberger (2013, p. 187) argues that emphasizing conventional symbolic use/knowledge in schooling would exclude SEN students from music education, since "[i]nstead of seeing them as virtuosos, they are seen as 'failing to perform'." This has important implications, "because when we begin to consider why music might have a place in the school curriculum we must believe that a teacher's commitment is to all the pupils, not only to those with conventional talent." (Paynter, 2008, p. 181)

Fourth, as already outlined, transfer chances across domains have been highlighted. diSessa, Hammer, et al. (1991, p. 159) said "that the very idea of meta-representation as a learning focus may be one important dimension on which this event may be generalized instructionally." In turn, Barrett (2005, p. 125) suggested "that there are possible links between the various representational systems in which children work", what matches up with the idea of "understanding representation in a general sense [instead of] learning new representations one at a time." (diSessa & B. L. Sherin, 2000, p. 392) For transfer across domains to be fruitful, similar instructional techniques are supposed to be used, what leads us to the importance of instruction in order to develop students' MRC. As diSessa (2002, p. 127) put it, "enmeshing students in the gritty details of assessing and designing representations is an especially valuable way to go." This is not to say that a rich and generative representational background is not "on tap" and hence positive signs of MRC can be shown in non intervention-based studies (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 709; Verschaffel, Reybrouck, Jans, et al., 2010, p. 499). The point here is that students in general –and SEN students in particular– could profit from instruction in MRC, what enhances the relevance of our findings.

5.5 Further research

This study was motivated by the desire to address previous claims in the literature on MRC, such as the crucial need of further study (diSessa & B. L.

Sherin, 2000, p. 396), or the suggestion that "music may be a very promising domain for the elaboration of children's MRC" (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 709; Verschaffel, Reybrouck, Jans, et al., 2010, p. 500). It is our contention that four concrete issues deserve to be explored in future studies, namely undertaking design experiments, studying children's verbal explanations of their own representations, designing sonic/music fragments encompassing, as far as possible, both usefulness in research and ecological validity, and ameliorating the measure instruments so as to increase their reliability. Next we elaborate on these claims.

First, de Corte and Verschaffel (2002, p. 519) distinguished between ascertaining and teaching experiments: "[w]hile ascertaining experiments aim mainly at describing how learning occurs under given conditions of instruction, teaching experiments are characterized by an intervention of the researcher" and provided a strategy for design experiments, namely "the creation and evaluation in real classrooms of complex instructional interventions that reflect and embody our present understanding of effective learning processes and high-powered learning environments." (p. 521) In turn, previous studies on MRC in the domain of music have repeatedly claimed an urgent need for design experiments (Reybrouck et al., 2009, p. 206; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 280; Verschaffel, Reybrouck, Jans, et al., 2010, p. 500). In view of these claims, our proposal entails designing, implementing and evaluating a hypermedia learning environment in a real educational setting, with students participating irrespective of their academic condition.

Second, children's verbal explanations could contribute to a large extent to a better understanding of their strategies when designing and judging both their own drawings and their peers' drawings, since as Elkoshi (2004a, p. 78) wrote, "child's notation does not necessarily capture all that he knows about a sound model. Children see, hear and know more than they represent in their notation." Previous studies have revealed the need for "[c]learly, richer, denser and more focused data about children's verbal descriptions and explanations" (Reybrouck et al., 2009, p. 206), as well as "a setting with children explaining their choices verbally (not only in written form) and with the researcher asking them for additional information." (Verschaffel, Reybrouck, Janssens, et al., 2010, p. 280) As explained earlier (see Section 5.4.2), this is an unresolved issue in our study, and therefore should be addressed in further research.

Third, as Reybrouck et al. (2009, p. 205) put it, "insights gathered from the representation of simplified and rather short musical fragments may be helpful to understand certain aspects of (the development of) children's listening and representational skills, but they may possibly fail in capturing the actual listening strategies that are at work in listening to 'real music'." This is in line with threats to ecological validity when requesting children to listen to sonic fragments detached to excess either from their musical taste or their everyday sonic experiences (see Section 5.4.2). As such, future studies should take into account what students' listening habits are before carrying out any intervention, so as to adapt to their reality as far as possible. We foresee that such a strategy is likely to exclude the so-called 'classical music' from consideration in many cases, what is not necessarily negative.

Fourth, in this study we adapted two existing instruments in order to measure the students' music experience (see Section 3.5.1), as well as MRC related to their critical capabilities (see Section 3.5.2). Regarding the former, we suggest considering which subscales should be added/removed to the instrument, according to the scope of the construct 'music user', whose practical utility awaits further research. In addition, more testing would be needed in order to gather evidence of internal consistency. As to the latter, we propose convert this true-false test in a multiple choice test, so as to increase the chance to obtain a better reliability. Furthermore, a test similar to the one devised by Verschaffel, Reybrouck, Jans, et al. (2010, p. 502) to validate the instrument should be replicated with same-age students than the participants in the study as raters, instead of turning to older and more experienced subjects.

5.6 Conclusions

Taking everything into account, some conclusions can be drawn from our findings:

1. A hypermedia learning environment has a positive overall influence on middle school students' MRC, as far as their critical capabilities are concerned.

2. Such an educational setting has the additional benefit to enhance the students' motivation related to representation, without considering drawing as a childish behaviour.

3. Stressing children's invented drawings of sonic fragments during schooling is beneficial insofar what learned can be transferred to other domains, and vice versa.

4. Far from being regarded somewhat as a menace, SMN has its place in music education, but this place is not an end itself, what means that it must not substitute children's idiosyncratic representations.

5. Understanding representation in a general sense is a process in which music education must take part, and hence their important role in the school curriculum as the rest of subjects on the same terms.

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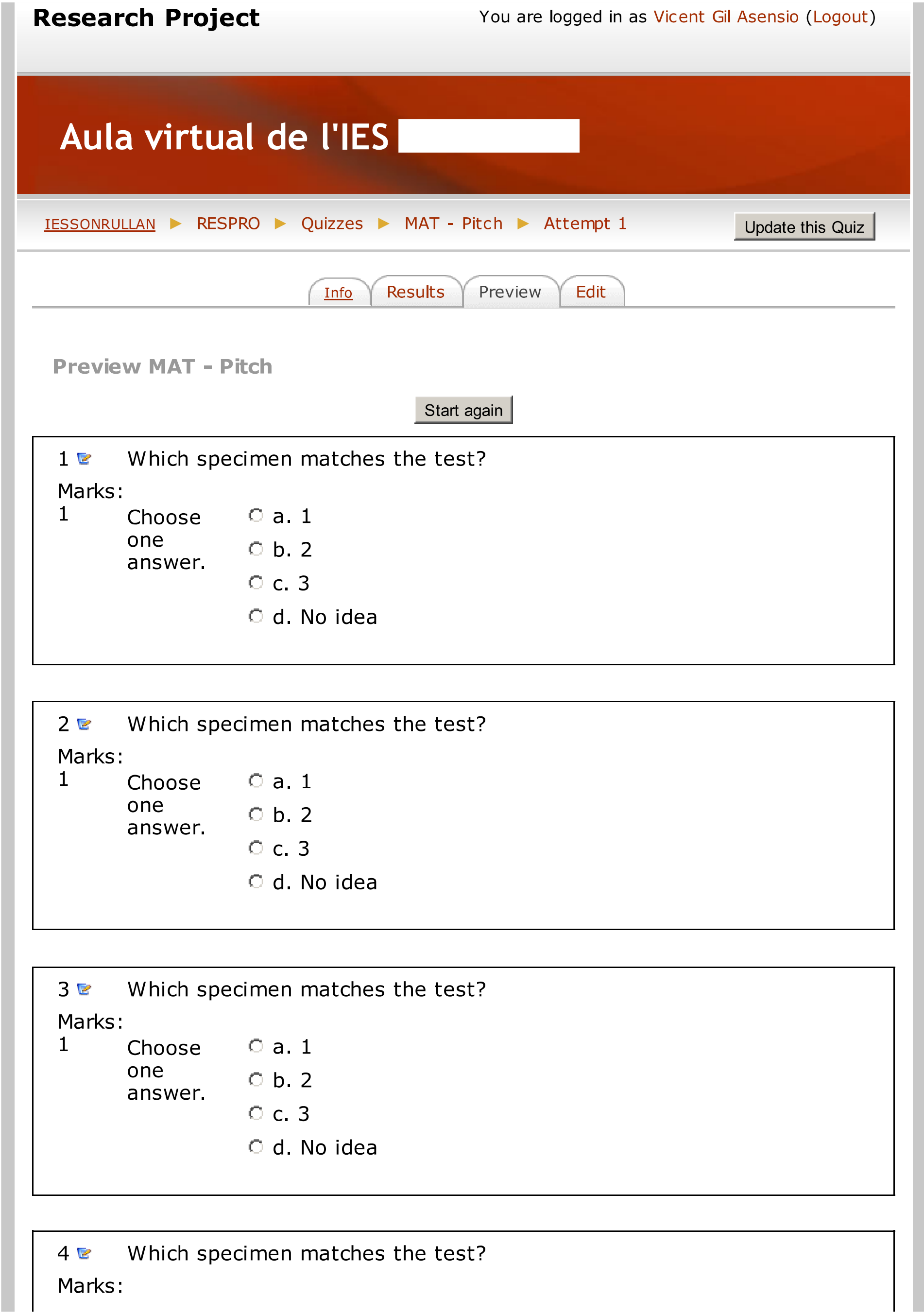
Appendices

Appendix A

Instruments

A.1 Music aptitude test (MAT)


Research Project

You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ MAT - Pitch ▶ Attempt 1

Update this Quiz

Info | Results | Preview | Edit

Preview MAT - Pitch

Start again

1 Which specimen matches the test?

Marks: 1

Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

2 Which specimen matches the test?

Marks: 1

Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

3 Which specimen matches the test?

Marks: 1

Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

4 Which specimen matches the test?

Marks:

1 Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

5 Which specimen matches the test?

Marks: 1 Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

6 Which specimen matches the test?

Marks: 1 Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

7 Which specimen matches the test?

Marks: 1 Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

8 Which specimen matches the test?

Marks: 1 Choose one answer.
- a. 1
- b. 2
- c. 3
- d. No idea

9 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

10 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

11 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

12 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

13 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

14 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

15 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

16 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

17 Which specimen matches the test?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

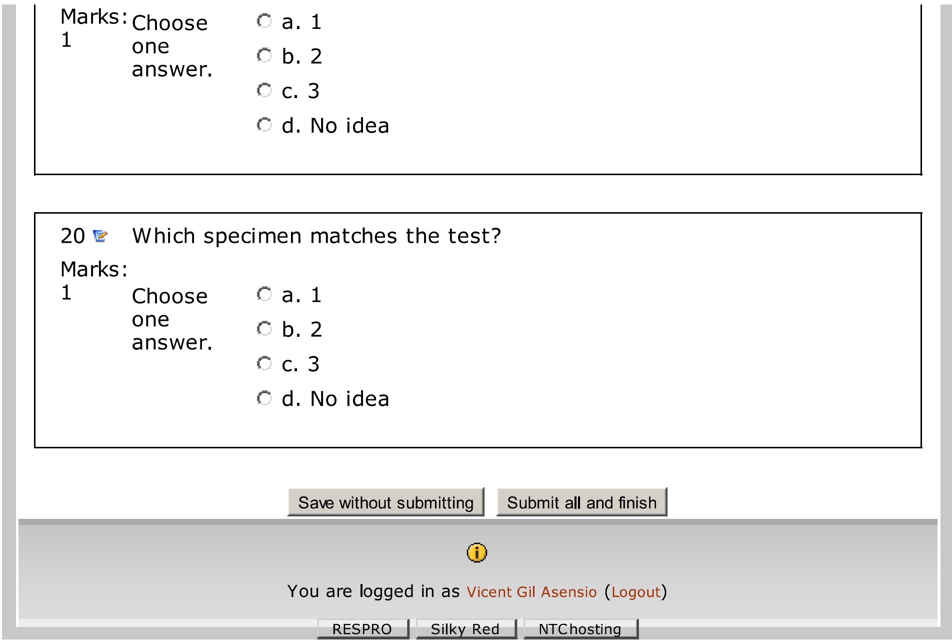
18 Which specimen matches the test?

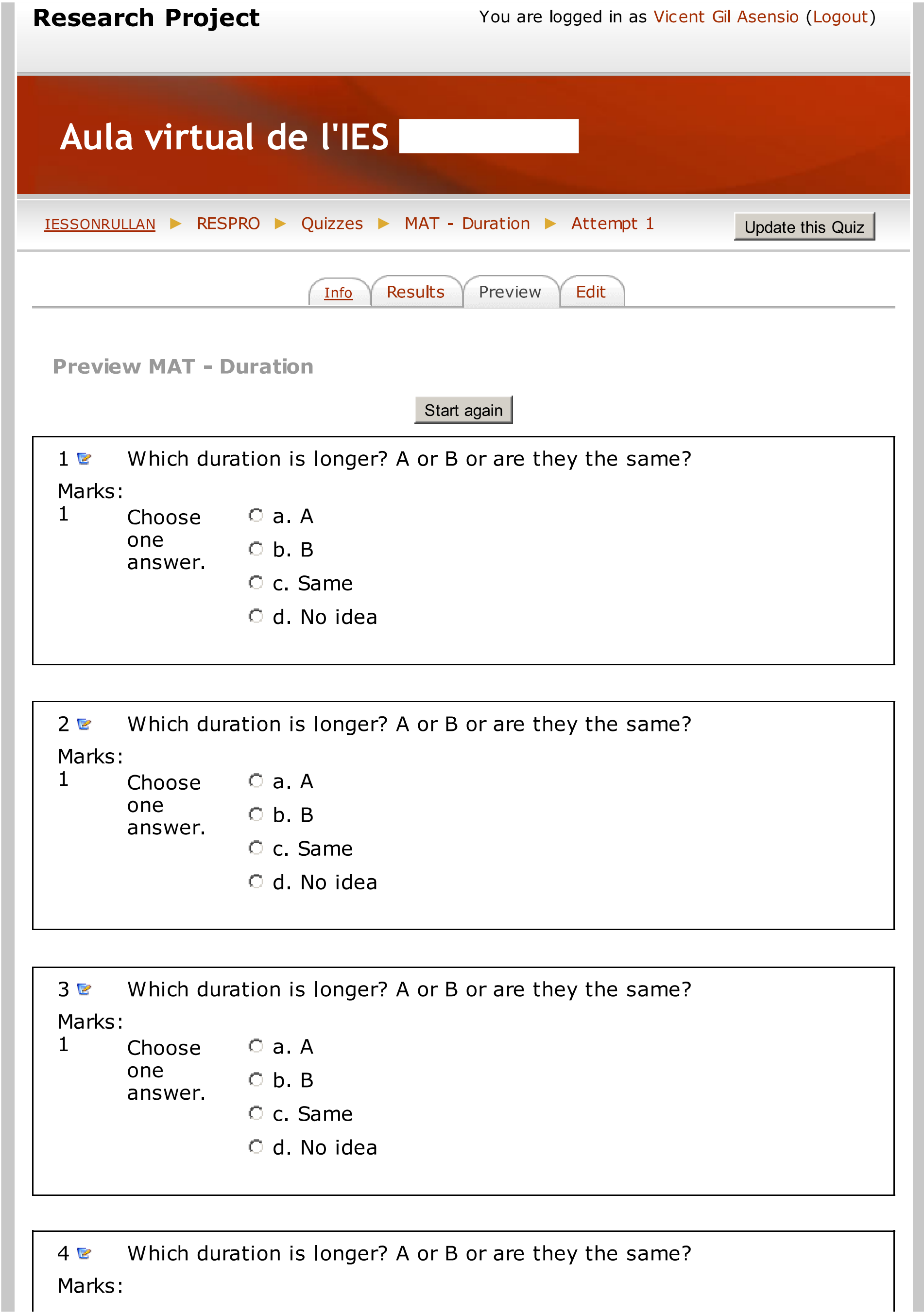
Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. No idea

19 Which specimen matches the test?


Marks: 1
Choose one answer.
a. 1
b. 2
c. 3
d. No idea
20 Which specimen matches the test?
Marks: 1
Choose one answer.
a. 1
b. 2
c. 3
d. No idea
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting


Research Project

You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ MAT - Duration ▶ Attempt 1

Update this Quiz

Info | Results | Preview | Edit

Preview MAT - Duration

Start again

1 Which duration is longer? A or B or are they the same?

Marks: 1

Choose one answer.

- a. A
- b. B
- c. Same
- d. No idea

2 Which duration is longer? A or B or are they the same?

Marks: 1

Choose one answer.

- a. A
- b. B
- c. Same
- d. No idea

3 Which duration is longer? A or B or are they the same?

Marks: 1

Choose one answer.

- a. A
- b. B
- c. Same
- d. No idea

4 Which duration is longer? A or B or are they the same?

Marks:

1 Choose one answer.
- a. A
- b. B
- c. Same
- d. No idea

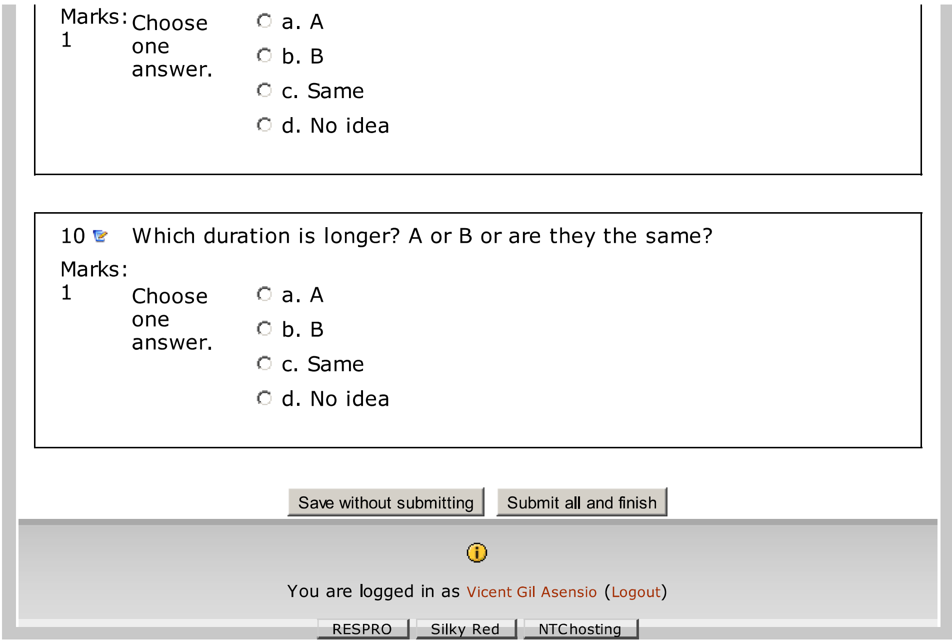
5 Which duration is longer? A or B or are they the same?
Marks: 1 Choose one answer.
- a. A
- b. B
- c. Same
- d. No idea

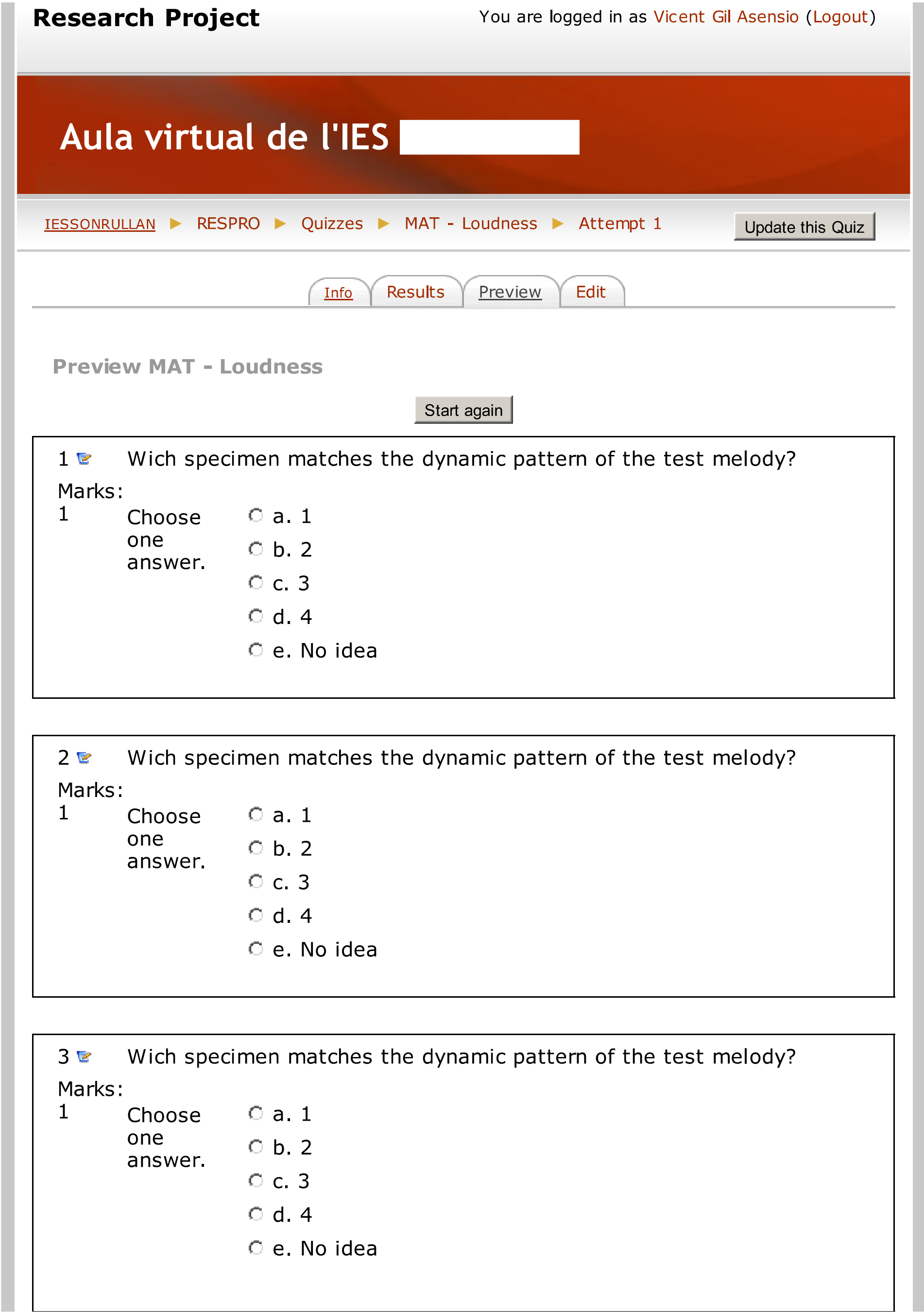
6 Which duration is longer? A or B or are they the same?
Marks: 1 Choose one answer.
- a. A
- b. B
- c. Same
- d. No idea

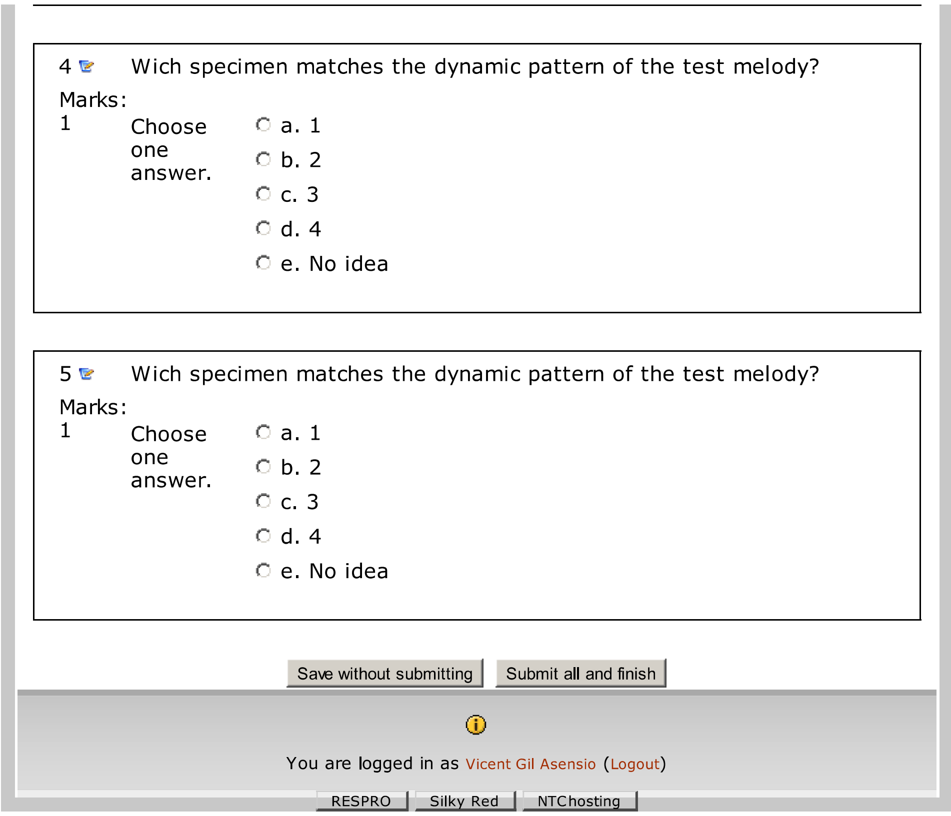
7 Which duration is longer? A or B or are they the same?
Marks: 1 Choose one answer.
- a. A
- b. B
- c. Same
- d. No idea

8 Which duration is longer? A or B or are they the same?
Marks: 1 Choose one answer.
- a. A
- b. B
- c. Same
- d. No idea

9 Which duration is longer? A or B or are they the same?


Marks: 1
Choose one answer.
a. A
b. B
c. Same
d. No idea
10
Which duration is longer? A or B or are they the same?
Marks: 1
Choose one answer.
a. A
b. B
c. Same
d. No idea
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ MAT - Loudness ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview MAT - Loudness
Start again
1 Wich specimen matches the dynamic pattern of the test melody?
Marks: 1
Choose one answer.
a. 1
b. 2
c. 3
d. 4
e. No idea
2 Wich specimen matches the dynamic pattern of the test melody?
Marks: 1
Choose one answer.
a. 1
b. 2
c. 3
d. 4
e. No idea
3 Wich specimen matches the dynamic pattern of the test melody?
Marks: 1
Choose one answer.
a. 1
b. 2
c. 3
d. 4
e. No idea



4 Wich specimen matches the dynamic pattern of the test melody?

Marks: 1

Choose one answer.

- a. 1
- b. 2
- c. 3
- d. 4
- e. No idea

5 Wich specimen matches the dynamic pattern of the test melody?

Marks: 1

Choose one answer.

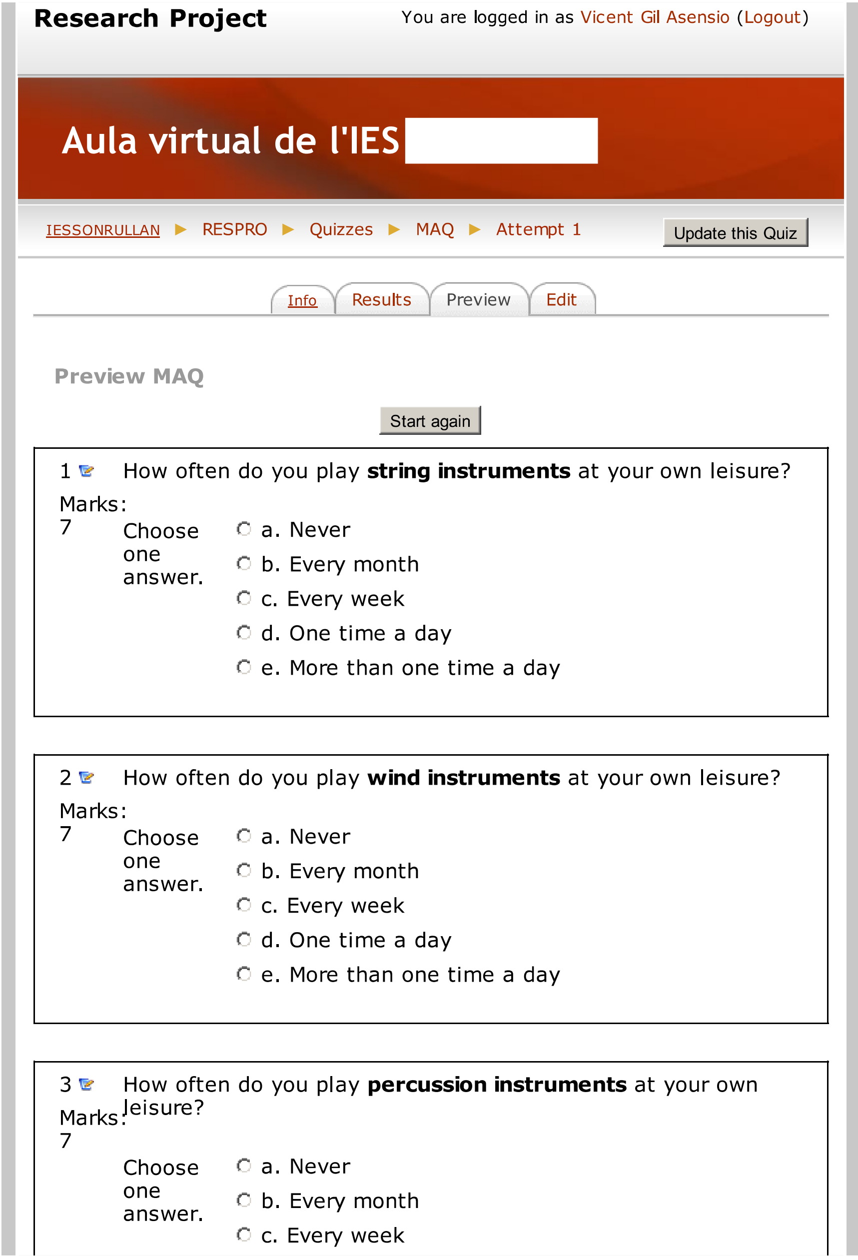
- a. 1
- b. 2
- c. 3
- d. 4
- e. No idea

Save without submitting | Submit all and finish

You are logged in as Vicent Gil Asensio (Logout)

RESPRO | Silky Red | NTChosting

A.2 Music experience questionnaire (MEQ)



Research Project

You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ MAQ ▶ Attempt 1

Update this Quiz

Info | Results | Preview | Edit

Preview MAQ

Start again

1 How often do you play **string instruments** at your own leisure?

Marks: 7

Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

2 How often do you play **wind instruments** at your own leisure?

Marks: 7

Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

3 How often do you play **percussion instruments** at your own leisure?

Marks: 7

Choose one answer.

- a. Never
- b. Every month
- c. Every week

○ d. One time a day
○ e. More than one time a day

4 How often do you participate in a **wind band**?
Marks: 5
Choose one answer.
○ a. Never
○ b. Every month
○ c. Every week
○ d. One time a day
○ e. More than one time a day

5 How often do you participate in a **choral**?
Marks: 5
Choose one answer.
○ a. Never
○ b. Every month
○ c. Every week
○ d. One time a day
○ e. More than one time a day

6 How often do you participate in a **rock group**?
Marks: 5
Choose one answer.
○ a. Never
○ b. Every month
○ c. Every week
○ d. One time a day
○ e. More than one time a day

7 How often do you participate in a **pop group**?
Marks: 5
Choose one answer.
○ a. Never
○ b. Every month
○ c. Every week

d. One time a day
e. More than one time a day

8 How often do you participate in a **string orchestra**?
Marks: 5
Choose one answer.
a. Never
b. Every month
c. Every week
d. One time a day
e. More than one time a day

9 What do you think about your ability to **read music on score**?
Marks: 10
Choose one answer.
a. Very low
b. Low
c. Medium
d. High
e. Very high

10 What do you think about your ability to **play or sing music at sight-reading**?
Marks: 10
Choose one answer.
a. Very low
b. Low
c. Medium
d. High
e. Very high

11 What do you think about your ability to **play or sing music without score, by ear**?
Marks: 10
Choose one answer.
a. Very low
b. Low

- c. Medium
- d. High
- e. Very high

12 Marks: 10

What do you think about your ability to **improvise music, either playing or singing**?

Choose one answer.

- a. Very low
- b. Low
- c. Medium
- d. High
- e. Very high

13 Marks: 10

What do you think about your ability to **compose music and write down on a score**?

Choose one answer.

- a. Very low
- b. Low
- c. Medium
- d. High
- e. Very high

14 Marks: 3

Do you usually attend **private music** lessons, out of the schooling?

Choose one answer.

- a. Never
- b. I did it more than two years ago
- c. I did it two years ago
- d. I did it last year
- e. Yes, currently I do

15 Marks: 3

Do you usually attend **music school** lessons, out of the schooling?

Choose one answer.
- a. Never
- b. I did it more than two years ago
- c. I did it two years ago
- d. I did it last year
- e. Yes, currently I do

16 Do you usually attend **conservatory** lessons, out of the schooling?
Marks: 3

Choose one answer.
- a. Never
- b. I did it more than two years ago
- c. I did it two years ago
- d. I did it last year
- e. Yes, currently I do

17 How often do you usually listen to **blues music**?
Marks: 5

Choose one answer.
- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

18 How often do you usually listen to **classic music**?
Marks: 5

Choose one answer.
- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

19 How often do you usually listen to **folk music**?
Marks:

5 Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

20 How often do you usually listen to **jazz music**?

Marks: 5 Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

21 How often do you usually listen to **pop music**?

Marks: 5 Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

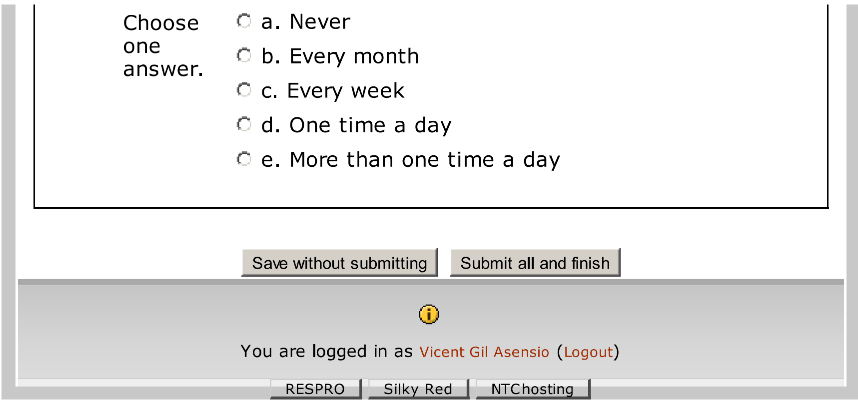
22 How often do you usually listen to **rock music**?

Marks: 5 Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

23 How often do you usually listen to **techno music**?

Marks: 5



Choose one answer.

- a. Never
- b. Every month
- c. Every week
- d. One time a day
- e. More than one time a day

Save without submitting | Submit all and finish

You are logged in as Vicent Gil Asensio (Logout)

RESPRO | Silky Red | NTChosting

A.3 Pretest

Research Project You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Pretest - Pitch ▶ Attempt 1 Update this Quiz

Info | Results | Preview | Edit

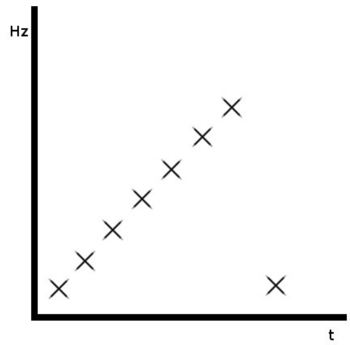
Preview Pretest - Pitch

Start again

1 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



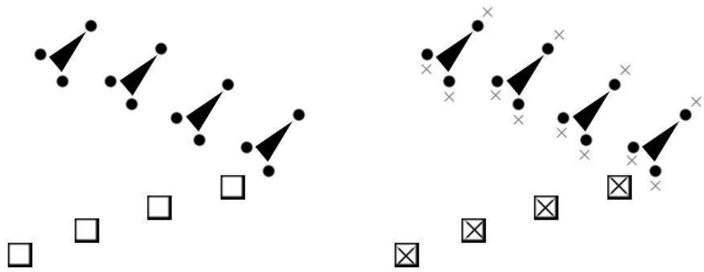
Choose one answer.

- ○ Picture 1
- ○ Picture 2

2 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

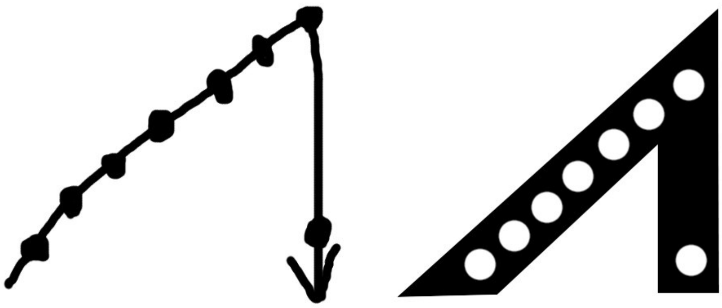
Picture 1 **Picture 2**

Choose one answer.
- ○ Picture 1
- ○ Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

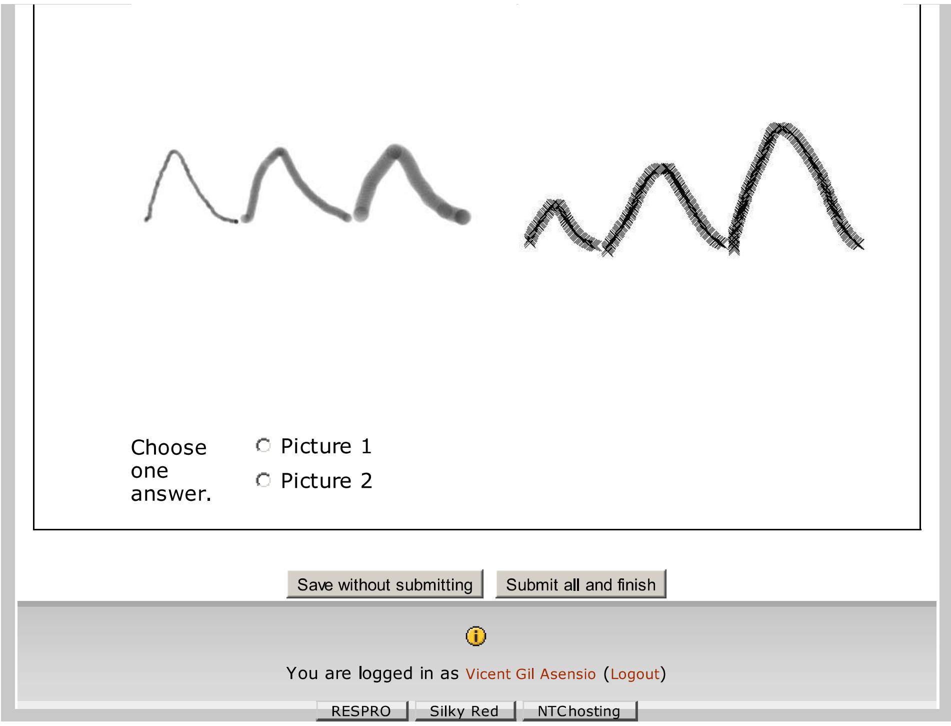


Choose one answer.
- ○ Picture 1
- ○ Picture 2

6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

Research Project You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES [redacted]

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Pretest - Duration ▶ Attempt 1 Update this Quiz

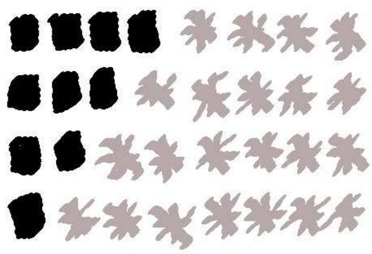
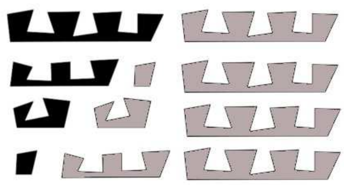
Info | Results | Preview | Edit

Preview Pretest - Duration

Start again

1 Marks: 1

Select the notation that fits better with the fragment that you have heard.

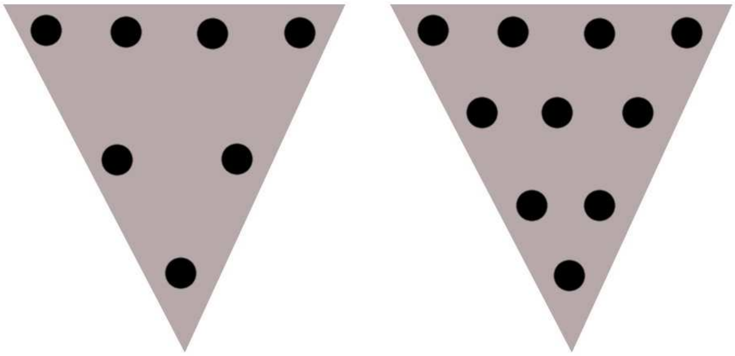
Picture 1	**Picture 2**
	

Choose one answer.
- ○ Picture 1
- ○ Picture 2

2 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1	**Picture 2**

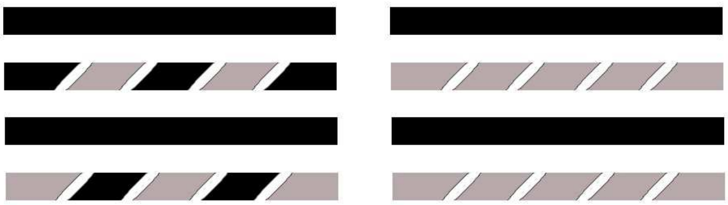


Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

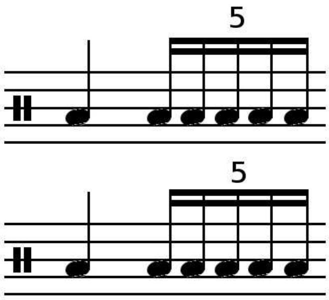


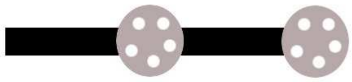
Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**





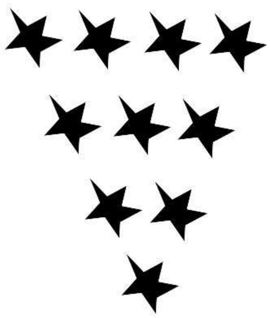
Choose one answer.

- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1



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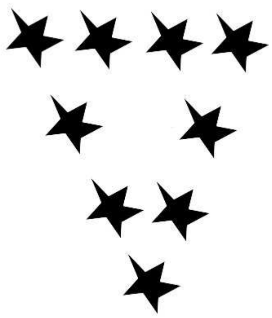


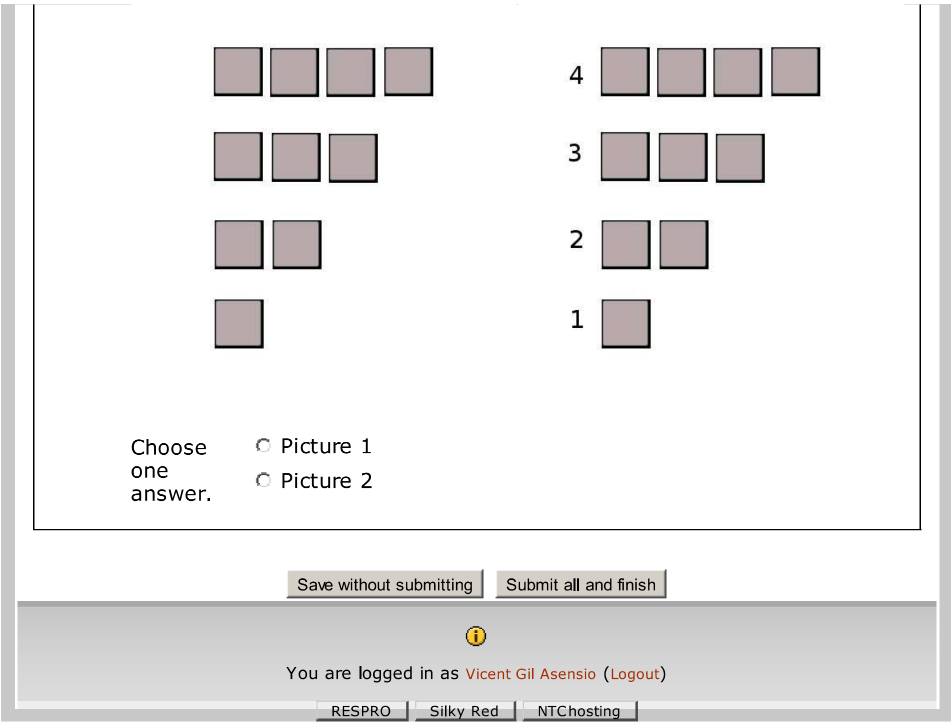
Choose one answer.

- Picture 1
- Picture 2

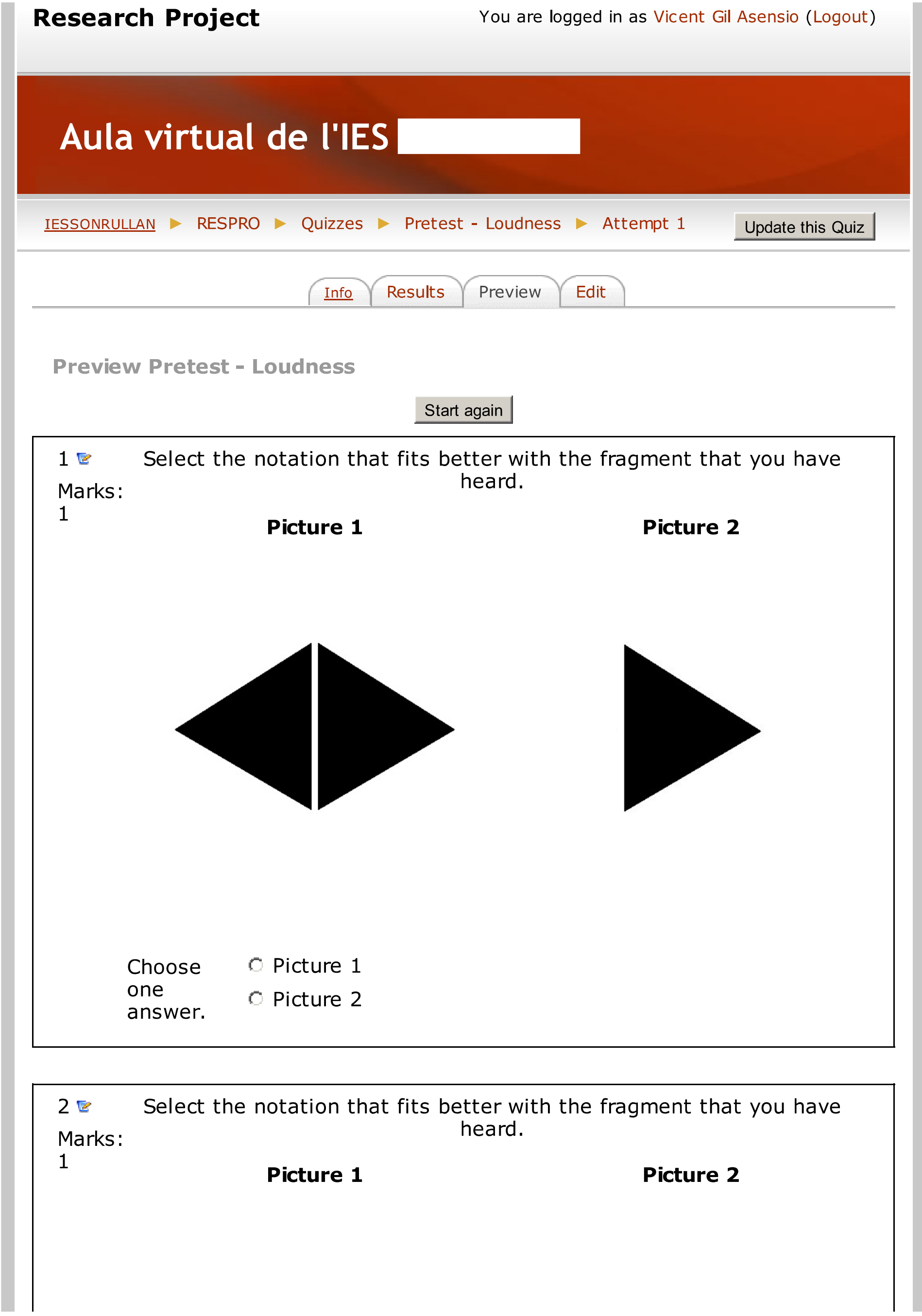
6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



4
3
2
1
Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting


Research Project
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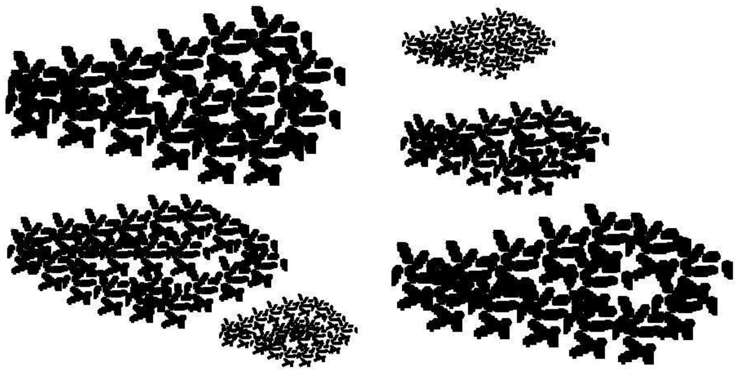
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Pretest - Loudness ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Pretest - Loudness
Start again
1
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2
Choose one answer.
Picture 1
Picture 2
2
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2

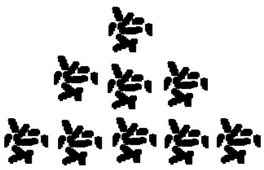


Choose one answer.
- Picture 1
- Picture 2

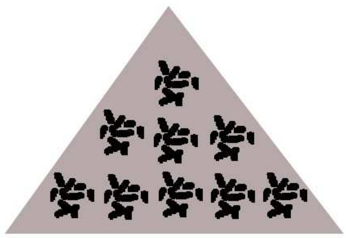
3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1



Picture 2

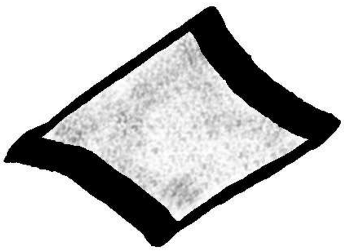


Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

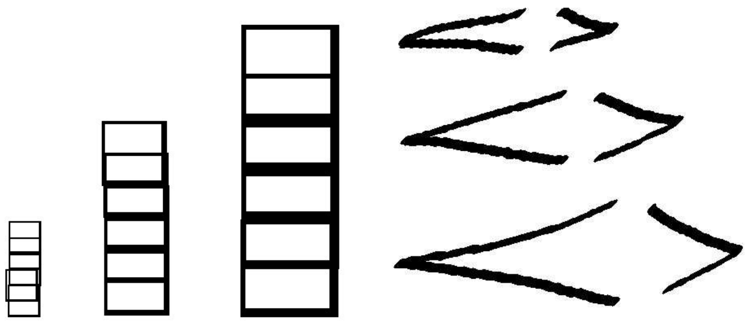


Choose one answer.
- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

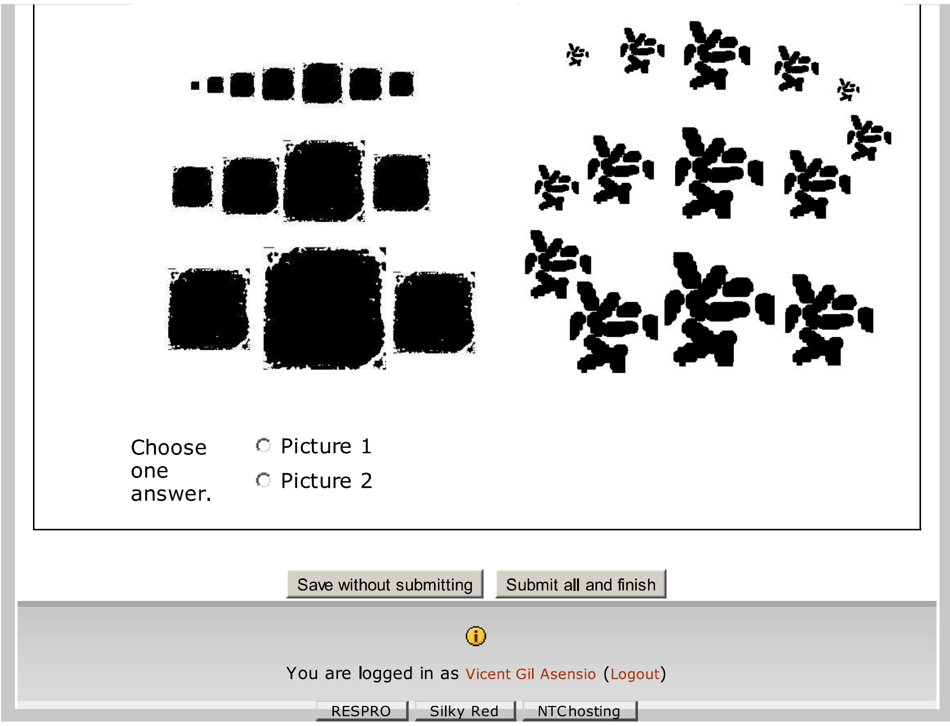


Choose one answer.
- Picture 1
- Picture 2

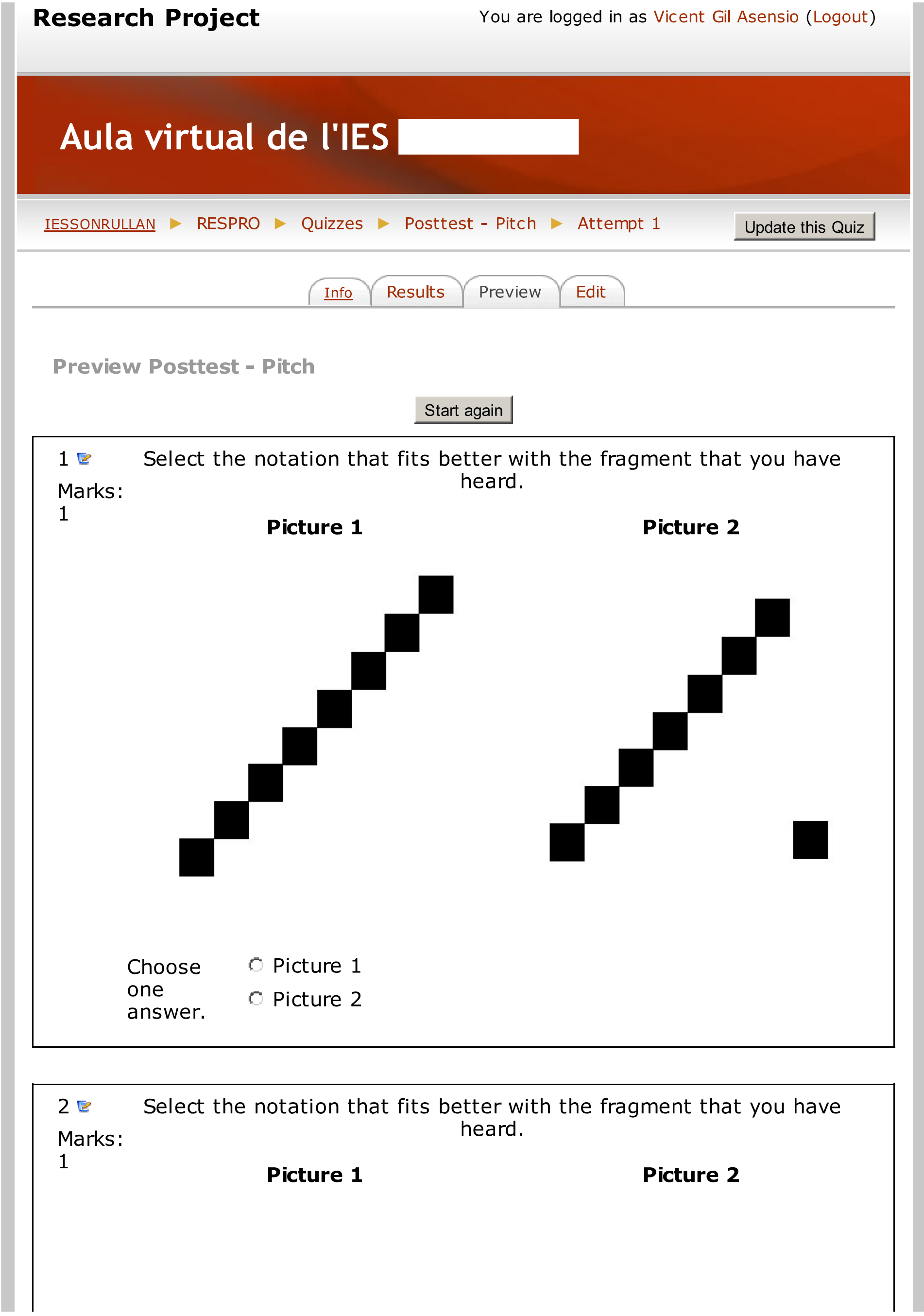
6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

A.4 Posttest


Research Project

You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Posttest - Pitch ▶ Attempt 1

Update this Quiz

Info | Results | Preview | Edit

Preview Posttest - Pitch

Start again

1 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

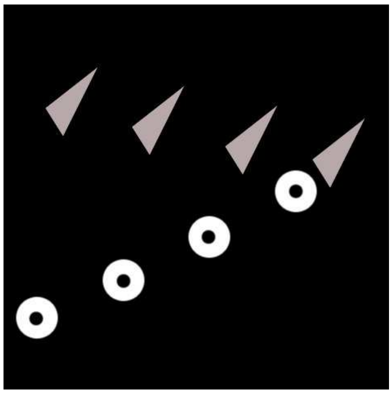
Choose one answer.

- Picture 1
- Picture 2

2 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

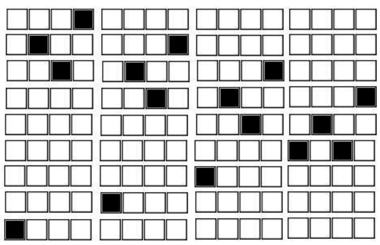


Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

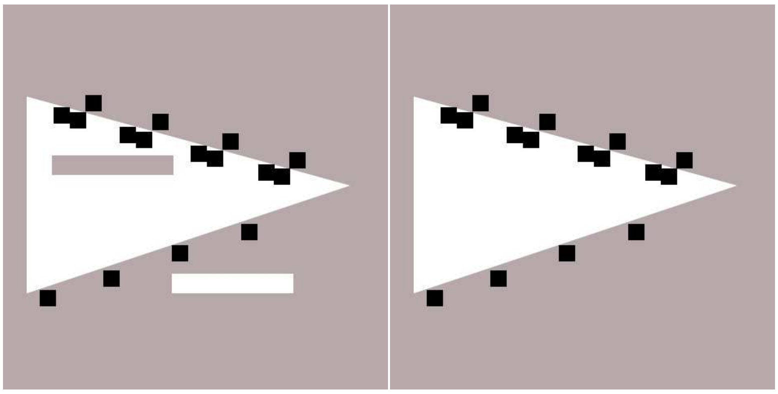


Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



Choose one answer.
- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

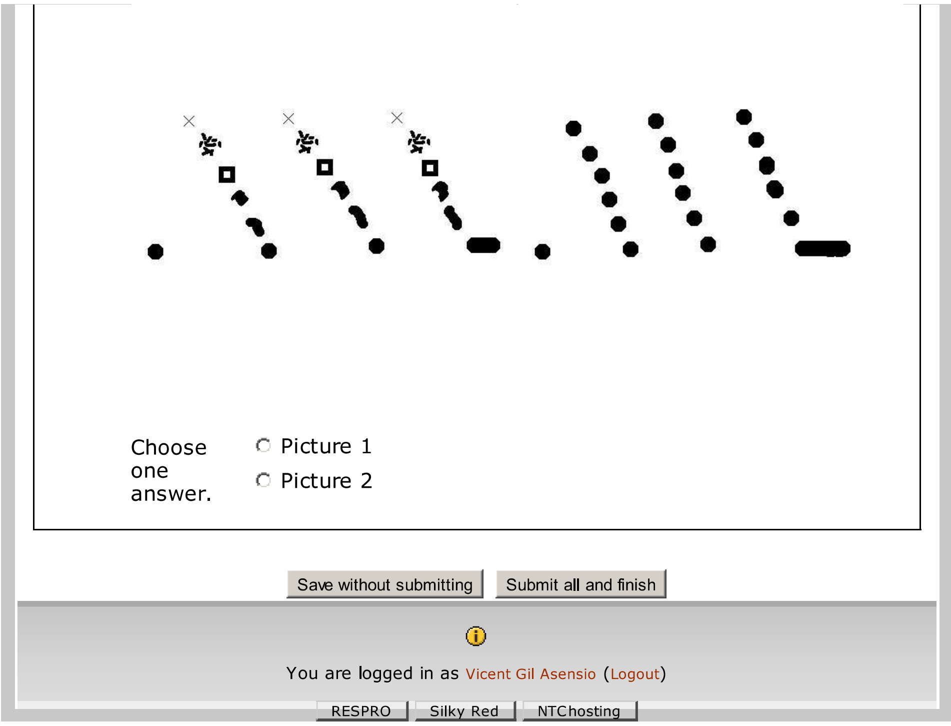
Picture 1 **Picture 2**

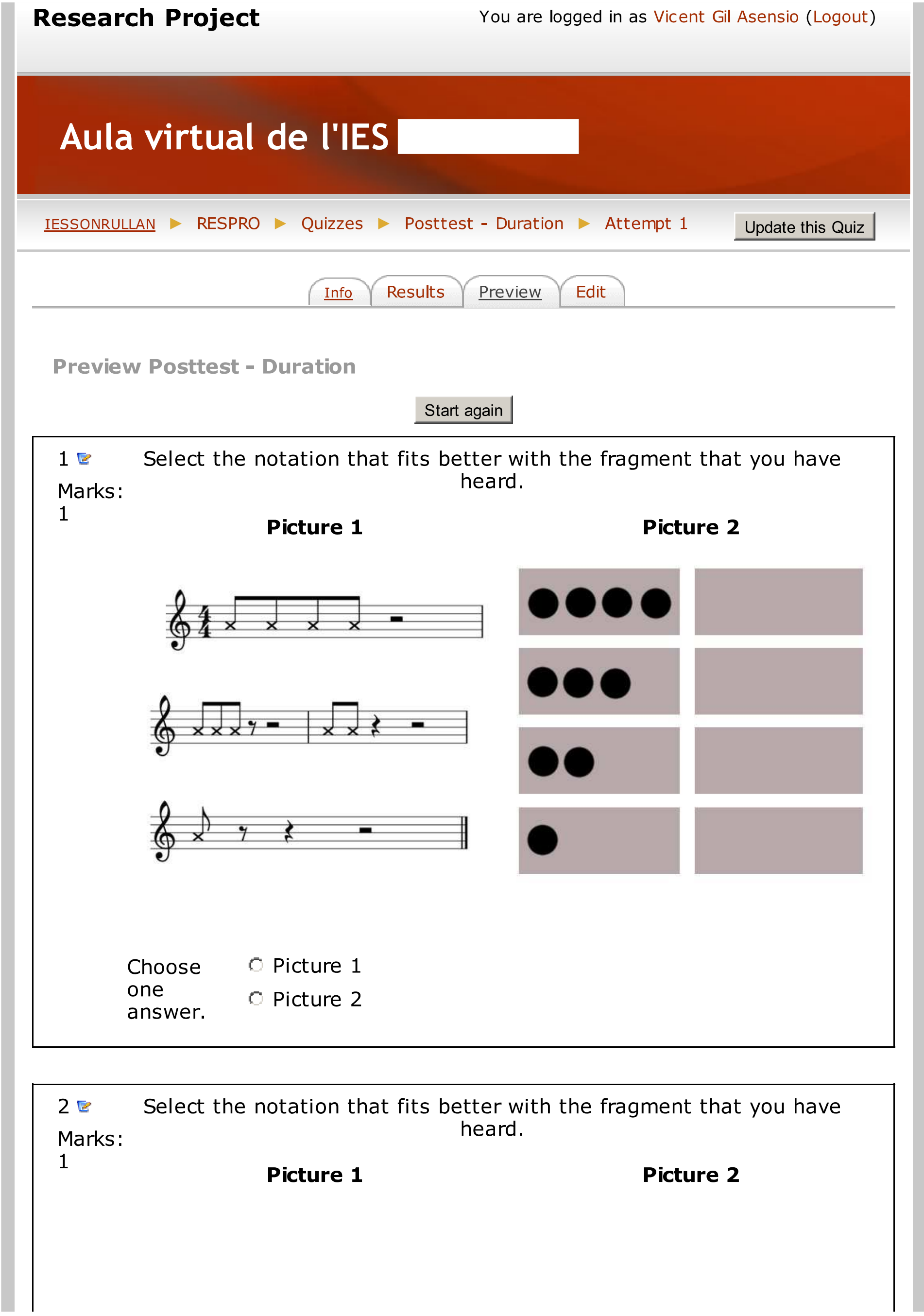
Choose one answer.
- Picture 1
- Picture 2

6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting



Research Project You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Posttest - Duration ▶ Attempt 1 Update this Quiz

Info | Results | Preview | Edit

Preview Posttest - Duration

Start again

1 Marks: 1

Select the notation that fits better with the fragment that you have heard.

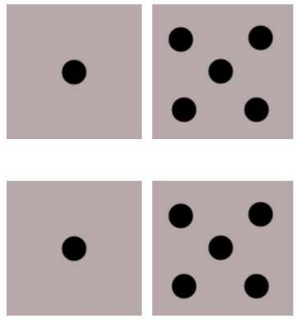
Picture 1 **Picture 2**

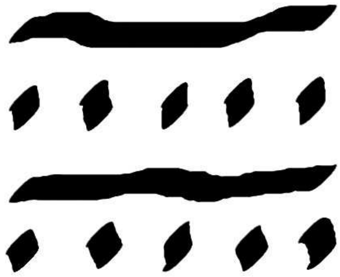
Choose one answer.
- Picture 1
- Picture 2

2 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**





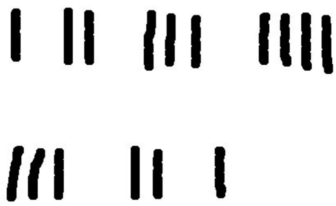
Choose one answer.

- ◌ Picture 1
- ◌ Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



Choose one answer.

- ◌ Picture 1
- ◌ Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

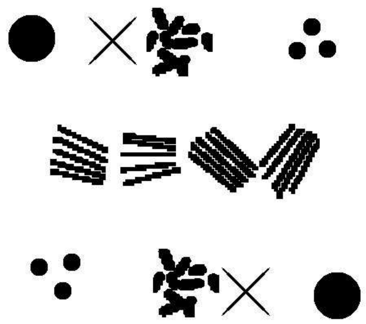
Picture 1 **Picture 2**

Choose one answer.
- Picture 1
- Picture 2

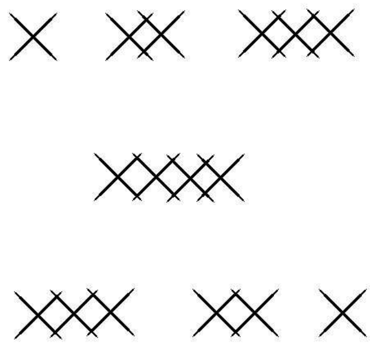
5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1



Picture 2

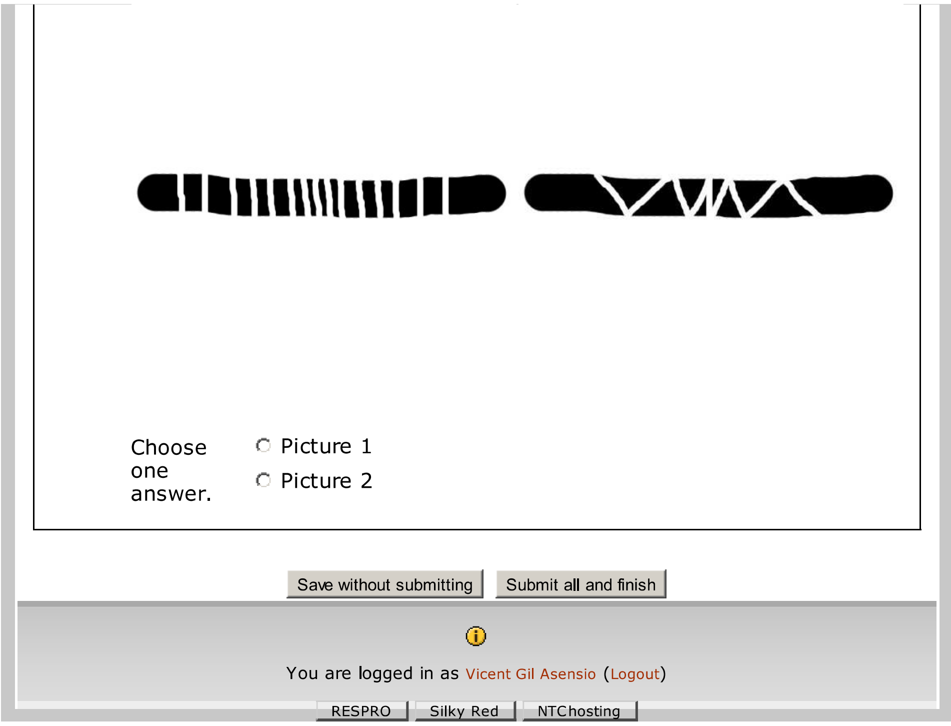


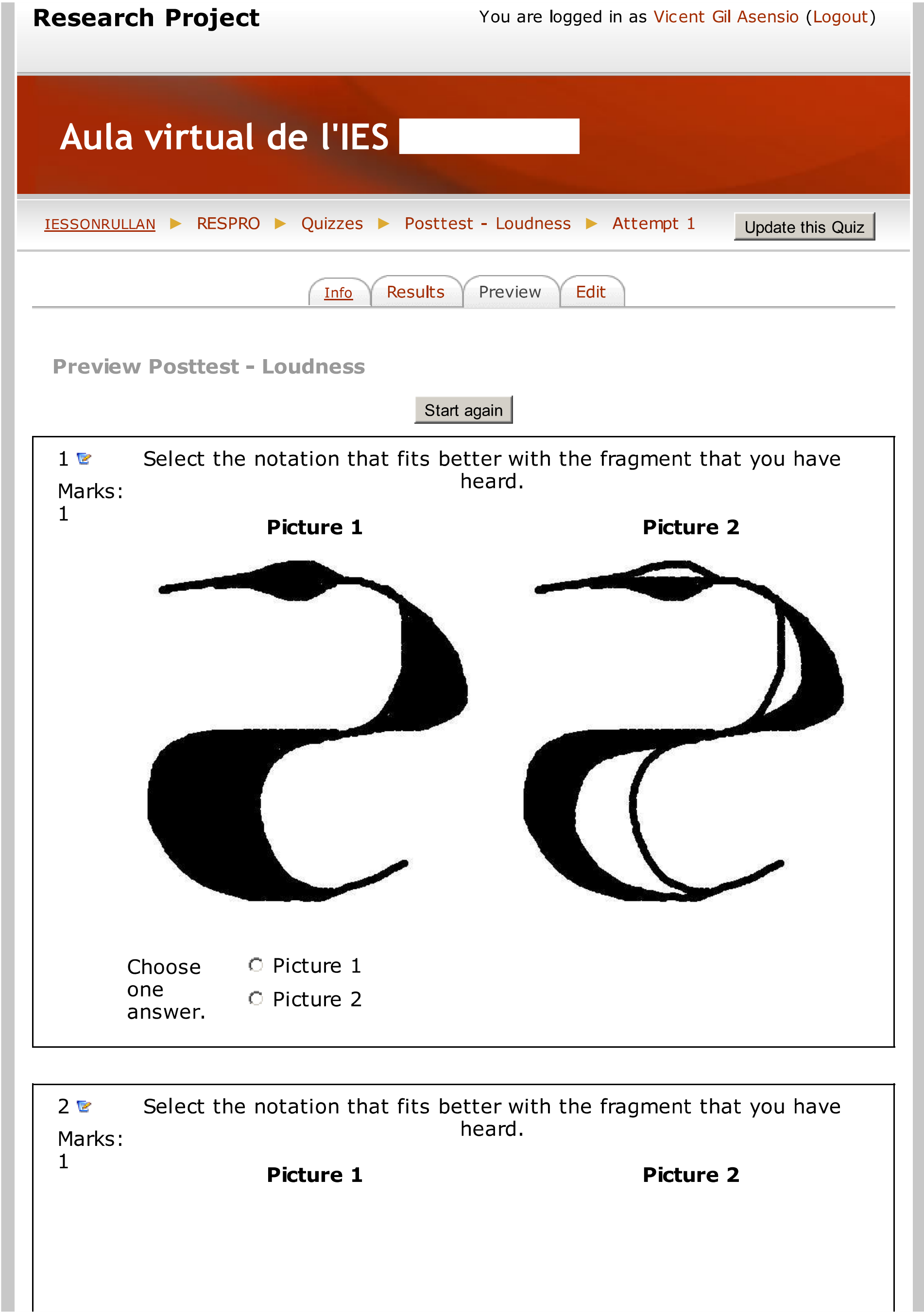
Choose one answer.
- Picture 1
- Picture 2

6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting


Research Project
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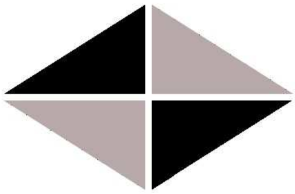
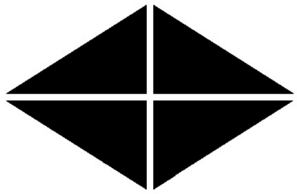
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Posttest - Loudness ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Posttest - Loudness
Start again
1
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2
Choose one answer.
Picture 1
Picture 2
2
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2



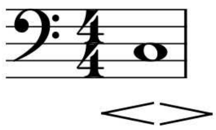


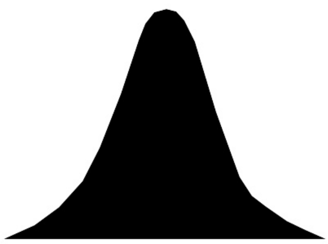
Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



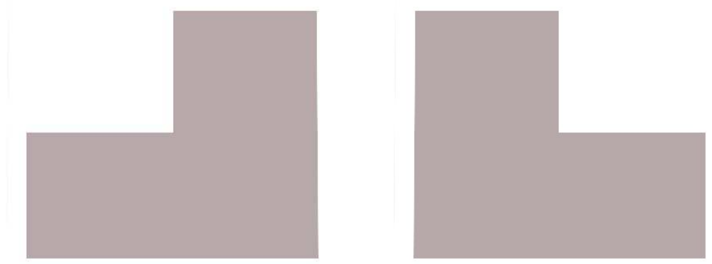


Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

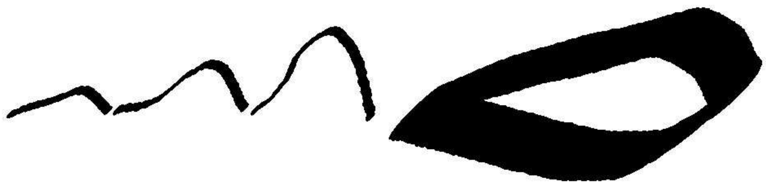


Choose one answer.
- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

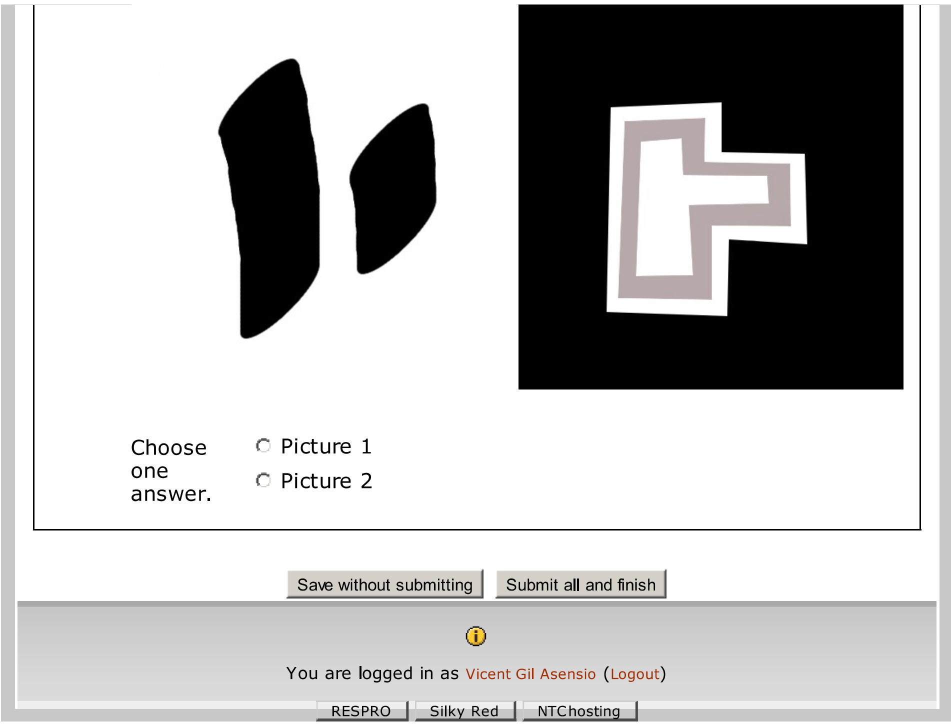


Choose one answer.
- Picture 1
- Picture 2

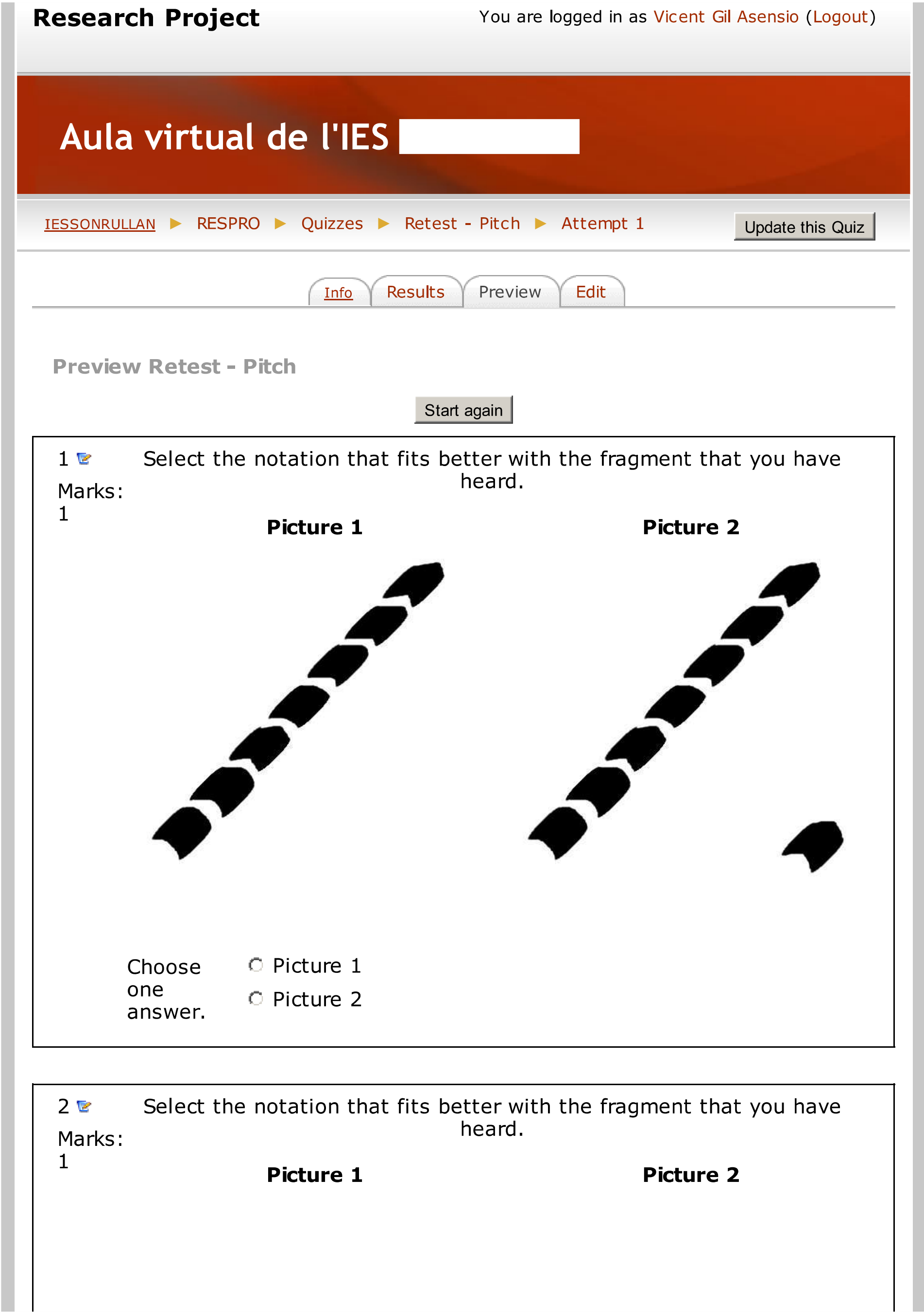
6 Marks: 1

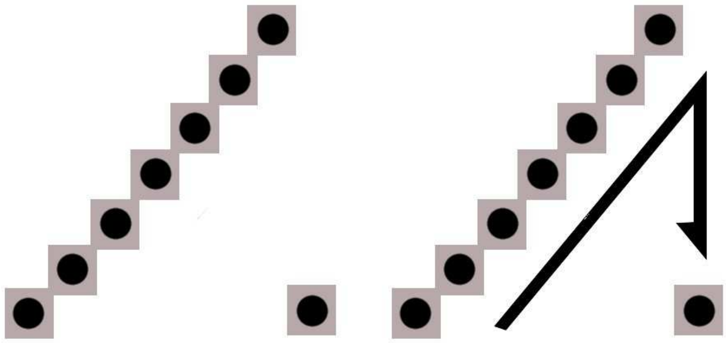
Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

A.5 Retention test



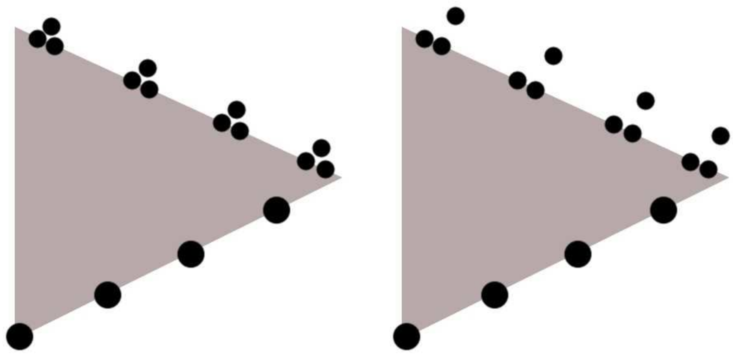


Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

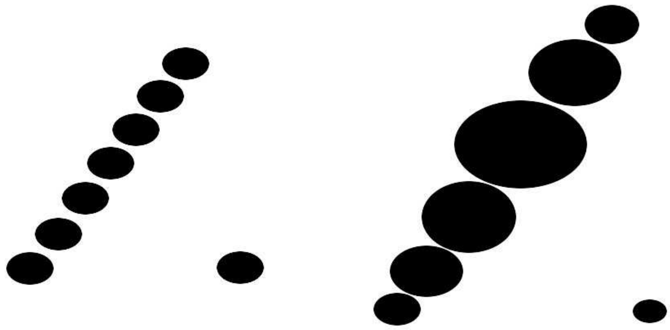


Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



Choose one answer.
- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

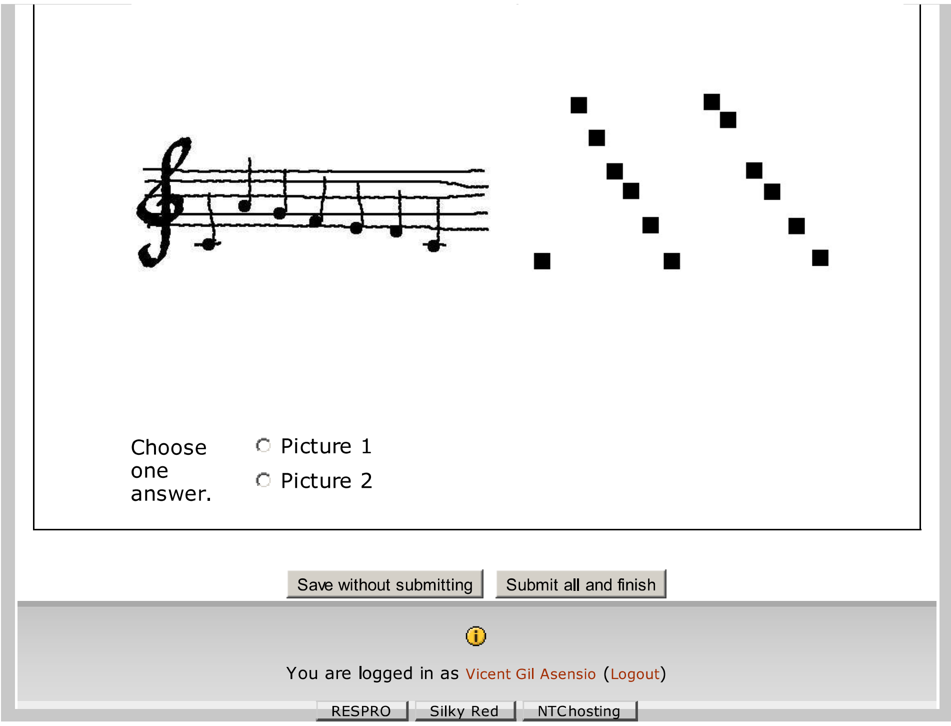
Picture 1 **Picture 2**

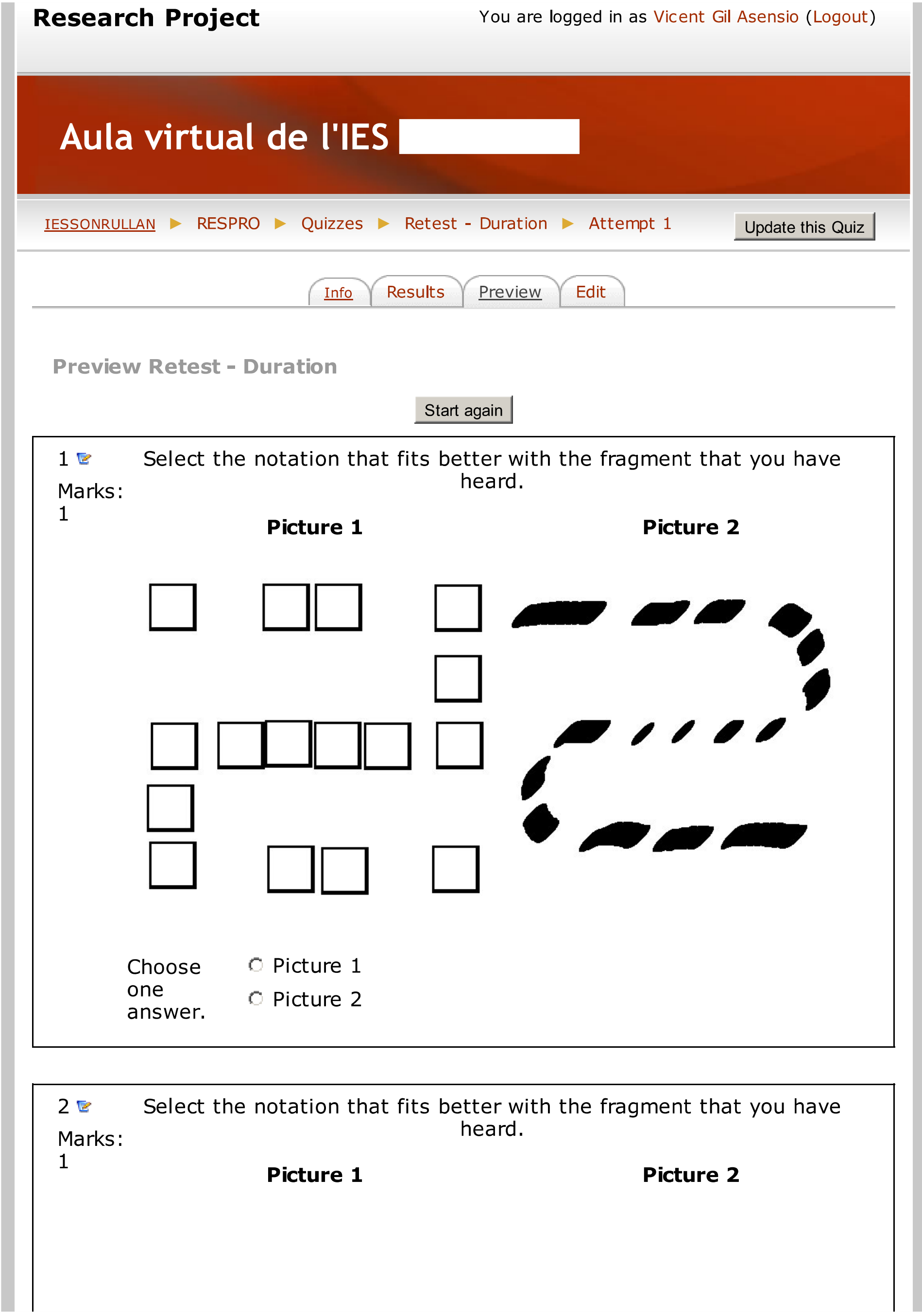
Choose one answer.
- Picture 1
- Picture 2

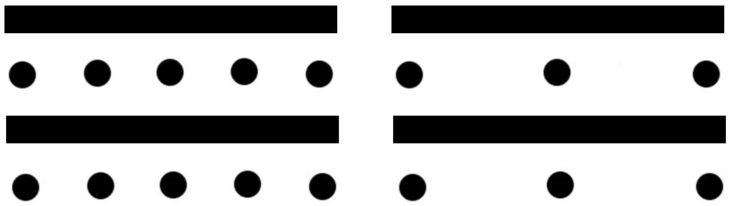
6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

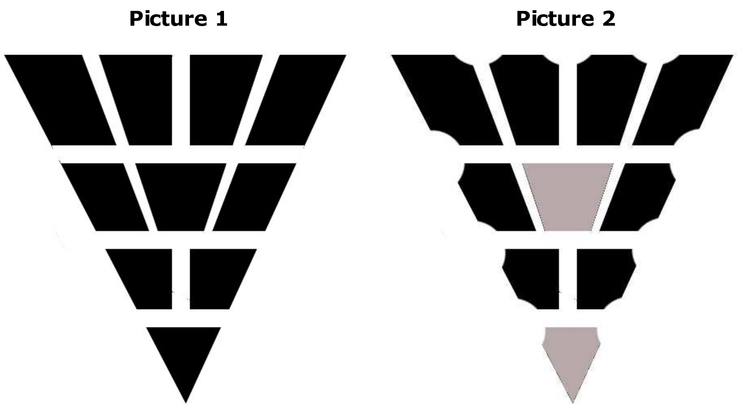

Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Retest - Duration ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Retest - Duration
Start again
1
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2
Choose one answer.
Picture 1
Picture 2
2
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2



Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

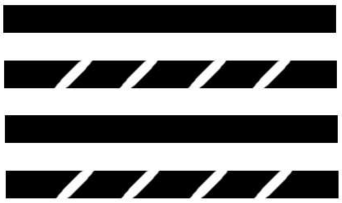


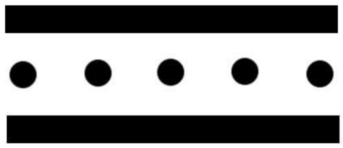
Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



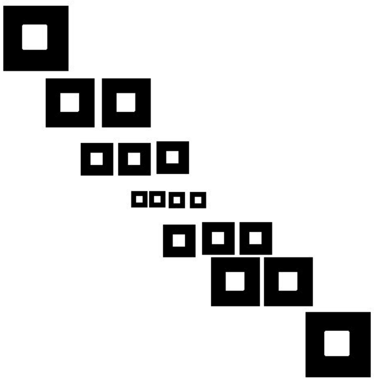


Choose one answer.
- Picture 1
- Picture 2

5
Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

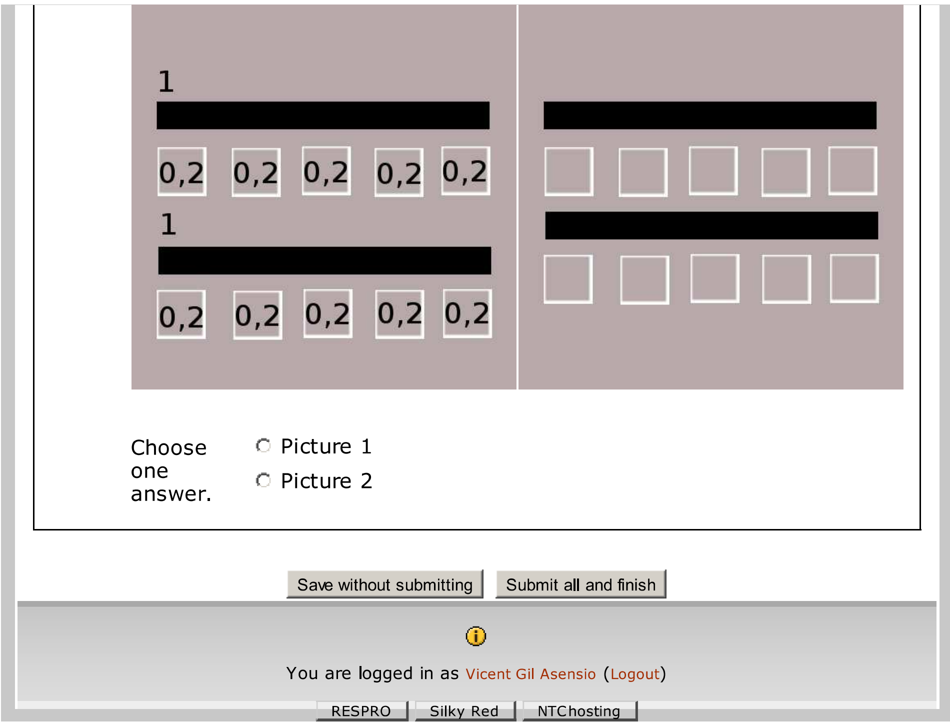


Choose one answer.
- Picture 1
- Picture 2

6
Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**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0,2 0,2 0,2 0,2 0,2
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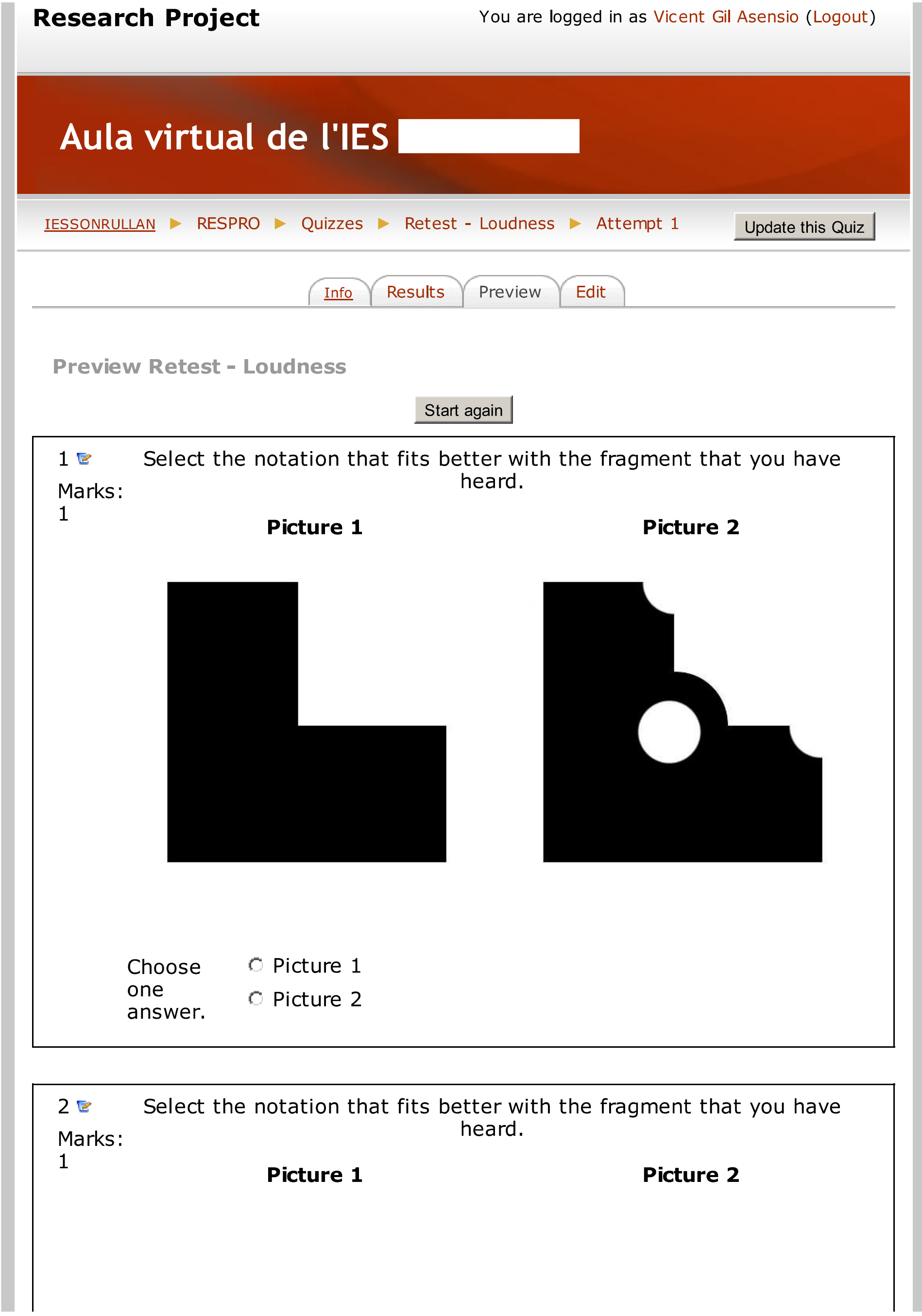
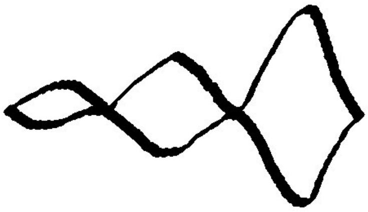
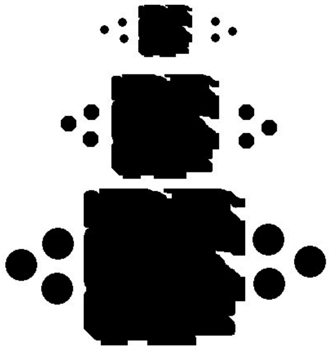
0,2 0,2 0,2 0,2 0,2
Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ► RESPRO ► Quizzes ► Retest - Loudness ► Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Retest - Loudness
Start again
1
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2
Choose one answer.
Picture 1
Picture 2
2
Marks: 1
Select the notation that fits better with the fragment that you have heard.
Picture 1
Picture 2



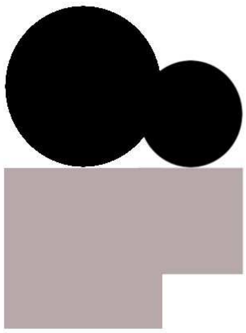


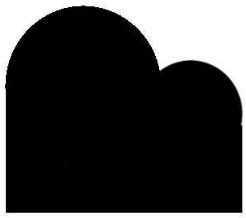
Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**



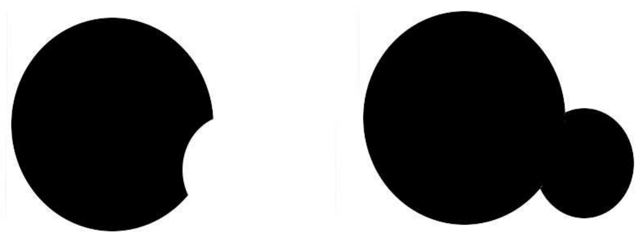


Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

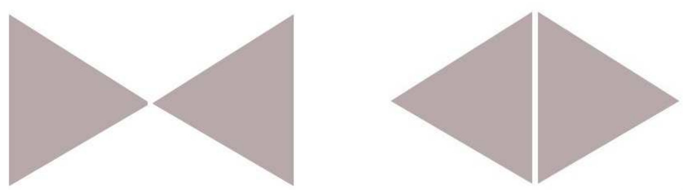


Choose one answer.
- Picture 1
- Picture 2

5 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**

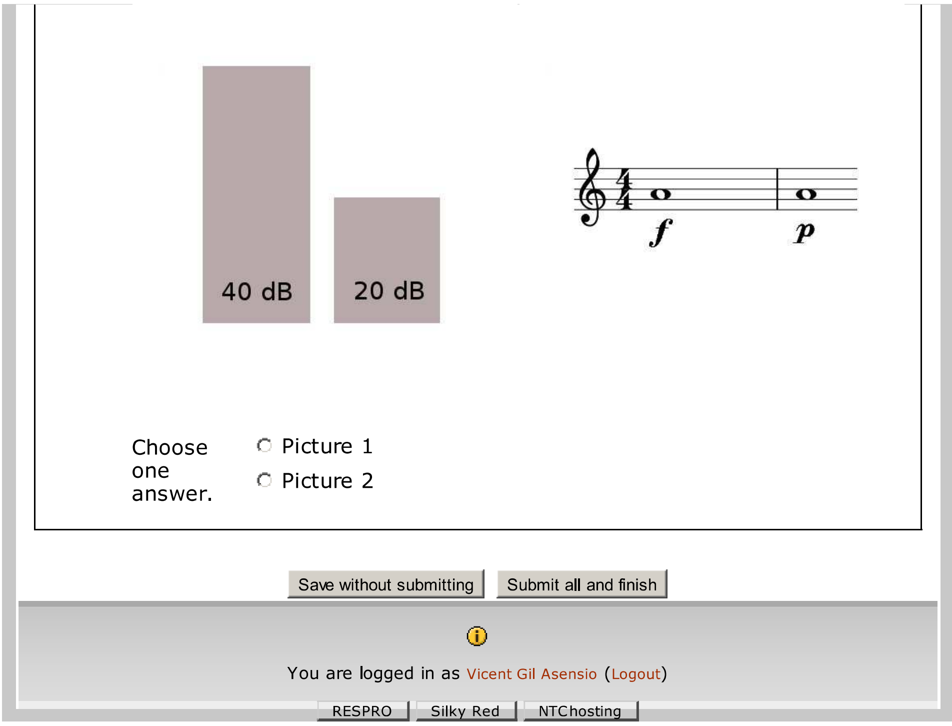


Choose one answer.
- Picture 1
- Picture 2

6 Marks: 1

Select the notation that fits better with the fragment that you have heard.

Picture 1 **Picture 2**


40 dB
20 dB
f
p
Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

A.6 Items grid

PITCH

PRE	12	14	1	4	18	7
10 10 10 01 01 10	IO	IO	IO	OI	OI	IO

POS	3	17	11	8	5	13
01 01 10 01 10 01	OI	OI	IO	OI	IO	OI

RET	6	15	2	9	16	10
01 10 01 10 10 10	OI	IO	OI	IO	IO	IO

DURATION

PRE	36	24	26	29	21	33
01 01 01 10 10 10	OI	OI	OI	IO	IO	IO

POS	30	35	22	25	31	19
10 10 01 10 01 10	IO	IO	OI	IO	OI	IO

RET	34	20	27	23	28	32
10 10 10 10 01 01	IO	IO	IO	IO	OI	OI

LOUDNESS

PRE	41	37	50	53	46	43
10 01 10 01 01 01	IO	OI	IO	OI	OI	OI

POS	49	44	47	39	40	54
10 01 10 01 10 01	IO	OI	IO	OI	IO	OI

RET	45	52	51	42	38	48
10 01 01 01 01 01	IO	OI	OI	OI	OI	OI

AUDIO 1	AUDIO 2	AUDIO 3

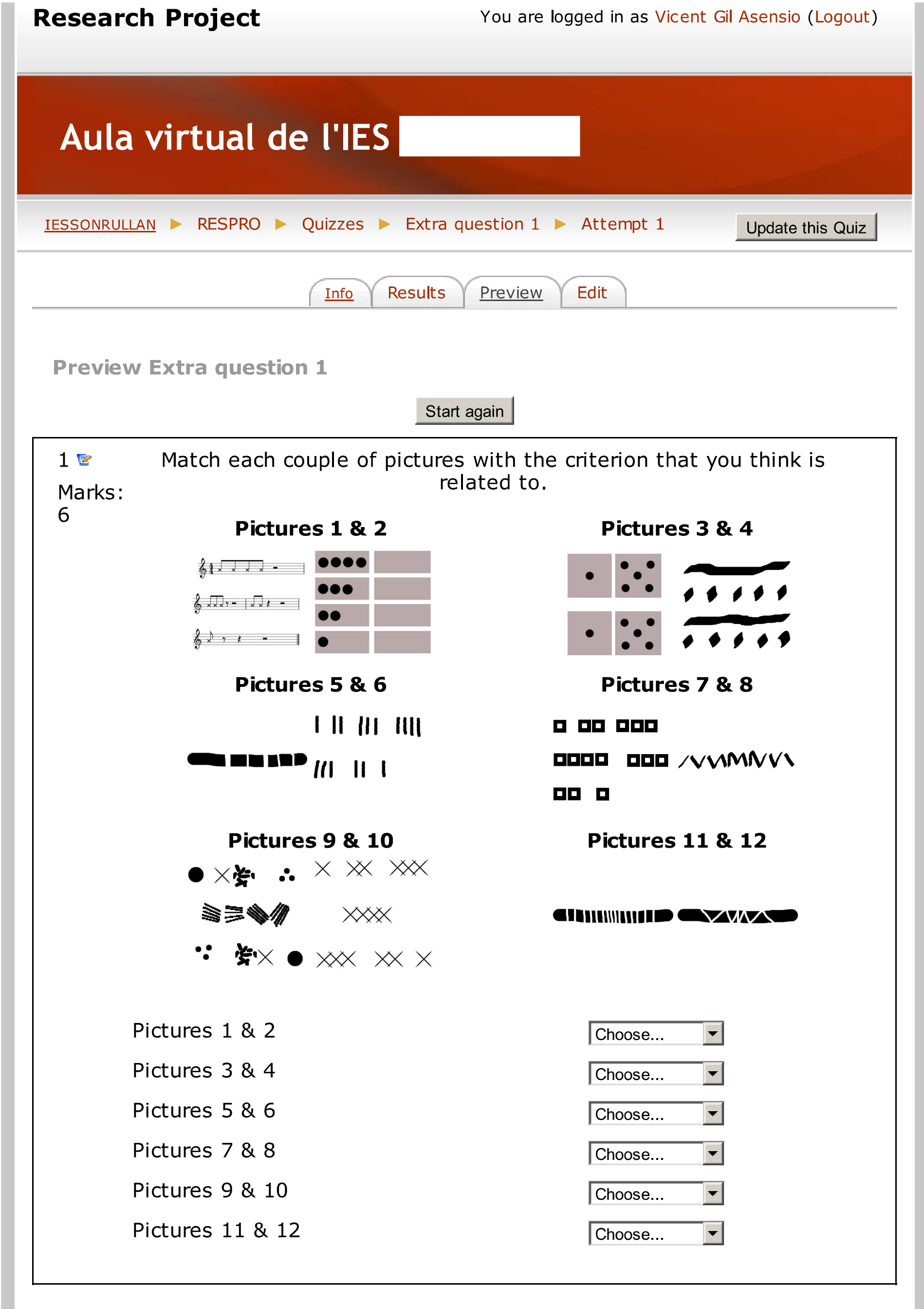
A.7 Sound fragments

No.	Music parameter	Duration (sec.)	Sound sample
1		13	`flute00.ogg`
2	Pitch	10	`tom03.ogg`
3		10	`space_strings01.ogg`
4		16	Default preset
5	Duration	8	Default preset
6		8	`bell_choir01.ogg`
7		12	`heaven_strings01.ogg`
8	Loudness	8	`bass_slap01.ogg`
9		8	`bell_choir01.ogg`

Table A.1: Set of sound fragments generated by the researchers.

The sound fragments can be accessed at `http://goo.gl/YBqdbY`

A.8 Extra questions

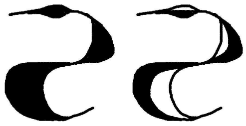


2

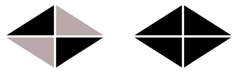
Marks: 6

Match each couple of pictures with the criterion that you think is related to.

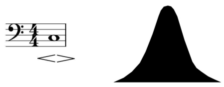
Pictures 1 & 2



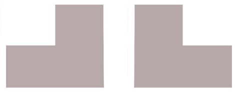
Pictures 3 & 4



Pictures 5 & 6

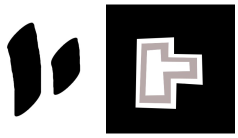


Pictures 7 & 8



Pictures 9 & 10

Pictures 11 & 12



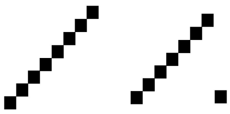
Pictures 1 & 2	Choose...
Pictures 3 & 4	Choose...
Pictures 5 & 6	Choose...
Pictures 7 & 8	Choose...
Pictures 9 & 10	Choose...
Pictures 11 & 12	Choose...

3

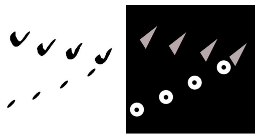
Marks: 6

Match each couple of pictures with the criterion that you think is related to.

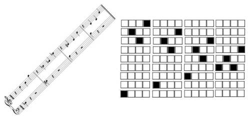
Pictures 1 & 2



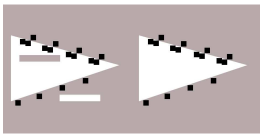
Pictures 3 & 4



Pictures 5 & 6

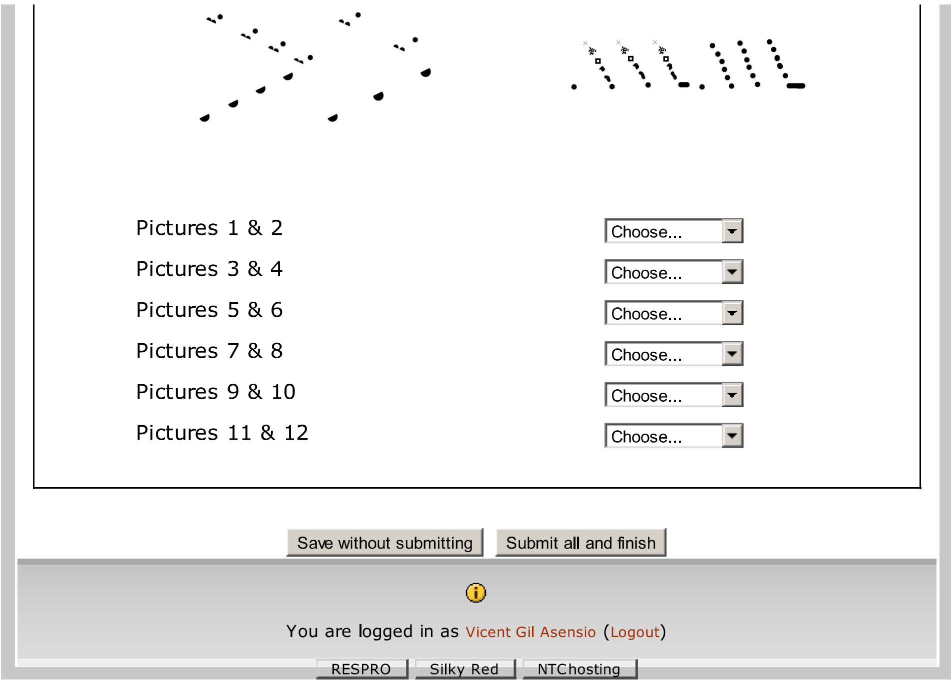


Pictures 7 & 8



Pictures 9 & 10

Pictures 11 & 12


Pictures 1 & 2
Choose...
Pictures 3 & 4
Choose...
Pictures 5 & 6
Choose...
Pictures 7 & 8
Choose...
Pictures 9 & 10
Choose...
Pictures 11 & 12
Choose...
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

Research Project You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Extra question 2 ▶ Attempt 1 Update this Quiz

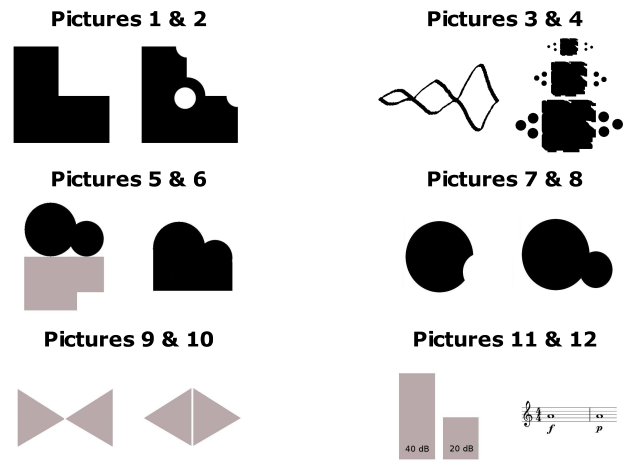
Info | Results | Preview | Edit

Preview Extra question 2

Start again

1 Marks: 6

Match each couple of pictures with the criterion that you think is related to.



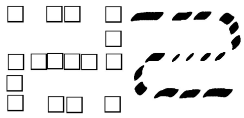
Pictures 1 & 2	Choose...
Pictures 3 & 4	Choose...
Pictures 5 & 6	Choose...
Pictures 7 & 8	Choose...
Pictures 9 & 10	Choose...
Pictures 11 & 12	Choose...

2

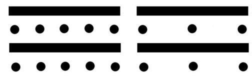
Marks: 6

Match each couple of pictures with the criterion that you think is related to.

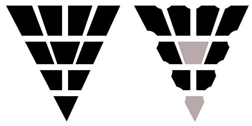
Pictures 1 & 2



Pictures 3 & 4

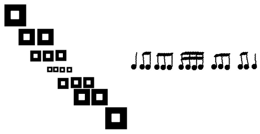


Pictures 5 & 6

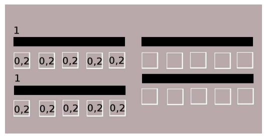


Pictures 7 & 8

Pictures 9 & 10



Pictures 11 & 12



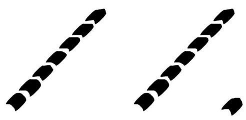
Pictures 1 & 2	Choose...
Pictures 3 & 4	Choose...
Pictures 5 & 6	Choose...
Pictures 7 & 8	Choose...
Pictures 9 & 10	Choose...
Pictures 11 & 12	Choose...

3

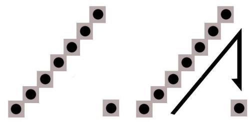
Marks: 6

Match each couple of pictures with the criterion that you think is related to.

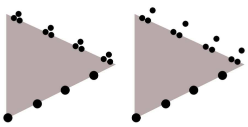
Pictures 1 & 2



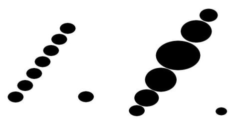
Pictures 3 & 4



Pictures 5 & 6

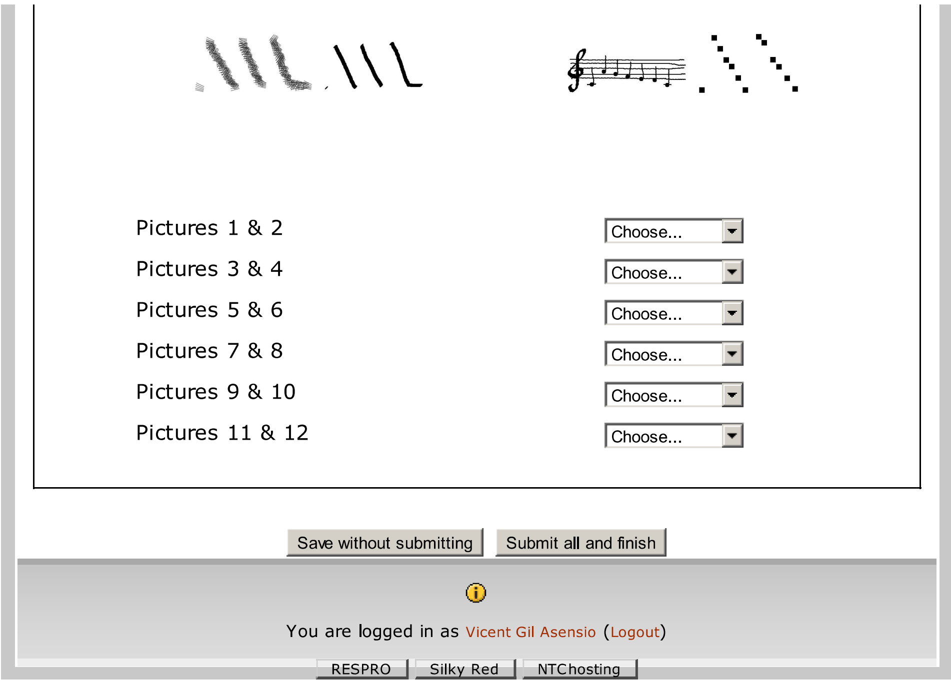


Pictures 7 & 8

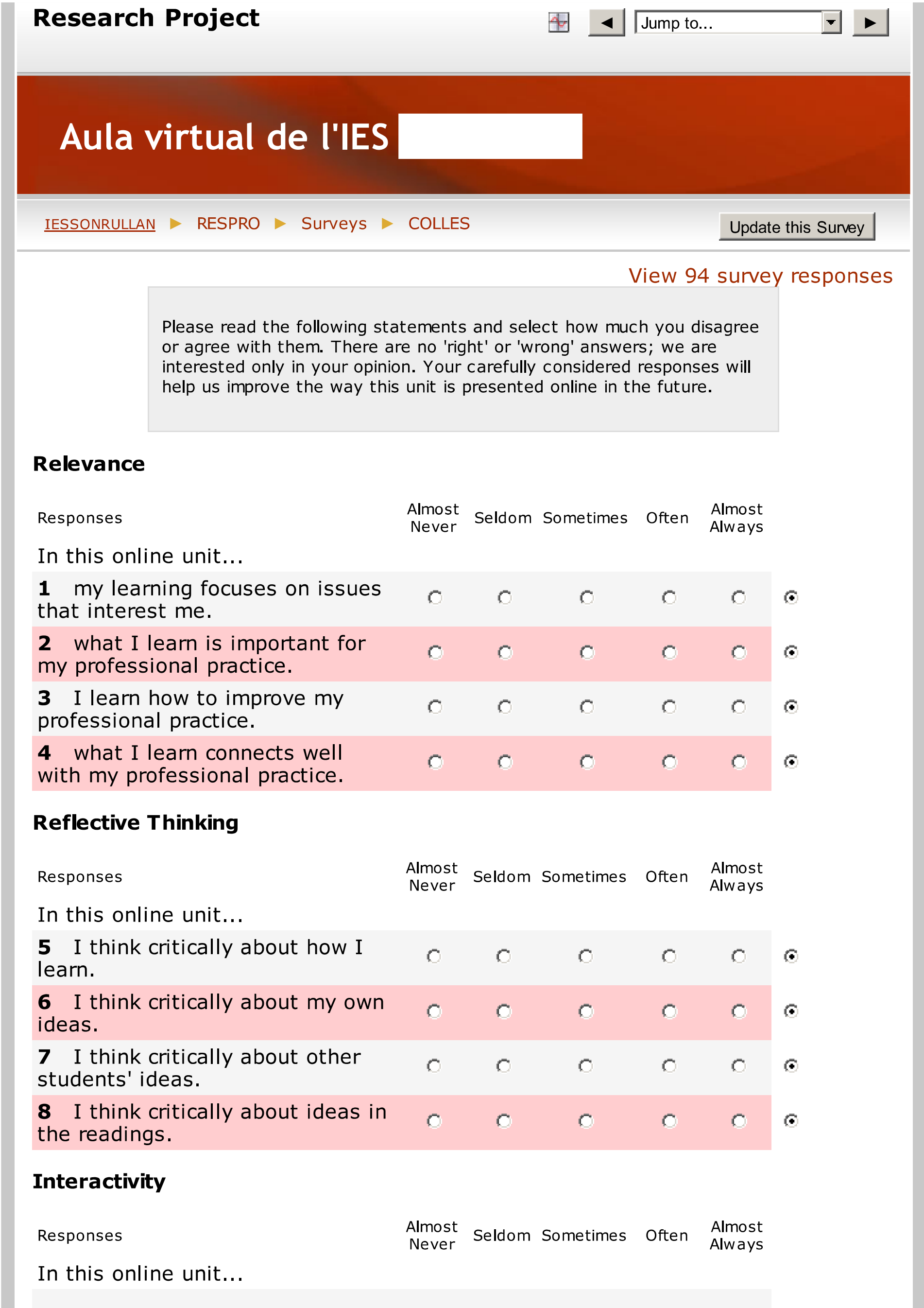


Pictures 9 & 10

Pictures 11 & 12


Pictures 1 & 2
Choose...
Pictures 3 & 4
Choose...
Pictures 5 & 6
Choose...
Pictures 7 & 8
Choose...
Pictures 9 & 10
Choose...
Pictures 11 & 12
Choose...
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

A.9 COLLES



Research Project

Jump to...

Aula virtual de l'IES

IESSONRULLAN ► RESPRO ► Surveys ► COLLES

Update this Survey

View 94 survey responses

Please read the following statements and select how much you disagree or agree with them. There are no 'right' or 'wrong' answers; we are interested only in your opinion. Your carefully considered responses will help us improve the way this unit is presented online in the future.

Relevance

Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					
1 my learning focuses on issues that interest me.					
2 what I learn is important for my professional practice.					
3 I learn how to improve my professional practice.					
4 what I learn connects well with my professional practice.					

Reflective Thinking

Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					
5 I think critically about how I learn.					
6 I think critically about my own ideas.					
7 I think critically about other students' ideas.					
8 I think critically about ideas in the readings.					

Interactivity

Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					

9 I explain my ideas to other students.					
10 I ask other students to explain their ideas.					
11 other students ask me to explain my ideas.					
12 other students respond to my ideas.					

Tutor Support

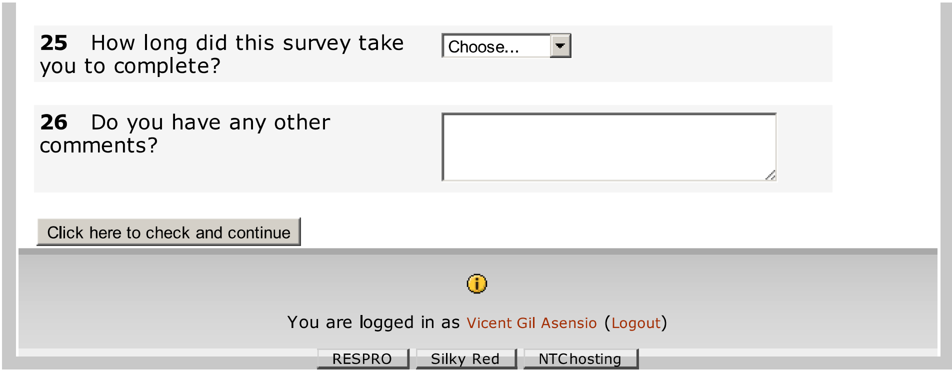
Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					
13 the tutor stimulates my thinking.					
14 the tutor encourages me to participate.					
15 the tutor models good discourse.					
16 the tutor models critical self-reflection.					

Peer Support

Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					
17 other students encourage my participation.					
18 other students praise my contribution.					
19 other students value my contribution.					
20 other students empathise with my struggle to learn.					

Interpretation

Responses	Almost Never	Seldom	Sometimes	Often	Almost Always
In this online unit...					
21 I make good sense of other students' messages.					
22 other students make good sense of my messages.					
23 I make good sense of the tutor's messages.					
24 the tutor makes good sense of my messages.					


25 How long did this survey take you to complete?
Choose...
26 Do you have any other comments?
Click here to check and continue
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

Appendix B

Procedures

B.1 Permission of the ethical review board

VNIVERSITAT
D VALÈNCIA
Vicerectorat d'Investigació i Política Científica

D. Fernando A. Verdú Pascual, Profesor Titular de Medicina Legal y Forense, y Secretario del Comité Ético de Investigación en Humanos de la Comisión de Ética en Investigación Experimental de la Universitat de València,

CERTIFICA:

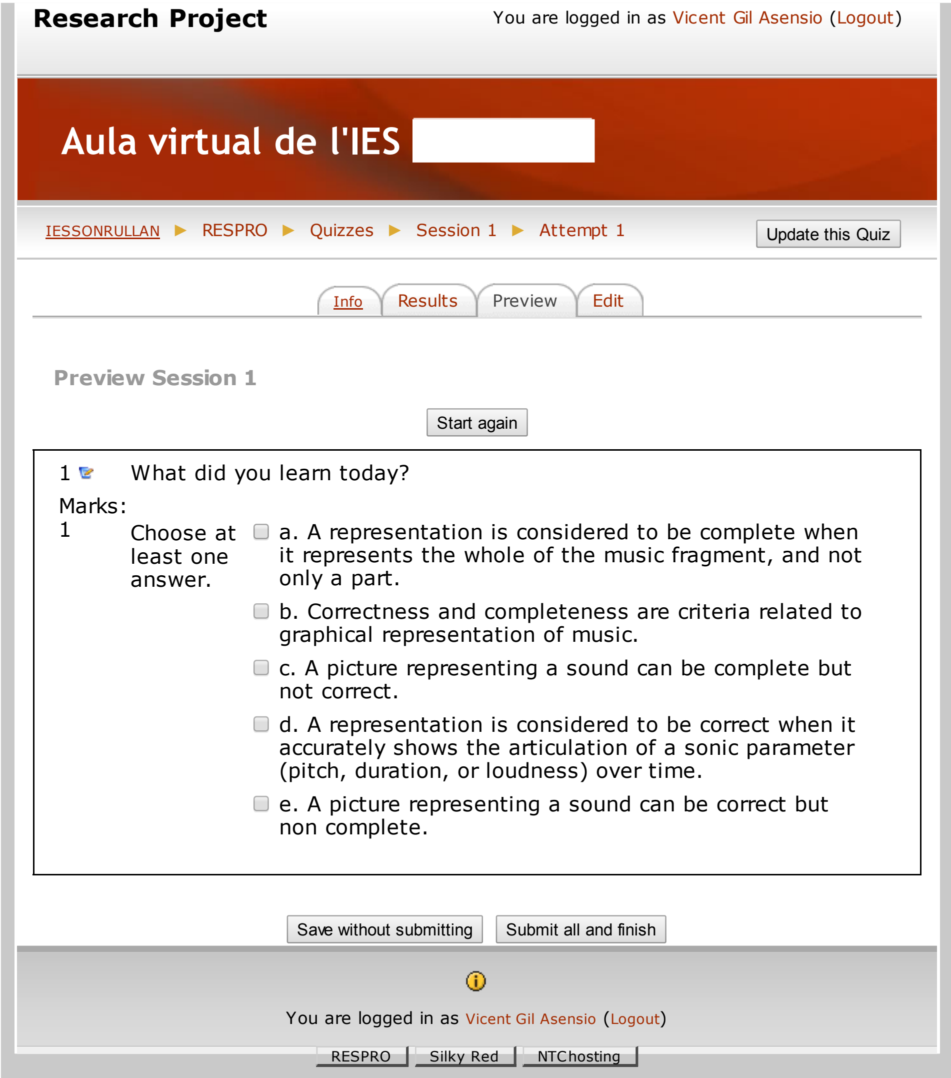
Que el Comité Ético de Investigación en Humanos, en la reunión celebrada el día 10 de febrero de 2014, una vez estudiado el proyecto de investigación titulado:
"Influència de l'entorn d'aprenentatge en les estratègies representacionals musicals dels estudiants de primer d'educació secundària obligatòria", número de procedimiento H1389506648750 ,
cuyo investigador responsable es D. Jesús Tejada Giménez,
ha acordado informar favorablemente el mismo dado que se respetan los principios fundamentales establecidos en la Declaración de Helsinki, en el Convenio del Consejo de Europa relativo a los derechos humanos y cumple los requisitos establecidos en la legislación española en el ámbito de la investigación biomédica, la protección de datos de carácter personal y la bioética.

Y para que conste, se firma el presente certificado en Valencia, a doce de febrero de dos mil catorce.

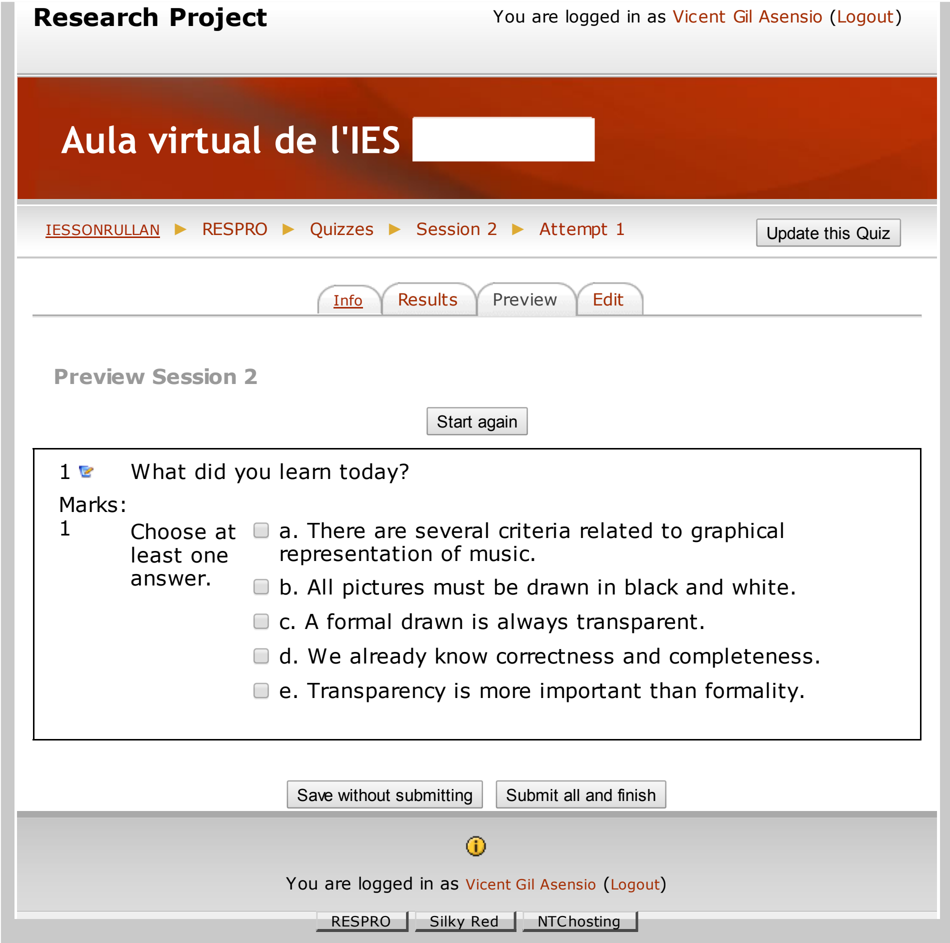
Carrer: Blasco Ibáñez, 13
VALÈNCIA 46071

Telèfon: (96) 386 41 09
Fax: (96) 398 32 21
e-mail: vicerec.investigacio@uv.es

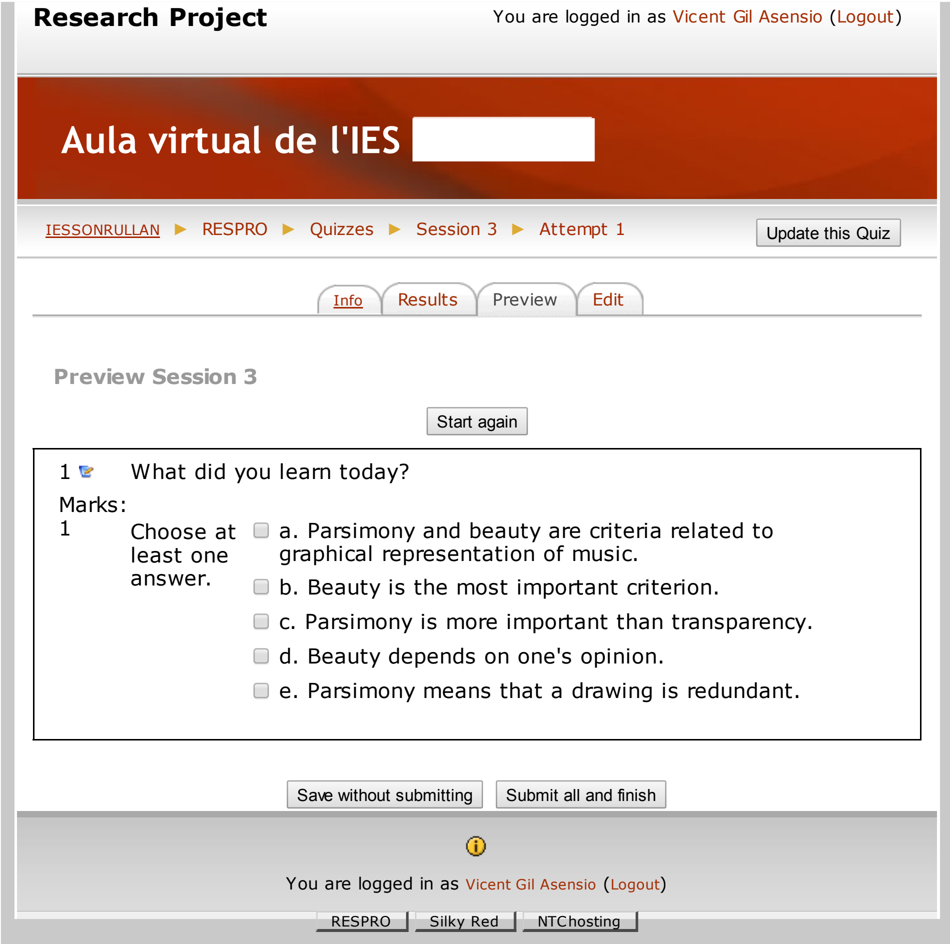
B.2 Session 1


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Session 1 ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Session 1
Start again
1 What did you learn today?
Marks: 1
Choose at least one answer.
a. A representation is considered to be complete when it represents the whole of the music fragment, and not only a part.
b. Correctness and completeness are criteria related to graphical representation of music.
c. A picture representing a sound can be complete but not correct.
d. A representation is considered to be correct when it accurately shows the articulation of a sonic parameter (pitch, duration, or loudness) over time.
e. A picture representing a sound can be correct but non complete.
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

B.3 Session 2


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ► RESPRO ► Quizzes ► Session 2 ► Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Session 2
Start again
1 What did you learn today?
Marks: 1
Choose at least one answer.
a. There are several criteria related to graphical representation of music.
b. All pictures must be drawn in black and white.
c. A formal drawn is always transparent.
d. We already know correctness and completeness.
e. Transparency is more important than formality.
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

B.4 Session 3


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Session 3 ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Session 3
Start again
1
What did you learn today?
Marks: 1
Choose at least one answer.
a. Parsimony and beauty are criteria related to graphical representation of music.
b. Beauty is the most important criterion.
c. Parsimony is more important than transparency.
d. Beauty depends on one's opinion.
e. Parsimony means that a drawing is redundant.
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
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Silky Red
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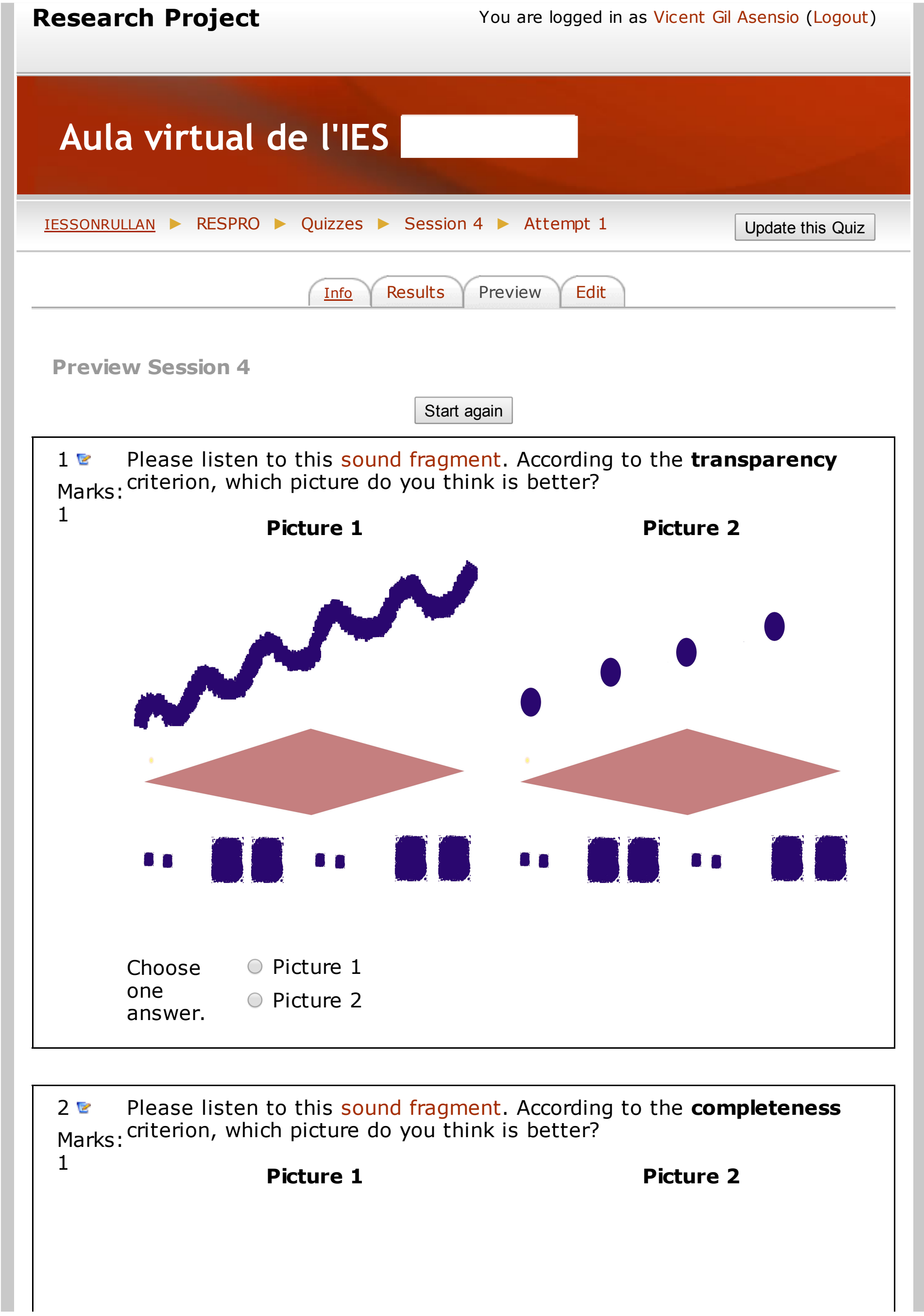
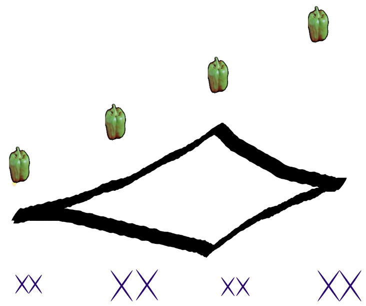
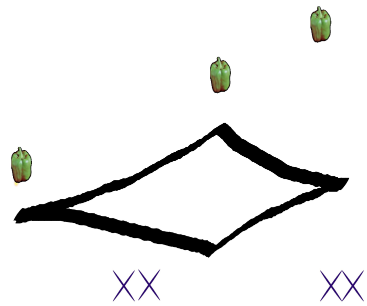
B.5 Session 4 (Control group)





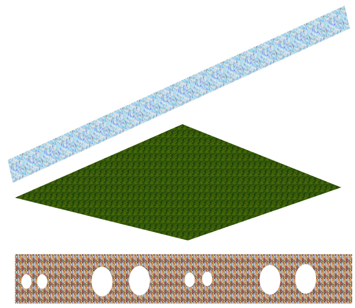


Choose one answer.
- Picture 1
- Picture 2

3 Marks: 1

Please listen to this sound fragment. According to the **beauty** criterion, which picture do you think is better?

Picture 1 **Picture 2**

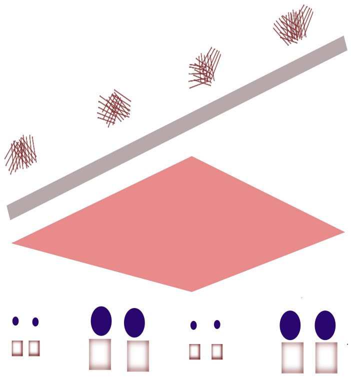


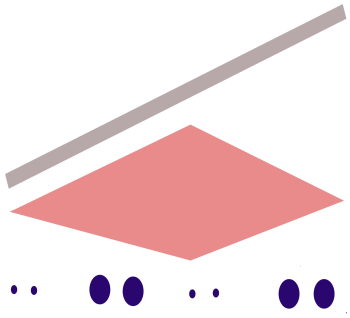
Choose one answer.
- Picture 1
- Picture 2

4 Marks: 1

Please listen to this sound fragment. According to the **parsimony** criterion, which picture do you think is better?

Picture 1 **Picture 2**





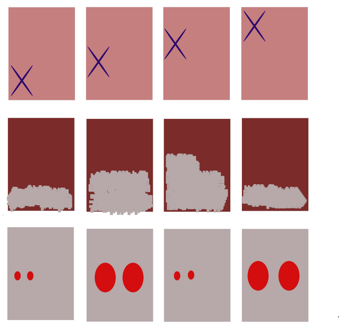
Choose one answer.

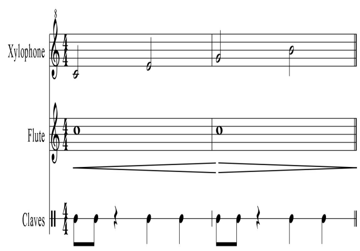
- Picture 1
- Picture 2

5 Marks: 1

Please listen to this sound fragment. According to the **formality** criterion, which picture do you think is better?

Picture 1 **Picture 2**





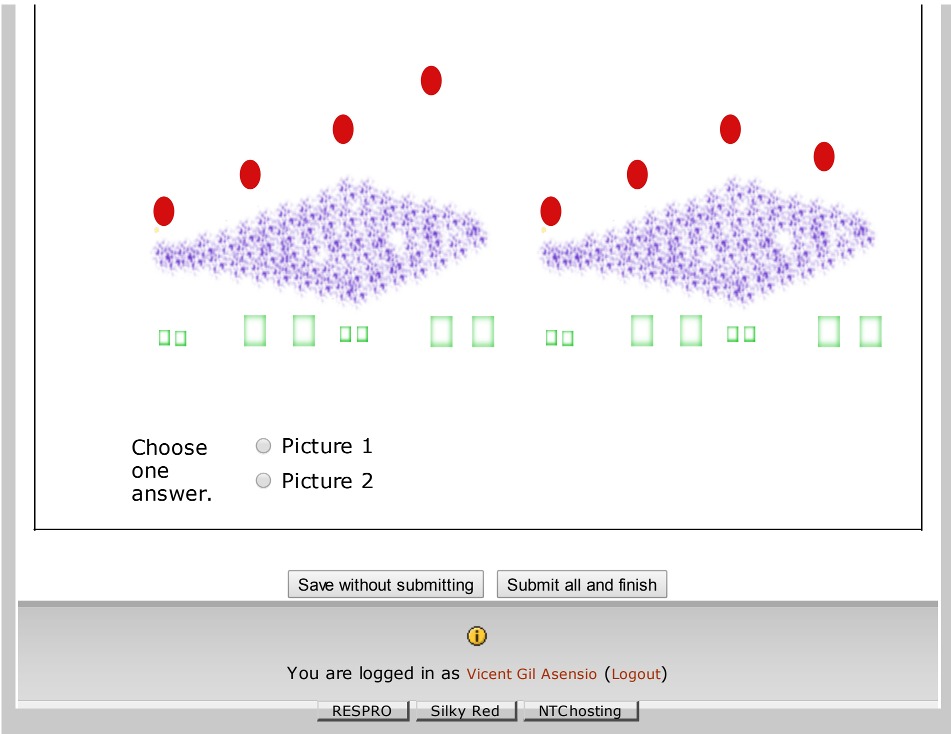
Choose one answer.

- Picture 1
- Picture 2

6 Marks: 1

Please listen to this sound fragment. According to the **correctness** criterion, which picture do you think is better?

Picture 1 **Picture 2**


Choose one answer.
Picture 1
Picture 2
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
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NTChosting

B.6 Session 4 (Experimental group)

Research Project

Jump to...

Aula virtual de l'IES

IESSONRULLAN ► RESPRO ► Lessons ► Session 4

Update this Lesson

Session 4

Preview | Edit | Reports | Grade Essays

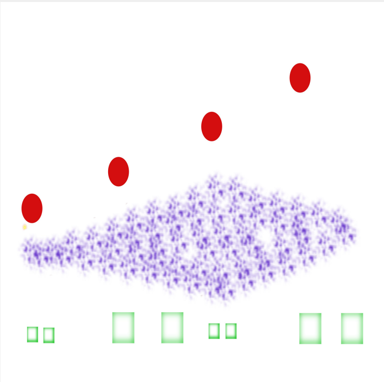
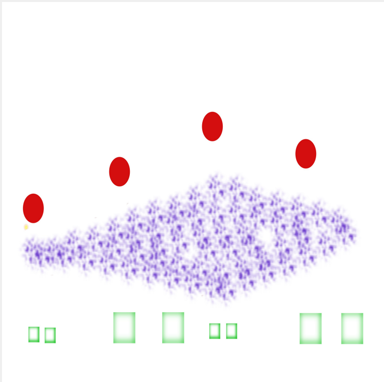
Collapsed Expanded

Import questions | Add a Cluster | Add a Branch Table | Add a question page here

Correctness

A representation is considered to be correct when it accurately shows the articulation of the relevant sonic parameter (pitch, duration, or loudness) over time.

Please listen to this sound fragment. According to the **correctness** criterion, which picture do you think is better?

Picture 1	**Picture 2**
	

Opcions múltiples

Answer 1:	Picture 1
Response 1:	Very good! Picture 1 is correct because you can see properly represented pitch (red bullets), duration (green squares) and loudness (blue rhombus).
Jump 1:	Completeness
Answer 2:	Picture 2
Response 2:	Sorry, you are wrong! Did you notice that there is a xylophone sound becoming higher? Red bullets represent

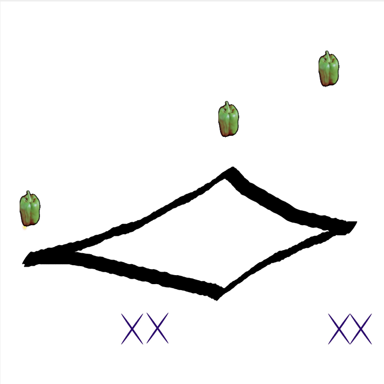
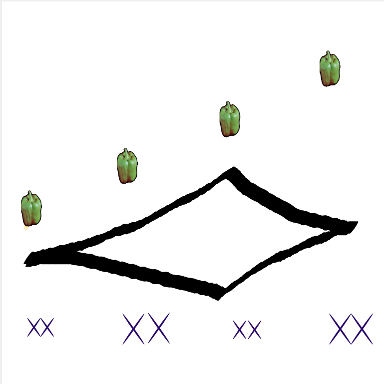
	that sound, but the last one is lower than the third one, which is incorrect. Instead, all red bullets should be drawn as in Picture 1. Please read again the explanation.
Jump 2:	This page

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Completeness

A representation is considered to be complete when it represents the whole of the music fragment, and not only a part.

Please listen to this sound fragment. According to the **completeness** criterion, which picture do you think is better?

Picture 1	**Picture 2**
	

Opcions múltiples

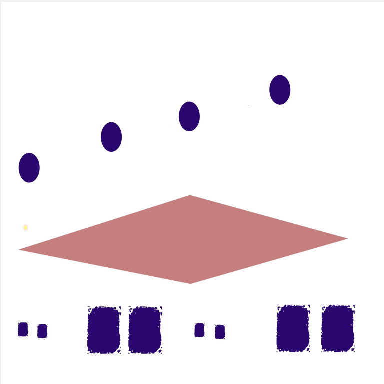
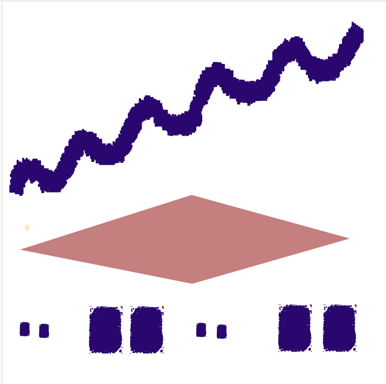
Answer 1:	Picture 1
Response 1:	Sorry, you are wrong! Did you notice that some items representing both pitch and duration are missing? Please read again the explanation.
Jump 1:	This page
Answer 2:	Picture 2
Response 2:	Very good! There are all the elements that you have heard in the sound fragment. Therefore, the drawing is complete.
Jump 2:	Transparency

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Transparency

When a representation contains an additional element that shows or suggests systematic variation that does not refer to any corresponding variation in the sound fragment that is to be represented, the representation is considered as misleading; when such misleading elements are absent, the representation is called transparent.

Please listen to this sound fragment. According to the **transparency** criterion, which picture do you think is better?

Picture 1	**Picture 2**
	

Opcions múltiples

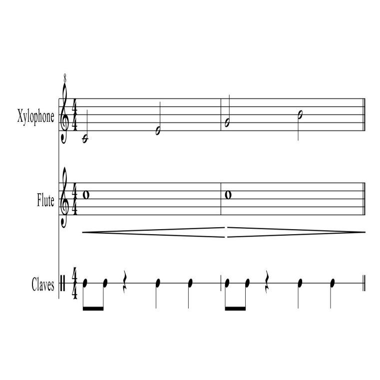
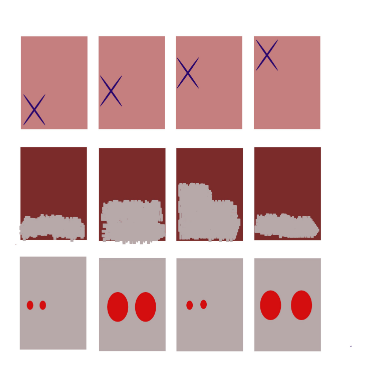
Answer 1:	Picture 1
Response 1:	Very good! In this drawing there are no misleading elements.
Jump 1:	Formality
Answer 2:	Picture 2
Response 2:	Sorry, you are wrong! Did you notice a xylophone sound becoming higuer? In this drawing, the waving line suggests a different sound effect, which is absent in the exemple that you have heard. Please read again the explanation.
Jump 2:	This page

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Formality

A representation is considered to be formal when it uses signs, symbols, rules, and/or conventions that belong to a formal notational system, and, more specifically, the Western “standard” system for music notation.

Please listen to this sound fragment. According to the **formality** criterion, which picture do you think is better?

Picture 1	Picture 2
	

Opcions múltiples	
Answer 1:	Picture 1
Response 1:	Very good! Here you can see three staves with the exact musical signs which represent the sound fragment that you have heard.
Jump 1:	Parsimony
Answer 2:	Picture 2
Response 2:	Sorry, you are wrong! You should always prefer the representation of music by means of a standard notational system. Please read again the explanation.
Jump 2:	This page

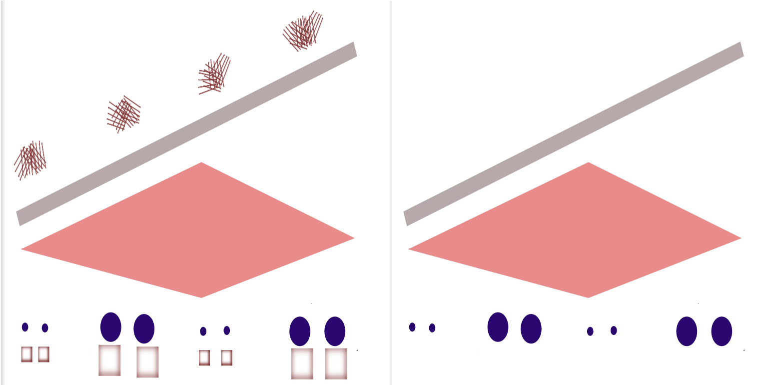
Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Parsimony

A representation is considered parsimonious when it contains no redundant information. This means that a given feature from the fragment is not represented by means of more than one feature in the representation.

Please listen to this sound fragment. According to the **parsimony** criterion, which picture do you think is better?

Picture 1	Picture 2



Opcions múltiples	
Answer 1:	Picture 1
Response 1:	Sorry, you are wrong! You can see squares below the bullets so as to indicate duration, and four shapes following the stright line. This is redundant, since the drawing could be easier with less information. Please read again the explanation.
Jump 1:	This page
Answer 2:	Picture 2
Response 2:	Very good! This is the best option, since the drawing has only the required information to represent the sound fragment.
Jump 2:	Beauty

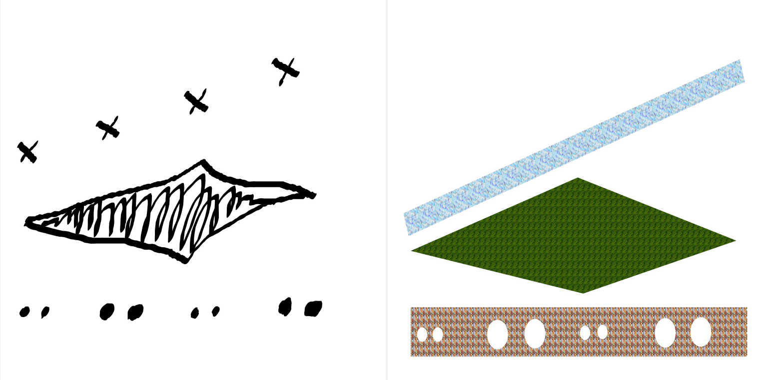
Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Beauty

This criterion refers to the presence or absence of a pleasant visual effect. For instance, the same representation can be made either with or without visual ornaments; it can be drawn neatly or sloppy.

Please listen to this sound fragment. According to the **beauty** criterion, which picture do you think is better?

Picture 1 **Picture 2**



Opcions múltiples	
Answer 1:	Picture 1
Response 1:	Sorry, you are wrong! Despite being difficult to describe beauty, this drawing seems to be sloppier than Picture 2. Please read again the explanation.
Jump 1:	This page
Answer 2:	Picture 2
Response 2:	Very good! Despite being difficult to describe beauty, this drawing seems to be neater than Picture 1.
Jump 2:	End of lesson

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

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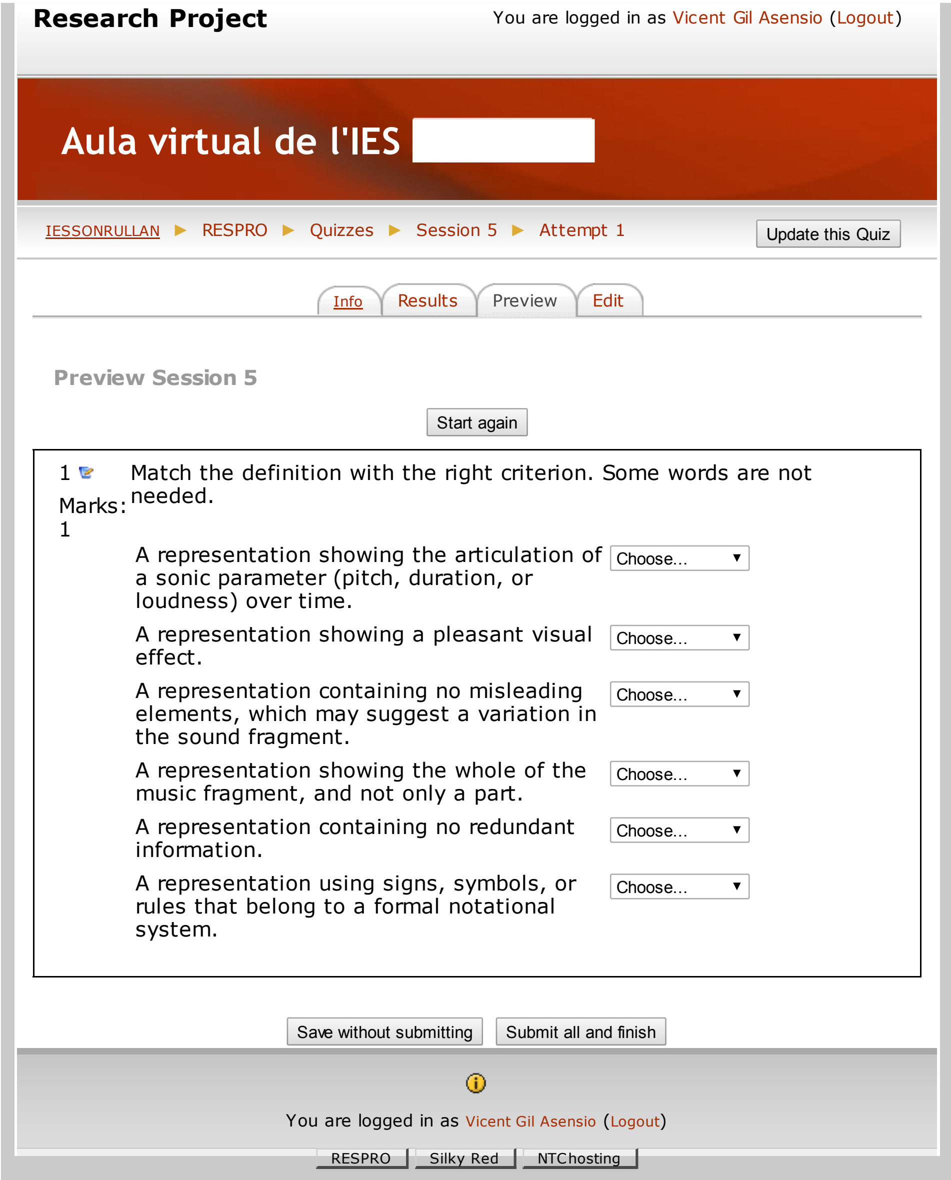
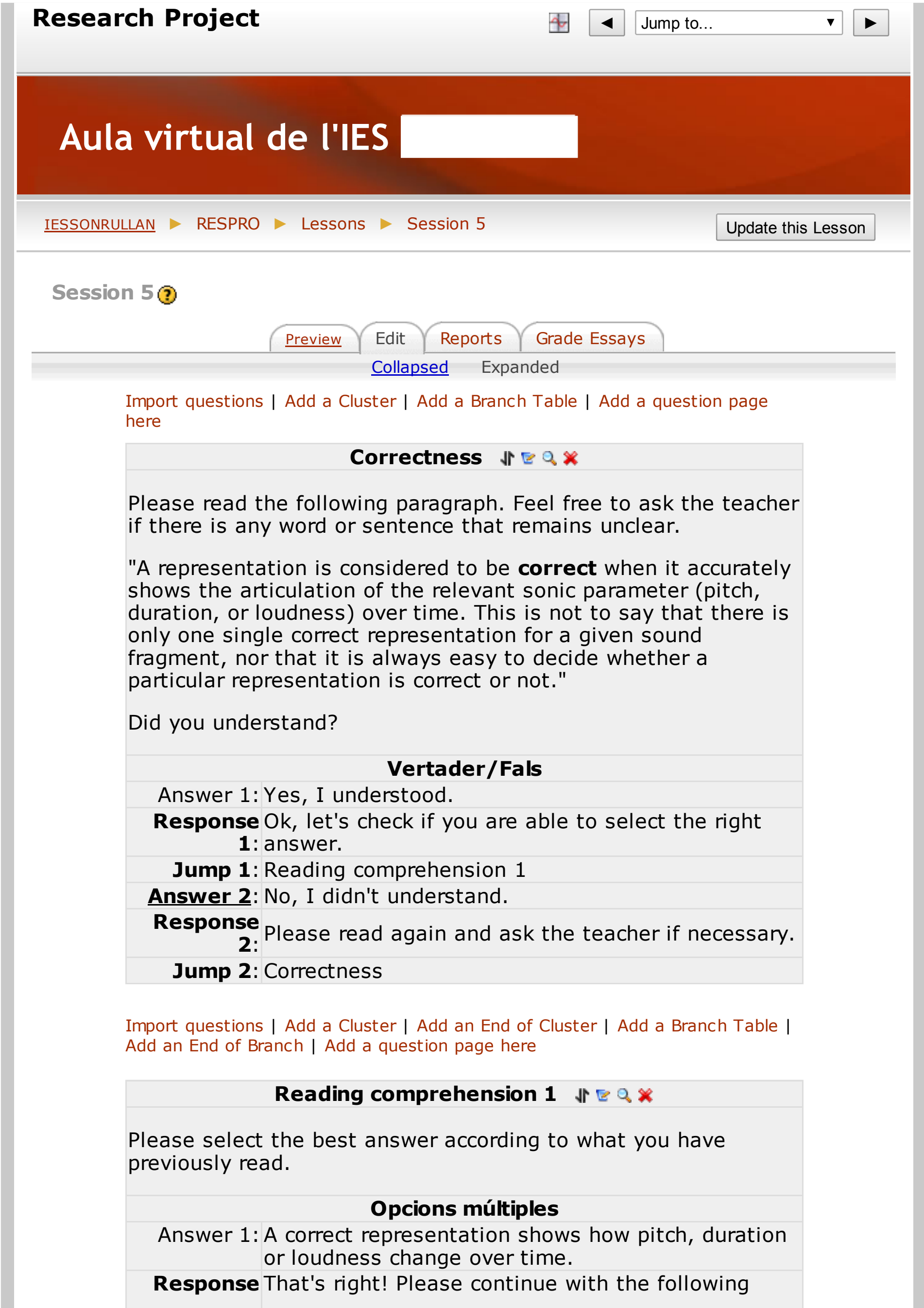
RESPRO | Silky Red | NTChosting

B.7 Session 5 (Control group)



B.8 Session 5 (Experimental group)



1:	page.
Jump 1:	Completeness
Answer 2:	A correct representation shows how pitch and duration change over time. There is no way to represent loudness.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Correctness
Answer 3:	There is only one single correct representation for a given sound fragment.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Correctness
Answer 4:	It is always easy to decide whether a particular representation is correct or not.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Correctness

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Completeness

Please read the following paragraph. Feel free to ask the teacher if there is any word or sentence that remains unclear.

"A representation is considered to be **complete** when it represents the whole of the music fragment, and not only a part. It could be argued that the difference between correctness and completeness is a complex or subtle matter. The fact is that a correct representation must be complete, but a complete one may be incorrect."

Did you understand?

Vertader/Fals	
Answer 1:	Yes, I understood.
Response 1:	Ok, let's check if you are able to select the right answer.
Jump 1:	Reading comprehension 2
Answer 2:	No, I didn't understand.
Response 2:	Please read again and ask the teacher if necessary.
Jump 2:	Completeness

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Reading comprehension 2

Please select the best answer according to what you have previously read.

Opcions múltiples	
Answer 1:	A complete representation shows the whole of the music fragment.
Response 1:	That's right! Please continue with the following page.
Jump 1:	Transparency
Answer 2:	A complete representation shows only a part of the music fragment.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Completeness
Answer 3:	The difference between correctness and completeness remains unclear.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Completeness
Answer 4:	A correct representation must be complete, and a complete representation must be correct.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Completeness

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Transparency

Please read the following paragraph. Feel free to ask the teacher if there is any word or sentence that remains unclear.

"When a representation contains an additional element that shows or suggests systematic variation that does not refer to any corresponding variation in the sound fragment that is to be represented, the representation is considered as misleading; when such misleading elements are absent, the representation is called **transparent**."

Did you understand?

Vertader/Fals	
Answer 1:	Yes, I understood.
Response 1:	Ok, let's check if you are able to select the right answer.
Jump 1:	Reading comprehension 3
Answer 2:	No, I didn't understand.
Response 2:	Please read again and ask the teacher if necessary.
Jump 2:	Transparency

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Reading comprehension 3	
Please select the best answer according to what you have previously read.	
Opcions múltiples	
Answer 1:	If there are no misleading elements, the representation is considered to be transparent.
Response 1:	That's right! Please continue with the following page.
Jump 1:	Formality
Answer 2:	A transparent representation contains misleading elements.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Transparency
Answer 3:	A misleading representation shows clearly the variation in the sound fragment.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Transparency
Answer 4:	A misleading representation may be transparent.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Transparency

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Formality	
Please read the following paragraph. Feel free to ask the teacher if there is any word or sentence that remains unclear. "A representation is considered to be **formal** when it uses signs, symbols, rules, and/or conventions that belong to a formal notational system, and, more specifically, the Western "standard" system for music notation." Did you understand?	
Vertader/Fals	
Answer 1:	Yes, I understood.
Response 1:	Ok, let's check if you are able to select the right answer.
Jump 1:	Reading comprehension 4
Answer 2:	No, I didn't understand.
Response 2:	Please read again and ask the teacher if necessary.
Jump 2:	Formality

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Reading comprehension 4

Please select the best answer according to what you have previously read.

Opcions múltiples	
Answer 1:	A formal representation uses staves and notes.
Response 1:	That's right! Please continue with the following page.
Jump 1:	Parsimony
Answer 2:	A formal representation is always correct.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Formality
Answer 3:	A formal representation uses only Western notational signs.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Formality
Answer 4:	A formal representation must be complete.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Formality

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Parsimony

Please read the following paragraph. Feel free to ask the teacher if there is any word or sentence that remains unclear.

"A representation is considered **parsimonious** when it contains no redundant information. This means that a given feature from the fragment is not represented by means of more than one feature in the representation."

Did you understand?

Vertader/Fals	
Answer 1:	Yes, I understood.
Response 1:	Ok, let's check if you are able to select the right answer.
Jump 1:	Reading comprehension 5
Answer 2:	No, I didn't understand.
Response 2:	Please read again and ask the teacher if necessary.
Jump 2:	Parsimony

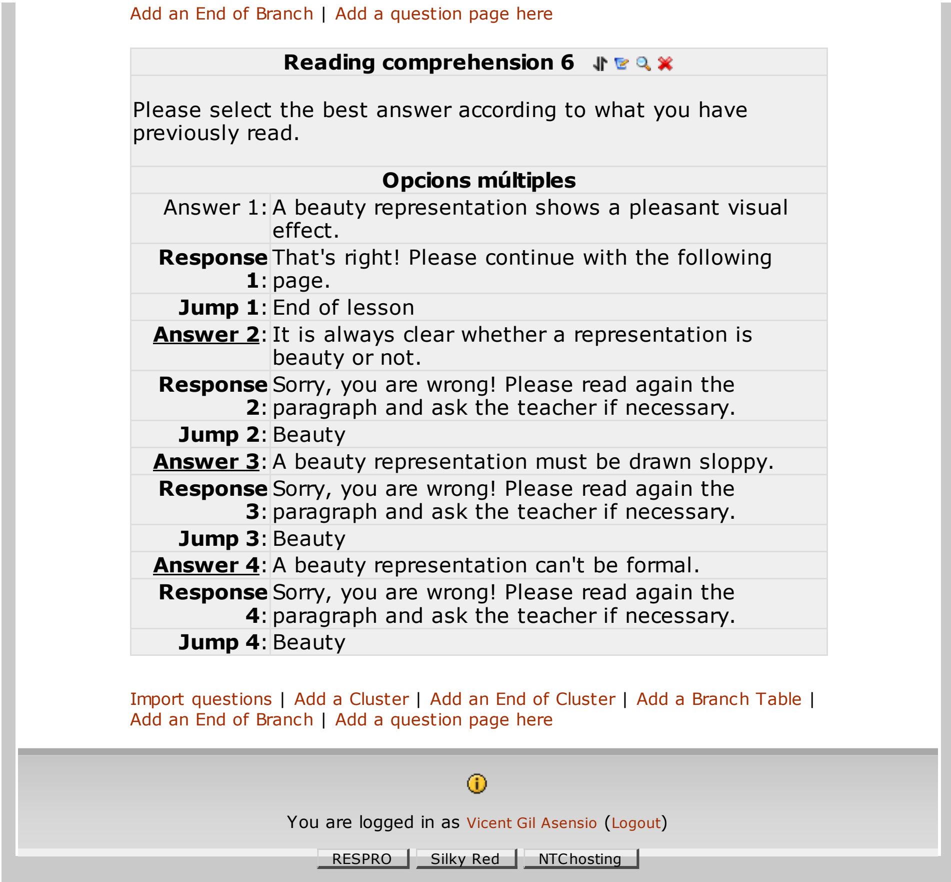
Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Reading comprehension 5	
Please select the best answer according to what you have previously read.	
Opcions múltiples	
Answer 1:	If there is no redundant information, the representation is parsimonious.
Response 1:	That's right! Please continue with the following page.
Jump 1:	Beauty
Answer 2:	In a parsimonious representation, a given feature from the sound fragment is represented by means of more than one graphical element.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Parsimony
Answer 3:	A parsimonious representation may be redundant.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Parsimony
Answer 4:	A parsimonious representation must be transparent.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Parsimony

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

Beauty	
Please read the following paragraph. Feel free to ask the teacher if there is any word or sentence that remains unclear. "**Beauty** criterion refers to the presence or absence of a pleasant visual effect. For instance, the same representation can be made either with or without visual ornaments; it can be drawn neatly or sloppy." Did you understand?	
Vertader/Fals	
Answer 1:	Yes, I understood.
Response 1:	Ok, let's check if you are able to select the right answer.
Jump 1:	Reading comprehension 6
Answer 2:	No, I didn't understand.
Response 2:	Please read again and ask the teacher if necessary.
Jump 2:	Beauty

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table |



Add an End of Branch | Add a question page here

Reading comprehension 6

Please select the best answer according to what you have previously read.

Opcions múltiples	
Answer 1:	A beauty representation shows a pleasant visual effect.
Response 1:	That's right! Please continue with the following page.
Jump 1:	End of lesson
Answer 2:	It is always clear whether a representation is beauty or not.
Response 2:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 2:	Beauty
Answer 3:	A beauty representation must be drawn sloppy.
Response 3:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 3:	Beauty
Answer 4:	A beauty representation can't be formal.
Response 4:	Sorry, you are wrong! Please read again the paragraph and ask the teacher if necessary.
Jump 4:	Beauty

Import questions | Add a Cluster | Add an End of Cluster | Add a Branch Table | Add an End of Branch | Add a question page here

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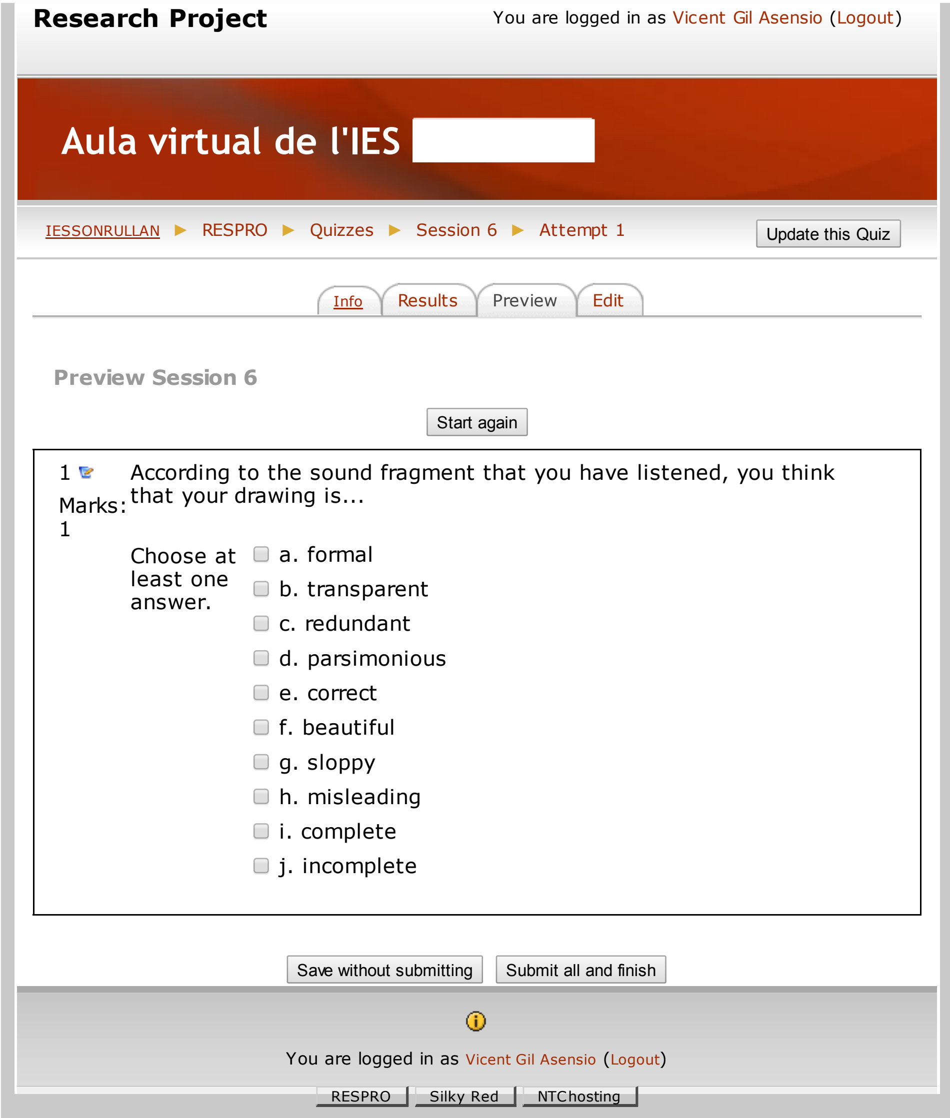
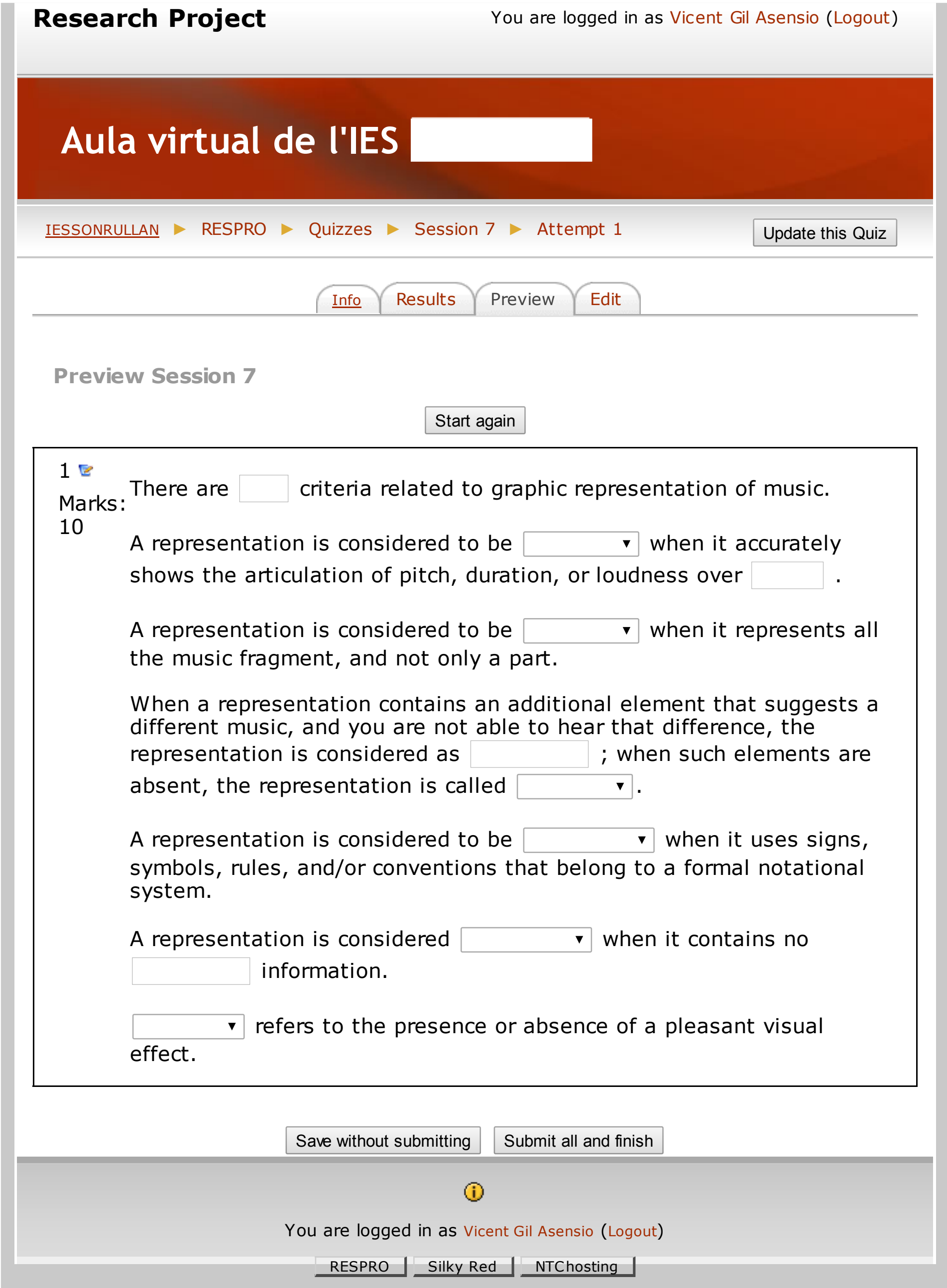
B.9 Session 6


Research Project
You are logged in as Vicent Gil Asensio (Logout)
Aula virtual de l'IES
IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Session 6 ▶ Attempt 1
Update this Quiz
Info
Results
Preview
Edit
Preview Session 6
Start again
1
Marks: 1
According to the sound fragment that you have listened, you think that your drawing is...
Choose at least one answer.
a. formal
b. transparent
c. redundant
d. parsimonious
e. correct
f. beautiful
g. sloppy
h. misleading
i. complete
j. incomplete
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
Silky Red
NTChosting

B.10 Session 7



Research Project You are logged in as Vicent Gil Asensio (Logout)

Aula virtual de l'IES

IESSONRULLAN ▶ RESPRO ▶ Quizzes ▶ Session 7 ▶ Attempt 1 Update this Quiz

Info | Results | Preview | Edit

Preview Session 7

Start again

1
Marks: 10

There are ____ criteria related to graphic representation of music.

A representation is considered to be ____ when it accurately shows the articulation of pitch, duration, or loudness over ____ .

A representation is considered to be ____ when it represents all the music fragment, and not only a part.

When a representation contains an additional element that suggests a different music, and you are not able to hear that difference, the representation is considered as ____ ; when such elements are absent, the representation is called ____.

A representation is considered to be ____ when it uses signs, symbols, rules, and/or conventions that belong to a formal notational system.

A representation is considered ____ when it contains no ____ information.

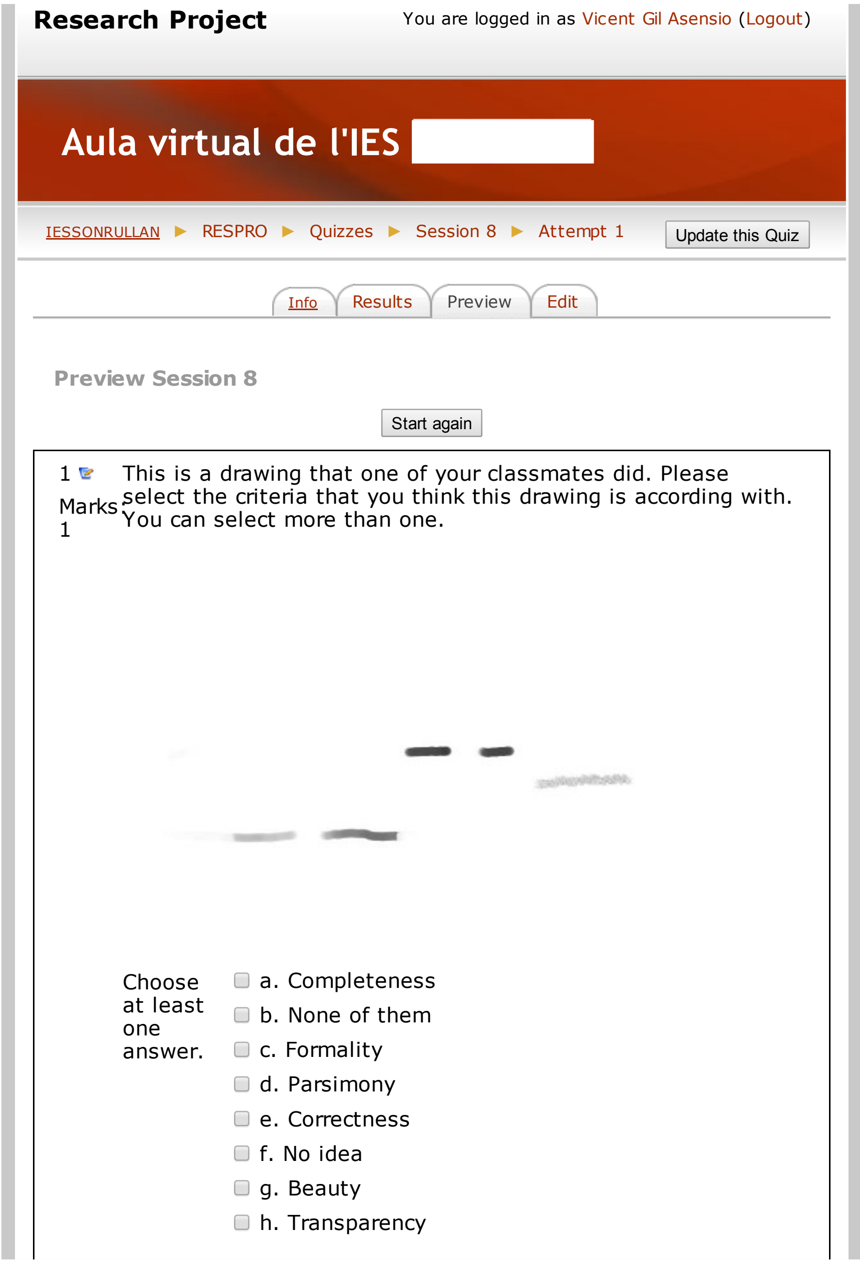
____ refers to the presence or absence of a pleasant visual effect.

Save without submitting | Submit all and finish

You are logged in as Vicent Gil Asensio (Logout)

RESPRO | Silky Red | NTChosting

B.11 Session 8



2 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Correctness
- b. Formality
- c. Parsimony
- d. No idea
- e. Beauty
- f. Completeness
- g. None of them
- h. Transparency

3 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Beauty
- b. No idea
- c. Correctness
- d. Parsimony
- e. None of them
- f. Completeness
- g. Transparency
- h. Formality

4 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Completeness
- b. Beauty
- c. No idea
- d. Transparency
- e. None of them
- f. Parsimony
- g. Correctness
- h. Formality

5 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Beauty
- b. Formality
- c. Parsimony
- d. Completeness
- e. None of them
- f. Correctness
- g. No idea
- h. Transparency

6 This is a drawing that one of your classmates did. Please

Marks: 1

select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Correctness
- b. Formality
- c. Completeness
- d. Transparency
- e. No idea
- f. Parsimony
- g. Beauty
- h. None of them

7

Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Completeness
- b. Beauty
- c. No idea
- d. Parsimony
- e. Correctness
- f. Transparency
- g. None of them
- h. Formality

8 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Formality
- b. Transparency
- c. Completeness
- d. Parsimony
- e. None of them
- f. No idea
- g. Correctness
- h. Beauty

9 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. No idea
- b. Completeness
- c. Correctness
- d. Parsimony
- e. Formality
- f. Transparency
- g. None of them
- h. Beauty

10 This is a drawing that one of your classmates did. Please

Marks: 1

select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Formality
- b. Completeness
- c. None of them
- d. Parsimony
- e. Transparency
- f. Beauty
- g. No idea
- h. Correctness

11

Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Beauty
- b. Correctness
- c. None of them
- d. Transparency
- e. Formality
- f. Completeness
- g. Parsimony
- h. No idea

12 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Correctness
- b. Formality
- c. No idea
- d. Beauty
- e. Completeness
- f. Transparency
- g. Parsimony
- h. None of them

13 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Parsimony
- b. Transparency
- c. Correctness
- d. Beauty
- e. No idea
- f. None of them
- g. Completeness
- h. Formality

14 This is a drawing that one of your classmates did. Please

Marks: 1

select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Correctness
- b. Parsimony
- c. Formality
- d. Transparency
- e. Completeness
- f. None of them
- g. No idea
- h. Beauty

15

Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Completeness
- b. None of them
- c. No idea
- d. Correctness
- e. Beauty
- f. Parsimony
- g. Transparency
- h. Formality

16 Marks 1

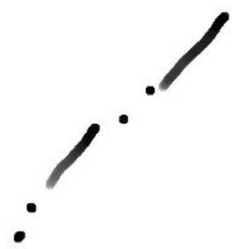
This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Beauty
- b. Formality
- c. Completeness
- d. Parsimony
- e. None of them
- f. Correctness
- g. No idea
- h. Transparency

17 Marks: 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.



Choose at least one answer.

- a. Beauty
- b. Formality
- c. Parsimony
- d. No idea
- e. Correctness
- f. Completeness
- g. Transparency
- h. None of them

18 This is a drawing that one of your classmates did. Please

Marks: 1

select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. Transparency
- b. Completeness
- c. Parsimony
- d. None of them
- e. Correctness
- f. No idea
- g. Formality
- h. Beauty

19

Marks: 1

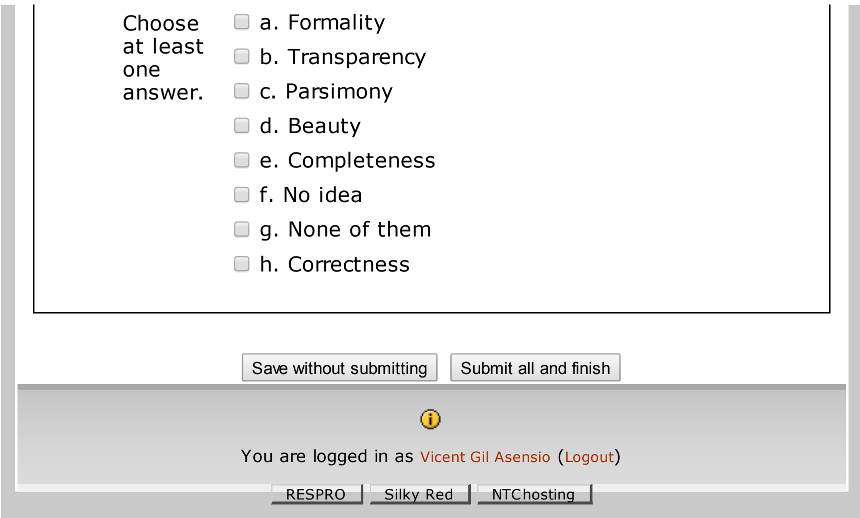
This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.

Choose at least one answer.

- a. No idea
- b. Completeness
- c. Beauty
- d. Transparency
- e. Correctness
- f. None of them
- g. Formality
- h. Parsimony

20 Marks 1

This is a drawing that one of your classmates did. Please select the criteria that you think this drawing is according with. You can select more than one.


Choose at least one answer.
a. Formality
b. Transparency
c. Parsimony
d. Beauty
e. Completeness
f. No idea
g. None of them
h. Correctness
Save without submitting
Submit all and finish
You are logged in as Vicent Gil Asensio (Logout)
RESPRO
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Appendix C

R output

C.1 Descriptive analysis

```
Call:
glm(formula = all ~ treat * time, family = "poisson", data = gee1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.1609  -0.3345   0.0000   0.4338   1.2243

Coefficients:
                                Estimate Std. Error z value Pr(>|z|)
(Intercept)                      2.30259    0.04939  46.624  < 2e-16 ***
treatControl                     0.04035    0.07255   0.556 0.578097
timePosttest                     0.22412    0.06624   3.383 0.000716 ***
timeRetention test               0.21825    0.06633   3.290 0.001001 **
treatControl:timePosttest       -0.06997    0.09816  -0.713 0.475952
treatControl:timeRetention test -0.12655    0.09900  -1.278 0.201190
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 95.502  on 224  degrees of freedom
Residual deviance: 75.639  on 219  degrees of freedom
AIC: 1049.7

Number of Fisher Scoring iterations: 4

with(m1, cbind(res.deviance = deviance, df = df.residual,
+ p = pchisq(deviance, df.residual, lower.tail = FALSE)))
     res.deviance  df p
[1,]     75.63947 219 1
```

C.2 Inferential analysis

C.2.1 Overall and lasting effect

```
Call:
geeglm(formula = all ~ treat * time, family = poisson(link = "log"),
    data = gee.pre.pos.1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                2.30259  0.03085 5570.307  < 2e-16 ***
treatControl               0.04035  0.03827    1.112    0.292
timePosttest               0.22412  0.04120   29.588 5.34e-08 ***
treatControl:timePosttest -0.06997  0.05476    1.633    0.201
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.287    0.04

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.1244  0.1223
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ treat * time, family = poisson(link = "log"),
    data = gee.pos.ret.1, id = id, corstr = "ar1")

 Coefficients:
                                 Estimate   Std.err      Wald Pr(>|W|)
(Intercept)                      2.526704  0.025134 10106.427   <2e-16 ***
treatControl                    -0.029617  0.034244     0.748    0.387
timeRetention test              -0.005865  0.029706     0.039    0.843
treatControl:timeRetention test -0.056577  0.052111     1.179    0.278
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3339 0.04662

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
```

```
alpha   0.1371  0.1306
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                                Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                      2.30259  0.03085 5570.307  < 2e-16 ***
treatControl                     0.04035  0.03827    1.112    0.292
timePosttest                     0.22412  0.04120   29.588 5.34e-08 ***
timeRetention test               0.21825  0.04500   23.524 1.23e-06 ***
treatControl:timePosttest       -0.06997  0.05476    1.633    0.201
treatControl:timeRetention test -0.12655  0.05645    5.025    0.025 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3211 0.03668

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01525 0.07298
Number of clusters:   75   Maximum cluster size: 3
```

C.2.2 Influence of music experience

```
Call:
geeglm(formula = all ~ meq * time * treat, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                                           Estimate   Std.err     Wald Pr(>|W|)
(Intercept)                                2.344549  0.042696 3015.460  < 2e-16 ***
meqMedium                                 -0.006873  0.066701    0.011  0.91793
meqLow                                    -0.082786  0.065052    1.620  0.20315
timePosttest                               0.103990  0.073308    2.012  0.15604
timeRetention test                         0.209350  0.077323    7.330  0.00678 **
treatControl                              -0.013793  0.045809    0.091  0.76334
meqMedium:timePosttest                     0.078332  0.101642    0.594  0.44091
meqLow:timePosttest                        0.191474  0.094576    4.099  0.04291 *
meqMedium:timeRetention test              -0.038589  0.112119    0.118  0.73071
meqLow:timeRetention test                  0.046583  0.102287    0.207  0.64881
meqMedium:treatControl                     0.003395  0.078710    0.002  0.96560
meqLow:treatControl                        0.112884  0.077934    2.098  0.14749
```

```
timePosttest:treatControl                  0.013793  0.107877    0.016  0.89826
timeRetention test:treatControl           -0.067176  0.092767    0.524  0.46899
meqMedium:timePosttest:treatControl        0.015581  0.139641    0.012  0.91116
meqLow:timePosttest:treatControl          -0.185205  0.135673    1.863  0.17223
meqMedium:timeRetention test:treatControl -0.055957  0.137920    0.165  0.68495
meqLow:timeRetention test:treatControl    -0.087178  0.125897    0.479  0.48865
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3088 0.03571

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0452 0.07401
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = all ~ meq * time * treat, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                                         Estimate   Std.err     Wald Pr(>|W|)
(Intercept)                              2.337676  0.051246 2080.910  < 2e-16 ***
meqLow                                  -0.075913  0.070958    1.145  0.28469
meqHigh                                  0.006873  0.066701    0.011  0.91793
timePosttest                             0.182322  0.070406    6.706  0.00961 **
timeRetention test                       0.170761  0.081190    4.424  0.03545 *
treatControl                            -0.010399  0.064006    0.026  0.87094
meqLow:timePosttest                      0.113143  0.092345    1.501  0.22049
meqHigh:timePosttest                    -0.078332  0.101642    0.594  0.44091
meqLow:timeRetention test                0.085173  0.105241    0.655  0.41834
meqHigh:timeRetention test               0.038589  0.112119    0.118  0.73071
meqLow:treatControl                      0.109490  0.089845    1.485  0.22298
meqHigh:treatControl                    -0.003395  0.078710    0.002  0.96560
timePosttest:treatControl                0.029375  0.088668    0.110  0.74043
timeRetention test:treatControl         -0.123133  0.102059    1.456  0.22763
meqLow:timePosttest:treatControl        -0.200786  0.120962    2.755  0.09693 .
meqHigh:timePosttest:treatControl       -0.015581  0.139641    0.012  0.91116
meqLow:timeRetention test:treatControl  -0.031221  0.132892    0.055  0.81426
meqHigh:timeRetention test:treatControl  0.055957  0.137920    0.165  0.68495
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3088 0.03571
```

```

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0452 0.07401
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = all ~ meq * time * treat, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                                            Estimate    Std.err     Wald
(Intercept)                                2.449e+00  5.753e-02 1811.501
meqMedium                                  7.146e-02  7.396e-02    0.933
meqLow                                     1.087e-01  6.602e-02    2.711
timeRetention test                         1.054e-01  4.280e-02    6.059
treatControl                              -1.578e-16  8.680e-02    0.000
meqMedium:timeRetention test              -1.169e-01  7.094e-02    2.717
meqLow:timeRetention test                 -1.449e-01  5.904e-02    6.023
meqMedium:treatControl                     1.898e-02  1.050e-01    0.033
meqLow:treatControl                       -7.232e-02  9.719e-02    0.554
timeRetention test:treatControl           -8.097e-02  8.452e-02    0.918
meqMedium:timeRetention test:treatControl -7.154e-02  1.250e-01    0.327
meqLow:timeRetention test:treatControl     9.803e-02  1.129e-01    0.754
                                          Pr(>|W|)
(Intercept)                                 <2e-16 ***
meqMedium                                   0.3340
meqLow                                      0.0997 .
timeRetention test                          0.0138 *
treatControl                                1.0000
meqMedium:timeRetention test                0.0993 .
meqLow:timeRetention test                   0.0141 *
meqMedium:treatControl                      0.8566
meqLow:treatControl                         0.4568
timeRetention test:treatControl             0.3381
meqMedium:timeRetention test:treatControl   0.5672
meqLow:timeRetention test:treatControl      0.3851
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3195 0.04497

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
```

```
alpha   0.1763  0.1223
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ meq * time * treat, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                                       Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                             2.52000  0.04649 2938.539   <2e-16 ***
meqLow                                  0.03723  0.05665    0.432   0.5111
meqHigh                                -0.07146  0.07396    0.933   0.3340
timeRetention test                     -0.01156  0.05657    0.042   0.8381
treatControl                            0.01898  0.05906    0.103   0.7480
meqLow:timeRetention test              -0.02797  0.06967    0.161   0.6881
meqHigh:timeRetention test              0.11692  0.07094    2.717   0.0993 .
meqLow:treatControl                    -0.09130  0.07349    1.543   0.2141
meqHigh:treatControl                   -0.01898  0.10499    0.033   0.8566
timeRetention test:treatControl        -0.15251  0.09212    2.741   0.0978 .
meqLow:timeRetention test:treatControl   0.16957  0.11866    2.042   0.1530
meqHigh:timeRetention test:treatControl  0.07154  0.12502    0.327   0.5672
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3195 0.04497

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.1763  0.1223
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = hi.gee, id = id, corstr = "ar1")

 Coefficients:
                               Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                     2.34455  0.04270 3015.460  < 2e-16 ***
timePosttest                    0.10399  0.07331    2.012  0.15604
timeRetention test              0.20935  0.07732    7.330  0.00678 **
treatControl                   -0.01379  0.04581    0.091  0.76334
timePosttest:treatControl       0.01379  0.10788    0.016  0.89826
timeRetention test:treatControl -0.06718  0.09277    0.524  0.46899
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.2071 0.06596

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.1848  0.1121
Number of clusters:   14   Maximum cluster size: 3
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = me.gee, id = id, corstr = "ar1")

 Coefficients:
                                Estimate Std.err    Wald Pr(>|W|)
(Intercept)                       2.3377  0.0512 2080.91   <2e-16 ***
timePosttest                      0.1823  0.0704    6.71   0.0096 **
timeRetention test                0.1708  0.0812    4.42   0.0354 *
treatControl                     -0.0104  0.0640    0.03   0.8709
timePosttest:treatControl         0.0294  0.0887    0.11   0.7404
timeRetention test:treatControl  -0.1231  0.1021    1.46   0.2276
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.303  0.0536

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0255   0.127
Number of clusters:   26   Maximum cluster size: 3
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = lo.gee, id = id, corstr = "ar1")

 Coefficients:
                                Estimate Std.err    Wald Pr(>|W|)
(Intercept)                       2.2618  0.0491 2123.65  < 2e-16 ***
timePosttest                      0.2955  0.0598   24.45  7.6e-07 ***
timeRetention test                0.2559  0.0670   14.61  0.00013 ***
treatControl                      0.0991  0.0630    2.47  0.11604
timePosttest:treatControl        -0.1714  0.0823    4.34  0.03722 *
timeRetention test:treatControl  -0.1544  0.0851    3.29  0.06976 .
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.354  0.0583

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0682   0.106
Number of clusters:   35   Maximum cluster size: 3
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = hi.gee, id = id, corstr = "ar1")

 Coefficients:
                                  Estimate    Std.err     Wald Pr(>|W|)
(Intercept)                      2.449e+00  5.753e-02 1811.501   <2e-16 ***
timeRetention test               1.054e-01  4.280e-02    6.059   0.0138 *
treatControl                    -1.003e-17  8.680e-02    0.000   1.0000
timeRetention test:treatControl -8.097e-02  8.452e-02    0.918   0.3381
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.2724 0.09401

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.4586   0.221
Number of clusters:   14   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = me.gee, id = id, corstr = "ar1")

 Coefficients:
                                Estimate Std.err    Wald Pr(>|W|)
(Intercept)                       2.5200  0.0465 2938.54   <2e-16 ***
timeRetention test               -0.0116  0.0566    0.04    0.838
treatControl                      0.0190  0.0591    0.10    0.748
timeRetention test:treatControl  -0.1525  0.0921    2.74    0.098 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
Estimated Scale Parameters:
            Estimate Std.err
(Intercept)     0.31  0.0664

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0297    0.25
Number of clusters:   26   Maximum cluster size: 2
```

```
Call:
geeglm(formula = all ~ time * treat, family = poisson(link = "log"),
    data = lo.gee, id = id, corstr = "ar1")

 Coefficients:
                                Estimate Std.err    Wald Pr(>|W|)
(Intercept)                       2.5572  0.0324 6236.24   <2e-16 ***
timeRetention test               -0.0395  0.0407    0.95    0.331
treatControl                     -0.0723  0.0437    2.73    0.098 .
timeRetention test:treatControl   0.0171  0.0748    0.05    0.820
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.346  0.0734

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha    0.224   0.153
Number of clusters:   35   Maximum cluster size: 2
```

C.2.3 Partial effects for each representational criterion

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                          Estimate  Std.err    Wald Pr(>|W|)
(Intercept)                                0.90155  0.04870 342.683  < 2e-16
criCompleteness                           -0.05077  0.05580   0.828 0.362905
criTransparency                           -0.57207  0.08396  46.430 9.49e-12
criFormality                              -0.58977  0.10879  29.390 5.92e-08
criParsimony                              -1.11861  0.15240  53.876 2.13e-13
criBeauty                                 -0.41043  0.10985  13.961 0.000187
```

```
timePosttest                                 0.04832  0.05873   0.677 0.410682
timeR. test                                 -0.08252  0.07192   1.316 0.251246
treatControl                                -0.03346  0.06716   0.248 0.618323
criCompleteness:timePosttest                 0.10583  0.07420   2.035 0.153756
criTransparency:timePosttest                 0.39727  0.10144  15.337 8.99e-05
criFormality:timePosttest                   -0.38479  0.18376   4.385 0.036260
criParsimony:timePosttest                    1.17367  0.16266  52.061 5.38e-13
criBeauty:timePosttest                      -0.26403  0.16711   2.496 0.114110
criCompleteness:timeR. test                  0.26310  0.07905  11.077 0.000874
criTransparency:timeR. test                  0.58276  0.12007  23.556 1.21e-06
criFormality:timeR. test                     0.18430  0.14476   1.621 0.202953
criParsimony:timeR. test                     1.08582  0.16793  41.809 1.01e-10
criBeauty:timeR. test                       -0.09682  0.15695   0.381 0.537318
criCompleteness:treatControl                 0.06304  0.07329   0.740 0.389697
criTransparency:treatControl                 0.20297  0.12615   2.589 0.107635
criFormality:treatControl                   -0.06701  0.18146   0.136 0.711919
criParsimony:treatControl                    0.43774  0.21536   4.131 0.042098
criBeauty:treatControl                      -0.03278  0.14319   0.052 0.818944
timePosttest:treatControl                    0.01158  0.07997   0.021 0.884872
timeR. test:treatControl                     0.04478  0.10024   0.200 0.655054
criCompleteness:timePosttest:treatControl -0.06159  0.10189   0.365 0.545530
criTransparency:timePosttest:treatControl -0.24841  0.15510   2.565 0.109245
criFormality:timePosttest:treatControl    -0.23472  0.29011   0.655 0.418473
criParsimony:timePosttest:treatControl    -0.40385  0.21897   3.401 0.065144
criBeauty:timePosttest:treatControl        0.14471  0.20871   0.481 0.488099
criCompleteness:timeR. test:treatControl  -0.09948  0.10216   0.948 0.330152
criTransparency:timeR. test:treatControl  -0.23964  0.18032   1.766 0.183856
criFormality:timeR. test:treatControl     -0.66536  0.30206   4.852 0.027614
criParsimony:timeR. test:treatControl     -0.58727  0.23558   6.214 0.012672
criBeauty:timeR. test:treatControl         0.11514  0.20278   0.322 0.570164

(Intercept)                               ***
criCompleteness
criTransparency                           ***
criFormality                              ***
criParsimony                              ***
criBeauty                                 ***
timePosttest
timeR. test
treatControl
criCompleteness:timePosttest
criTransparency:timePosttest              ***
criFormality:timePosttest                 *
criParsimony:timePosttest                 ***
criBeauty:timePosttest
criCompleteness:timeR. test               ***
criTransparency:timeR. test               ***
criFormality:timeR. test
criParsimony:timeR. test                  ***
criBeauty:timeR. test
```

```
criCompleteness:treatControl
criTransparency:treatControl
criFormality:treatControl
criParsimony:treatControl                 *
criBeauty:treatControl
timePosttest:treatControl
timeR. test:treatControl
criCompleteness:timePosttest:treatControl
criTransparency:timePosttest:treatControl
criFormality:timePosttest:treatControl
criParsimony:timePosttest:treatControl    .
criBeauty:timePosttest:treatControl
criCompleteness:timeR. test:treatControl
criTransparency:timeR. test:treatControl
criFormality:timeR. test:treatControl     *
criParsimony:timeR. test:treatControl     *
criBeauty:timeR. test:treatControl
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3669 0.01492

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01019 0.02962
Number of clusters:   75   Maximum cluster size: 18
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                          Estimate   Std.err    Wald Pr(>|W|)
(Intercept)                               0.949867  0.035237 726.650  < 2e-16
criCompleteness                           0.055060  0.044371   1.540  0.21464
criTransparency                          -0.174803  0.065944   7.027  0.00803
criFormality                             -0.974560  0.141987  47.111 6.71e-12
criParsimony                              0.055060  0.042536   1.676  0.19552
criBeauty                                -0.674455  0.133765  25.422 4.61e-07
timeR. test                              -0.130840  0.064119   4.164  0.04129
treatControl                             -0.021880  0.051550   0.180  0.67124
criCompleteness:timeR. test               0.157273  0.068941   5.204  0.02253
criTransparency:timeR. test               0.185498  0.087993   4.444  0.03502
criFormality:timeR. test                  0.569095  0.129006  19.460 1.03e-05
criParsimony:timeR. test                 -0.087850  0.098461   0.796  0.37227
criBeauty:timeR. test                     0.167207  0.183447   0.831  0.36205
```

```
criCompleteness:treatControl              0.001452  0.063707   0.001  0.98181
criTransparency:treatControl             -0.045438  0.099636   0.208  0.64836
criFormality:treatControl                -0.301734  0.245672   1.508  0.21937
criParsimony:treatControl                 0.033888  0.062122   0.298  0.58541
criBeauty:treatControl                    0.111928  0.165565   0.457  0.49902
timeR. test:treatControl                  0.033201  0.089943   0.136  0.71203
criCompleteness:timeR. test:treatControl -0.037894  0.106392   0.127  0.72171
criTransparency:timeR. test:treatControl  0.008767  0.133191   0.004  0.94752
criFormality:timeR. test:treatControl    -0.430634  0.311195   1.915  0.16642
criParsimony:timeR. test:treatControl    -0.183419  0.128823   2.027  0.15450
criBeauty:timeR. test:treatControl       -0.029563  0.225320   0.017  0.89561

(Intercept)                              ***
criCompleteness
criTransparency                          **
criFormality                             ***
criParsimony
criBeauty                                ***
timeR. test                              *
treatControl
criCompleteness:timeR. test              *
criTransparency:timeR. test              *
criFormality:timeR. test                 ***
criParsimony:timeR. test
criBeauty:timeR. test
criCompleteness:treatControl
criTransparency:treatControl
criFormality:treatControl
criParsimony:treatControl
criBeauty:treatControl
timeR. test:treatControl
criCompleteness:timeR. test:treatControl
criTransparency:timeR. test:treatControl
criFormality:timeR. test:treatControl
criParsimony:timeR. test:treatControl
criBeauty:timeR. test:treatControl
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3445 0.01651

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0774 0.04016
Number of clusters:   75   Maximum cluster size: 12
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                         Estimate  Std.err    Wald Pr(>|W|)
(Intercept)                               0.85078  0.04567 347.081  < 2e-16
criTransparency                          -0.52130  0.08371  38.776 4.75e-10
criFormality                             -0.53900  0.10619  25.765 3.86e-07
criParsimony                             -1.06784  0.16289  42.976 5.54e-11
criBeauty                                -0.35966  0.10306  12.178 0.000484
timePosttest                              0.15415  0.04872  10.010 0.001557
timeR. test                               0.18058  0.05293  11.638 0.000646
treatControl                              0.02958  0.06249   0.224 0.635934
criTransparency:timePosttest              0.29143  0.10018   8.463 0.003625
criFormality:timePosttest                -0.49062  0.17542   7.823 0.005160
criParsimony:timePosttest                 1.06784  0.16950  39.688 2.98e-10
criBeauty:timePosttest                   -0.36986  0.14885   6.174 0.012962
criTransparency:timeR. test               0.31966  0.10420   9.411 0.002157
criFormality:timeR. test                 -0.07880  0.13993   0.317 0.573335
criParsimony:timeR. test                  0.82272  0.17218  22.831 1.77e-06
criBeauty:timeR. test                    -0.35992  0.13643   6.960 0.008336
criTransparency:treatControl              0.13993  0.12405   1.272 0.259330
criFormality:treatControl                -0.13005  0.17434   0.556 0.455688
criParsimony:treatControl                 0.37469  0.22100   2.875 0.089992
criBeauty:treatControl                   -0.09582  0.13612   0.496 0.481460
timePosttest:treatControl                -0.05001  0.08082   0.383 0.536055
timeR. test:treatControl                 -0.05470  0.07547   0.525 0.468532
criTransparency:timePosttest:treatControl -0.18682  0.16064   1.353 0.244841
criFormality:timePosttest:treatControl   -0.17313  0.29204   0.351 0.553288
criParsimony:timePosttest:treatControl   -0.34226  0.22827   2.248 0.133786
criBeauty:timePosttest:treatControl       0.20630  0.20818   0.982 0.321703
criTransparency:timeR. test:treatControl -0.14016  0.15946   0.773 0.379413
criFormality:timeR. test:treatControl    -0.56587  0.29291   3.732 0.053372
criParsimony:timeR. test:treatControl    -0.48778  0.23631   4.261 0.039001
criBeauty:timeR. test:treatControl        0.21463  0.19215   1.248 0.264008

(Intercept)                              ***
criTransparency                          ***
criFormality                             ***
criParsimony                             ***
criBeauty                                ***
timePosttest                             **
timeR. test                              ***
treatControl
criTransparency:timePosttest             **
criFormality:timePosttest                **
criParsimony:timePosttest                ***
criBeauty:timePosttest                   *
criTransparency:timeR. test              **
```

```
criFormality:timeR. test
criParsimony:timeR. test                  ***
criBeauty:timeR. test                     **
criTransparency:treatControl
criFormality:treatControl
criParsimony:treatControl                 .
criBeauty:treatControl
timePosttest:treatControl
timeR. test:treatControl
criTransparency:timePosttest:treatControl
criFormality:timePosttest:treatControl
criParsimony:timePosttest:treatControl
criBeauty:timePosttest:treatControl
criTransparency:timeR. test:treatControl
criFormality:timeR. test:treatControl     .
criParsimony:timeR. test:treatControl     *
criBeauty:timeR. test:treatControl
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.4025 0.01696

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01286 0.03316
Number of clusters:   75   Maximum cluster size: 15
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                          Estimate    Std.err     Wald
(Intercept)                              1.005e+00  2.830e-02 1260.641
criTransparency                         -2.299e-01  5.773e-02   15.854
criFormality                            -1.030e+00  1.405e-01   53.691
criParsimony                             4.493e-17  3.341e-02    0.000
criBeauty                               -7.295e-01  1.240e-01   34.628
timeR. test                              2.643e-02  3.399e-02    0.605
treatControl                            -2.043e-02  4.406e-02    0.215
criTransparency:timeR. test              2.823e-02  6.506e-02    0.188
criFormality:timeR. test                 4.118e-01  1.206e-01   11.665
criParsimony:timeR. test                -2.451e-01  7.810e-02    9.850
criBeauty:timeR. test                    9.934e-03  1.650e-01    0.004
criTransparency:treatControl            -4.689e-02  8.785e-02    0.285
criFormality:treatControl               -3.032e-01  2.454e-01    1.527
```

```
criParsimony:treatControl                3.244e-02  4.883e-02    0.441
criBeauty:treatControl                   1.105e-01  1.613e-01    0.469
timeR. test:treatControl                -4.693e-03  5.509e-02    0.007
criTransparency:timeR. test:treatControl  4.666e-02  1.024e-01    0.208
criFormality:timeR. test:treatControl   -3.927e-01  2.985e-01    1.732
criParsimony:timeR. test:treatControl   -1.455e-01  1.033e-01    1.986
criBeauty:timeR. test:treatControl       8.331e-03  2.288e-01    0.001
                                        Pr(>|W|)
(Intercept)                              < 2e-16 ***
criTransparency                         6.84e-05 ***
criFormality                            2.35e-13 ***
criParsimony                            1.000000
criBeauty                               3.99e-09 ***
timeR. test                             0.436777
treatControl                            0.642900
criTransparency:timeR. test             0.664431
criFormality:timeR. test                0.000637 ***
criParsimony:timeR. test                0.001699 **
criBeauty:timeR. test                   0.951980
criTransparency:treatControl            0.593500
criFormality:treatControl               0.216638
criParsimony:treatControl               0.506555
criBeauty:treatControl                  0.493463
timeR. test:treatControl                0.932106
criTransparency:timeR. test:treatControl 0.648469
criFormality:timeR. test:treatControl   0.188218
criParsimony:timeR. test:treatControl   0.158790
criBeauty:timeR. test:treatControl      0.970948
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3778 0.01985

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.08214 0.04383
Number of clusters:   75   Maximum cluster size: 10
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                       Estimate  Std.err   Wald Pr(>|W|)
(Intercept)                             0.32948  0.08551 14.847 0.000117 ***
criFormality                           -0.01770  0.12396  0.020 0.886462
```

```
criParsimony                           -0.54654  0.17127 10.183 0.001417 **
criBeauty                               0.16164  0.12220  1.750 0.185903
timePosttest                            0.44559  0.10352 18.527 1.67e-05 ***
timeR. test                             0.50024  0.10240 23.867 1.03e-06 ***
treatControl                            0.16951  0.11391  2.214 0.136735
criFormality:timePosttest              -0.78206  0.20143 15.075 0.000103 ***
criParsimony:timePosttest               0.77641  0.19012 16.676 4.43e-05 ***
criBeauty:timePosttest                 -0.66129  0.18329 13.016 0.000309 ***
criFormality:timeR. test               -0.39846  0.17036  5.470 0.019340 *
criParsimony:timeR. test                0.50306  0.17846  7.946 0.004819 **
criBeauty:timeR. test                  -0.67958  0.13210 26.466 2.68e-07 ***
criFormality:treatControl              -0.26998  0.18052  2.237 0.134754
criParsimony:treatControl               0.23476  0.21993  1.139 0.285772
criBeauty:treatControl                 -0.23575  0.17887  1.737 0.187495
timePosttest:treatControl              -0.23683  0.14388  2.710 0.099751 .
timeR. test:treatControl               -0.19486  0.14662  1.766 0.183829
criFormality:timePosttest:treatControl  0.01369  0.28034  0.002 0.961062
criParsimony:timePosttest:treatControl -0.15544  0.24160  0.414 0.519979
criBeauty:timePosttest:treatControl     0.39312  0.25668  2.346 0.125635
criFormality:timeR. test:treatControl  -0.42571  0.29303  2.111 0.146272
criParsimony:timeR. test:treatControl  -0.34763  0.24856  1.956 0.161948
criBeauty:timeR. test:treatControl      0.35478  0.22599  2.465 0.116429
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.4744 0.02083

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01754 0.03438
Number of clusters:   75   Maximum cluster size: 12
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                      Estimate  Std.err    Wald Pr(>|W|)
(Intercept)                            0.77506  0.05925 171.133  < 2e-16 ***
criFormality                          -0.79976  0.13975  32.751 1.05e-08 ***
criParsimony                           0.22986  0.06144  13.996 0.000183 ***
criBeauty                             -0.49965  0.15079  10.980 0.000921 ***
timeR. test                            0.05466  0.05863   0.869 0.351187
treatControl                          -0.06732  0.08657   0.605 0.436810
criFormality:timeR. test               0.38360  0.12827   8.944 0.002784 **
criParsimony:timeR. test              -0.27335  0.08374  10.655 0.001098 **
```

```
criBeauty:timeR. test                 -0.01829  0.17773   0.011 0.918032
criFormality:treatControl             -0.25630  0.23137   1.227 0.267968
criParsimony:treatControl              0.07933  0.09646   0.676 0.410867
criBeauty:treatControl                 0.15737  0.19082   0.680 0.409559
timeR. test:treatControl               0.04197  0.09785   0.184 0.667988
criFormality:timeR. test:treatControl -0.43940  0.29046   2.288 0.130341
criParsimony:timeR. test:treatControl -0.19219  0.13495   2.028 0.154405
criBeauty:timeR. test:treatControl    -0.03833  0.23521   0.027 0.870545
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.4512 0.02445

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.09192  0.0459
Number of clusters:   75   Maximum cluster size: 8
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                        Estimate  Std.err   Wald Pr(>|W|)
(Intercept)                              0.31178  0.09366 11.080 0.000873 ***
criParsimony                            -0.52884  0.19354  7.466 0.006287 **
criBeauty                                0.17934  0.12247  2.144 0.143106
timePosttest                            -0.33647  0.17046  3.896 0.048390 *
timeR. test                              0.10178  0.13030  0.610 0.434725
treatControl                            -0.10047  0.15355  0.428 0.512919
criParsimony:timePosttest                1.55846  0.22535 47.827 4.66e-12 ***
criBeauty:timePosttest                   0.12076  0.18551  0.424 0.515054
criParsimony:timeR. test                 0.90152  0.19619 21.116 4.32e-06 ***
criBeauty:timeR. test                   -0.28112  0.17389  2.614 0.105941
criParsimony:treatControl                0.50475  0.25220  4.006 0.045351 *
criBeauty:treatControl                   0.03423  0.19197  0.032 0.858466
timePosttest:treatControl               -0.22314  0.28147  0.628 0.427909
timeR. test:treatControl                -0.62058  0.27328  5.157 0.023156 *
criParsimony:timePosttest:treatControl -0.16913  0.33895  0.249 0.617807
criBeauty:timePosttest:treatControl      0.37943  0.33721  1.266 0.260501
criParsimony:timeR. test:treatControl    0.07809  0.33977  0.053 0.818224
criBeauty:timeR. test:treatControl       0.78050  0.34734  5.049 0.024637 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
```

```
            Estimate Std.err
(Intercept)   0.5345 0.02373

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01022 0.03799
Number of clusters:   75   Maximum cluster size: 9
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                    Estimate  Std.err   Wald Pr(>|W|)
(Intercept)                         -0.02469  0.14356  0.030 0.863437
criParsimony                         1.02962  0.14310 51.768 6.25e-13 ***
criBeauty                            0.30010  0.18400  2.660 0.102883
timeR. test                          0.43825  0.12523 12.248 0.000466 ***
treatControl                        -0.32361  0.24626  1.727 0.188802
criParsimony:timeR. test            -0.65694  0.15410 18.173 2.02e-05 ***
criBeauty:timeR. test               -0.40189  0.20922  3.690 0.054748 .
criParsimony:treatControl            0.33562  0.24981  1.805 0.179100
criBeauty:treatControl               0.41366  0.29316  1.991 0.158237
timeR. test:treatControl            -0.39743  0.30165  1.736 0.187661
criParsimony:timeR. test:treatControl  0.24721  0.32065  0.594 0.440721
criBeauty:timeR. test:treatControl     0.40107  0.35811  1.254 0.262735
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.5165 0.02974

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.05295 0.04696
Number of clusters:   75   Maximum cluster size: 6
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                  Estimate Std.err   Wald Pr(>|W|)
(Intercept)                        -0.2171  0.1558  1.941  0.16359
criBeauty                           0.7082  0.1891 14.027  0.00018 ***
```

```
timePosttest                         1.2220  0.1581 59.733 1.09e-14 ***
timeR. test                          1.0033  0.1665 36.306 1.69e-09 ***
treatControl                         0.4043  0.2017  4.018  0.04501 *
criBeauty:timePosttest              -1.4377  0.2249 40.879 1.62e-10 ***
criBeauty:timeR. test               -1.1826  0.2152 30.206 3.89e-08 ***
criBeauty:treatControl              -0.4705  0.2591  3.297  0.06941 .
timePosttest:treatControl           -0.3923  0.2005  3.828  0.05039 .
timeR. test:treatControl            -0.5425  0.2188  6.145  0.01318 *
criBeauty:timePosttest:treatControl  0.5486  0.2827  3.764  0.05237 .
criBeauty:timeR. test:treatControl   0.7024  0.2982  5.547  0.01852 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.4586 0.02861

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha -0.01663 0.04296
Number of clusters:   75   Maximum cluster size: 6
```

```
Call:
geeglm(formula = mrc ~ cri * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                   Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                         1.00493  0.02533 1573.892  < 2e-16 ***
criBeauty                          -0.72951  0.13485   29.265 6.31e-08 ***
timeR. test                        -0.21869  0.07009    9.735  0.00181 **
treatControl                        0.01201  0.03652    0.108  0.74234
criBeauty:timeR. test               0.25506  0.19052    1.792  0.18066
criBeauty:treatControl              0.07804  0.16084    0.235  0.62753
timeR. test:treatControl           -0.15022  0.09485    2.508  0.11325
criBeauty:timeR. test:treatControl  0.15386  0.24226    0.403  0.52537
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3977 0.03232

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.01616 0.06014
```

```
Number of clusters:   75   Maximum cluster size: 4
```

```
Call:
geeglm(formula = cor ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate  Std.err    Wald Pr(>|W|)
(Intercept)               0.90155  0.04870 342.683   <2e-16 ***
treatControl             -0.03346  0.06716   0.248    0.618
timePosttest              0.04832  0.05873   0.677    0.411
timeR. test              -0.08252  0.07192   1.316    0.251
treatControl:timePosttest  0.01158  0.07997   0.021    0.885
treatControl:timeR. test   0.04478  0.10024   0.200    0.655
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.1885 0.02205

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.03119 0.07161
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = cor ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                        Estimate  Std.err    Wald Pr(>|W|)
(Intercept)              0.94987  0.03524 726.650   <2e-16 ***
treatControl            -0.02188  0.05155   0.180   0.6712
timeR. test             -0.13084  0.06412   4.164   0.0413 *
treatControl:timeR. test  0.03320  0.08994   0.136   0.7120
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.178  0.0223

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha -0.02272  0.1083
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = com ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate Std.err   Wald Pr(>|W|)
(Intercept)                 0.8508  0.0457 347.08  < 2e-16 ***
treatControl                0.0296  0.0625   0.22  0.63593
timePosttest                0.1542  0.0487  10.01  0.00156 **
timeR. test                 0.1806  0.0529  11.64  0.00065 ***
treatControl:timePosttest  -0.0500  0.0808   0.38  0.53606
treatControl:timeR. test   -0.0547  0.0755   0.53  0.46853
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.115  0.0118

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0022  0.0718
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = com ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate  Std.err    Wald Pr(>|W|)
(Intercept)               1.00493  0.02830 1260.64   <2e-16 ***
treatControl             -0.02043  0.04406    0.21     0.64
timeR. test               0.02643  0.03399    0.60     0.44
treatControl:timeR. test -0.00469  0.05509    0.01     0.93
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.0843  0.0139

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha    0.112   0.118
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
```

```
geeglm(formula = tra ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate Std.err  Wald Pr(>|W|)
(Intercept)                 0.3295  0.0855 14.85  0.00012 ***
treatControl                0.1695  0.1139  2.21  0.13674
timePosttest                0.4456  0.1035 18.53  1.7e-05 ***
timeR. test                 0.5002  0.1024 23.87  1.0e-06 ***
treatControl:timePosttest  -0.2368  0.1439  2.71  0.09975 .
treatControl:timeR. test   -0.1949  0.1466  1.77  0.18383
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.294  0.0297

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0959   0.069
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = tra ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err   Wald Pr(>|W|)
(Intercept)                0.7751  0.0592 171.13   <2e-16 ***
treatControl              -0.0673  0.0866   0.60     0.44
timeR. test                0.0547  0.0586   0.87     0.35
treatControl:timeR. test   0.0420  0.0978   0.18     0.67
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.255   0.031

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha    0.275   0.121
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = rof ~ treat * time, family = poisson(link = "log"),
```

```
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err  Wald Pr(>|W|)
(Intercept)                0.3118  0.0937 11.08  0.00087 ***
treatControl              -0.1005  0.1536  0.43  0.51292
timePosttest              -0.3365  0.1705  3.90  0.04839 *
timeR. test                0.1018  0.1303  0.61  0.43472
treatControl:timePosttest  -0.2231  0.2815  0.63  0.42791
treatControl:timeR. test   -0.6206  0.2733  5.16  0.02316 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.686  0.0537

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha    0.119  0.0779
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = rof ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err  Wald Pr(>|W|)
(Intercept)               -0.0247  0.1436  0.03  0.86344
treatControl              -0.3236  0.2463  1.73  0.18880
timeR. test                0.4383  0.1252 12.25  0.00047 ***
treatControl:timeR. test  -0.3974  0.3016  1.74  0.18766
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.754  0.0735

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha      0.2   0.105
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = par ~ treat * time, family = poisson(link = "log"),
```

```
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err  Wald Pr(>|W|)
(Intercept)                -0.217   0.156  1.94    0.164
treatControl                0.404   0.202  4.02    0.045 *
timePosttest                1.222   0.158 59.73  1.1e-14 ***
timeR. test                 1.003   0.167 36.31  1.7e-09 ***
treatControl:timePosttest  -0.392   0.200  3.83    0.050 .
treatControl:timeR. test   -0.542   0.219  6.14    0.013 *
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.379  0.0399

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0453  0.0435
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = par ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                        Estimate Std.err    Wald Pr(>|W|)
(Intercept)               1.0049  0.0253 1573.89   <2e-16 ***
treatControl              0.0120  0.0365    0.11   0.7423
timeR. test              -0.2187  0.0701    9.73   0.0018 **
treatControl:timeR. test  -0.1502  0.0949    2.51   0.1133
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.196  0.0297

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0405  0.0904
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = bea ~ treat * time, family = poisson(link = "log"),
```

```
   data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err  Wald Pr(>|W|)
(Intercept)                0.4911  0.0838 34.36  4.6e-09 ***
treatControl              -0.0662  0.1177  0.32     0.57
timePosttest              -0.2157  0.1483  2.12     0.15
timeR. test               -0.1793  0.1220  2.16     0.14
treatControl:timePosttest   0.1563  0.1929  0.66     0.42
treatControl:timeR. test    0.1599  0.1746  0.84     0.36
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.539   0.039

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0372   0.076
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = bea ~ treat * time, family = poisson(link = "log"),
   data = gee1, id = id, corstr = "ar1")

 Coefficients:
                        Estimate Std.err Wald Pr(>|W|)
(Intercept)              0.27541 0.12406 4.93    0.026 *
treatControl             0.09005 0.15181 0.35    0.553
timeR. test              0.03637 0.16331 0.05    0.824
treatControl:timeR. test  0.00364 0.21716 0.00    0.987
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.599  0.0547

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0562   0.102
Number of clusters:   75   Maximum cluster size: 2
```

C.2.4 Partial effects for each musical parameter

```
Call:
geeglm(formula = mrc ~ prm * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                        Estimate    Std.err    Wald Pr(>|W|)
(Intercept)                            1.115e+00  5.179e-02 463.371  < 2e-16 ***
prmDuration                            2.469e-01  6.481e-02  14.509 0.000139 ***
prmLoudness                           -5.043e-17  8.764e-02   0.000 1.000000
timePosttest                           4.081e-01  6.024e-02  45.907 1.24e-11 ***
timeR. test                            2.776e-01  7.485e-02  13.759 0.000208 ***
treatControl                           1.380e-01  6.954e-02   3.940 0.047164 *
prmDuration:timePosttest              -3.242e-01  6.311e-02  26.395 2.78e-07 ***
prmLoudness:timePosttest              -2.192e-01  9.619e-02   5.191 0.022700 *
prmDuration:timeR. test               -1.058e-01  7.564e-02   1.956 0.161978
prmLoudness:timeR. test               -6.252e-02  1.050e-01   0.355 0.551452
prmDuration:treatControl              -1.133e-01  8.939e-02   1.607 0.204891
prmLoudness:treatControl              -1.840e-01  1.293e-01   2.024 0.154786
timePosttest:treatControl             -1.700e-01  8.335e-02   4.158 0.041432 *
timeR. test:treatControl              -2.365e-01  9.548e-02   6.134 0.013262 *
prmDuration:timePosttest:treatControl  1.363e-01  1.062e-01   1.647 0.199424
prmLoudness:timePosttest:treatControl  1.650e-01  1.460e-01   1.278 0.258245
prmDuration:timeR. test:treatControl   1.218e-01  1.101e-01   1.222 0.268896
prmLoudness:timeR. test:treatControl   2.137e-01  1.487e-01   2.065 0.150752
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.295 0.01718

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0119 0.04092
Number of clusters:   75   Maximum cluster size: 9
```

```
Call:
geeglm(formula = mrc ~ prm * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                      Estimate  Std.err    Wald Pr(>|W|)
(Intercept)                            1.36160  0.04402 956.694  < 2e-16 ***
prmLoudness                           -0.24686  0.07422  11.064  0.00088 ***
timePosttest                           0.08388  0.05575   2.264  0.13245
timeR. test                            0.17185  0.05268  10.640  0.00111 **
```

```
treatControl                           0.02469  0.05875   0.177  0.67427
prmLoudness:timePosttest               0.10508  0.08094   1.686  0.19419
prmLoudness:timeR. test                0.04326  0.08537   0.257  0.61234
prmLoudness:treatControl              -0.07067  0.11327   0.389  0.53266
timePosttest:treatControl             -0.03369  0.08173   0.170  0.68017
timeR. test:treatControl              -0.11469  0.07098   2.611  0.10613
prmLoudness:timePosttest:treatControl  0.02873  0.13502   0.045  0.83150
prmLoudness:timeR. test:treatControl   0.09195  0.12617   0.531  0.46612
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.3053  0.0227

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.02025 0.05458
Number of clusters:   75   Maximum cluster size: 6
```

```
Call:
geeglm(formula = mrc ~ prm * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                     Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                           1.52287  0.03189 2279.962  < 2e-16 ***
prmDuration                          -0.07739  0.04121    3.526 0.060425 .
prmLoudness                          -0.21916  0.06266   12.234 0.000469 ***
timeR. test                          -0.13050  0.04854    7.228 0.007177 **
treatControl                         -0.03195  0.04847    0.434 0.509809
prmDuration:timeR. test               0.21847  0.05889   13.764 0.000207 ***
prmLoudness:timeR. test               0.15664  0.08878    3.113 0.077661 .
prmDuration:treatControl              0.02295  0.06769    0.115 0.734577
prmLoudness:treatControl             -0.01899  0.08398    0.051 0.821065
timeR. test:treatControl             -0.06650  0.07983    0.694 0.404839
prmDuration:timeR. test:treatControl -0.01450  0.10313    0.020 0.888201
prmLoudness:timeR. test:treatControl  0.04872  0.12536    0.151 0.697512
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.2666 0.02364

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
```

```
      Estimate Std.err
alpha  0.09246  0.0737
Number of clusters:   75   Maximum cluster size: 6
```

```
Call:
geeglm(formula = mrc ~ prm * time * treat, family = poisson(link = "log"),
    data = gee2, id = id, corstr = "ar1")

 Coefficients:
                                     Estimate   Std.err     Wald Pr(>|W|)
(Intercept)                          1.445483  0.035222 1684.177   <2e-16 ***
prmLoudness                         -0.141775  0.056003    6.409   0.0114 *
timeR. test                          0.087969  0.036712    5.742   0.0166 *
treatControl                        -0.008999  0.052763    0.029   0.8646
prmLoudness:timeR. test             -0.061823  0.080347    0.592   0.4416
prmLoudness:treatControl            -0.041946  0.087299    0.231   0.6309
timeR. test:treatControl            -0.081000  0.072676    1.242   0.2650
prmLoudness:timeR. test:treatControl  0.063223  0.116228    0.296   0.5865
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.2689 0.03005

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.04116 0.09622
Number of clusters:   75   Maximum cluster size: 4
```

```
Call:
geeglm(formula = pit ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate  Std.err    Wald Pr(>|W|)
(Intercept)                1.11474  0.05179 463.371  < 2e-16 ***
treatControl               0.13802  0.06954   3.940 0.047164 *
timePosttest               0.40813  0.06024  45.907 1.24e-11 ***
timeR. test                0.27763  0.07485  13.759 0.000208 ***
treatControl:timePosttest -0.16997  0.08335   4.158 0.041432 *
treatControl:timeR. test  -0.23647  0.09548   6.134 0.013262 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)   0.2745 0.02114
```

```

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.06907 0.06296
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = dur ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate Std.err   Wald Pr(>|W|)
(Intercept)                 1.3616  0.0440 956.69   <2e-16 ***
treatControl                0.0247  0.0588   0.18   0.6743
timePosttest                0.0839  0.0558   2.26   0.1324
timeR. test                 0.1719  0.0527  10.64   0.0011 **
treatControl:timePosttest  -0.0337  0.0817   0.17   0.6802
treatControl:timeR. test   -0.1147  0.0710   2.61   0.1061
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.218  0.0241

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0294  0.0906
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = lou ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate  Std.err   Wald Pr(>|W|)
(Intercept)                1.11474  0.06395 303.84   <2e-16 ***
treatControl              -0.04598  0.09412   0.24   0.6252
timePosttest               0.18897  0.07069   7.15   0.0075 **
timeR. test                0.21511  0.07654   7.90   0.0049 **
treatControl:timePosttest -0.00496  0.11249   0.00   0.9648
treatControl:timeR. test  -0.02274  0.11241   0.04   0.8397
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
```

```
            Estimate Std.err
(Intercept)    0.393  0.0378

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.0635  0.0813
Number of clusters:   75   Maximum cluster size: 3
```

```
Call:
geeglm(formula = pit ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate  Std.err     Wald Pr(>|W|)
(Intercept)                1.52287  0.03189 2279.962  < 2e-16 ***
treatControl              -0.03195  0.04847    0.434  0.50981
timeR. test               -0.13050  0.04854    7.228  0.00718 **
treatControl:timeR. test -0.06650  0.07983    0.694  0.40484
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.262 0.02948

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha   0.1153  0.1043
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = dur ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                          Estimate Std.err    Wald Pr(>|W|)
(Intercept)                 1.4455  0.0352 1684.18   <2e-16 ***
treatControl               -0.0090  0.0528    0.03    0.865
timeR. test                 0.0880  0.0367    5.74    0.017 *
treatControl:timeR. test  -0.0810  0.0727    1.24    0.265
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.195  0.0295
```

```

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  0.00647   0.155
Number of clusters:   75   Maximum cluster size: 2
```

```
Call:
geeglm(formula = lou ~ treat * time, family = poisson(link = "log"),
    data = gee1, id = id, corstr = "ar1")

 Coefficients:
                         Estimate Std.err   Wald Pr(>|W|)
(Intercept)                1.3037  0.0517 636.58   <2e-16 ***
treatControl              -0.0509  0.0705   0.52     0.47
timeR. test                0.0261  0.0716   0.13     0.71
treatControl:timeR. test  -0.0178  0.1004   0.03     0.86
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Estimated Scale Parameters:
            Estimate Std.err
(Intercept)    0.342  0.0467

Correlation: Structure = ar1  Link = identity

Estimated Correlation Parameters:
      Estimate Std.err
alpha  -0.0181   0.142
Number of clusters:   75   Maximum cluster size: 2
```

Part II

CATALAN VERSION

Segons el reglament sobre dipòsit, avaluació i defensa de tesis doctorals a la Universitat de València[1] (ACGUV 195/2013), en cas que la tesi doctoral haja estat redactada en una llengua diferent de les oficials a la Universitat de València "el doctorand o doctoranda ha d'incloure en la tesi doctoral un resum ampli redactat en una de les llengües que són oficials a la Universitat de València, en el qual en tot cas han de constar els objectius, la metodologia i les conclusions de la tesi, amb una extensió màxima de 8000 paraules." (Art. 7.2)

Els Estatuts de la Universitat de València–Estudi General[2] (Decret 45/2013, de 28 de març, del Consell) estableixen que "la llengua pròpia de la Universitat de València és la llengua pròpia de la Comunitat Valenciana. Als efectes d'aquests Estatuts, hom admet com a denominacions seues tant l'acadèmica, llengua catalana, com la recollida en l'Estatut d'Autonomia, valencià." (Art. 6.2)

Per tant, en compliment de la normativa anterior, incloem tot seguit una versió resumida de la tesi en català.

According to regulations on deposit, evaluation and defence of doctoral theses at the University of Valencia (ACGUV 195/2013), doctoral students submitting theses written in a language different to the official languages at the University of Valencia must include in their report an abridged version of the main text written in one of those official languages, including anyway aims, methods and conclusions of the thesis up to 8,000 words. (Art. 7.2)

The University of Valencia statutes (Decree 45/2013, 28 March, of the Council) establish that Catalan –also known as Valencian at a local level– is the characteristic language of this university. (Art. 6.2)

Therefore, in compliance with these regulations, next we include a Catalan abridged version of the doctoral thesis.

[1] `http://www.uv.es/sgeneral/Reglamentacio/Doc/Estudis/C63.pdf`
[2] `http://www.uv.es/sgeneral/epub/estatuts_UV_2013_val_ebook.pdf`

Influència de l'entorn d'aprenentatge en les estratègies representacionals dels estudiants de música d'educació secundària: estudi amb intervenció

TESI DOCTORAL
Versió resumida

Facultat de Magisteri "Ausiàs March"
Doctorat en didàctiques específiques

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2015

Introducció

Context de l'estudi

El 2006, el Parlament Europeu i El Consell de la Unió Europea van recomanar els Estats Membres el desenvolupament de competències bàsiques en el marc del seus respectius àmbits, a fi d'harmonitzar les seves polítiques educatives. Es van distingir vuit competències bàsiques, entre les quals hi ha l'anomenada 'expressió i conscienciació cultural', on té el seu lloc l'educació musical. Prèviament a aquesta recomanació, els Estats Membres van ratificar la Declaració de Salamanca (1994), la qual propugnava oportunitats iguals en termes d'accés a l'aprenentatge, i respecte per les diferències individuals (Bauer et al., 2009, p. 13). A partir d'aquestes directives europees, és obvi que l'educació musical pot contribuir a una educació comprensiva, partint de dues premisses: (a) la música ha de contribuir a aconseguir valors socials i cívics essencials com la ciutadania, igualtat, tolerància i respecte; i (b) no només els dotats, sinó cada estudiant, de qualsevol extracció social, ha de tenir garantit l'accès a la música.

Declaració del problema

A la dècada dels setanta es van publicar treballs que destacaven el potencial educatiu de la música per a tots els alumnes (Paynter, 2008, p. 97) i reclamaven un nou enfocament de l'educació musical alternatiu a l'ús de la notació estàndard. Recentment, Verschaffel, Reybrouck, Jans, et al. (2010, p. 476) han adoptat una aproximació molt semblant a l'abans descrita en afirmar que ja no té sentit ensenyar només unes poques formes de representació estàndard, car el 'paisatge representacional' ha canviat per complet a causa del desenvolupament científic, tecnològic i social. Aquest estudi s'inscriu en una línia de recerca (Reybrouck et al., 2009; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Janssens, et al., 2010) en la qual els autors han esdevingut gradualment conscients de la rellevància del concepte competència metarepresentacional (CMR) (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 692), d'acord amb la descripció feta per diSessa i associats (diSessa, 2002, 2004; diSessa, Hammer, et al., 1991; diSessa & B. L. Sherin, 2000).

Aquesta línia d'investigació és la primera aproximació al fenomen de la representació musical sota el concepte teòric de la CMR. Malgrat això, els estudis realitzats a hores d'ara són de tall descriptiu, la qual cosa fa necessària la realització d'experiments amb intervenció educativa. En aquest context, un estudi pilot (Gil et al., in press) ha adreçat l'estudi de la influència de variables de subjecte (edat, experiència musical) i variables de tasca (intervenció educativa) en la CMR d'estudiants d'educació secundària (ESO). Aquest estudi va suggerir com a futura línia d'investigació el disseny i implementació d'un entorn d'aprenentatge tecnològic, la qual cosa és el punt de partida per a l'actual estudi.

Focus de l'estudi

Aquesta recerca explora fins a quin punt una intervenció educativa pot millorar les habilitats representacionals dels estudiants. Un dels conceptes principals en aquest estudi és la CMR, descrita com la facultat per generar, criticar, i refinar formes representacionals (diSessa, Hammer, et al., 1991, p. 118). Cal destacar dos aspectes en aquest concepte: (a) 'recursos constructius' es refereixen al conjunt d'idees i estratègies per generar representacions; i (b) 'capacitats crítiques' impliquen el judici de l'efectivitat del resultat per tal de millorar el disseny (diSessa, 2002, p. 107).

En el decurs de la seva recerca en CMR, diSessa, Hammer, et al. (1991, p. 148) van observar que els estudiants semblaven seguir un patró regular en el disseny de representacions, i van proposar una llista de criteris metarepresentacionals. Sis d'aquests criteris són utilitzats en aquest estudi:

Correcció Una representació es considera correcta quan mostra de forma exacta l'articulació de paràmetres sonors al llarg del temps (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482).

Compleció Una representació es considera completa quan representa la totalitat del fragment de música, i no només una part (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482).

Transparència Quan una representació conté un element addicional que suggereix una variació que no és present al fragment sonor, la representació es considera enganyosa. Altrament, és transparent (Verschaffel, Reybrouck, Jans, et al., 2010, p. 482).

Formalitat Una representació es considera formal quan utilitza signes, símbols, regles, i/o convencions que pertanyen a un sistema de notació formal (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483).

Parsimònia Una representació es considera parsinomiosa quan no conté cap informació redundant (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483).

Bellesa Aquest criteri es refereix a la presència o absència d'un efecte visual agradable (Verschaffel, Reybrouck, Jans, et al., 2010, p. 483).

Marc conceptual

La base teòrica del nostre estudi es fonamenta damunt dos camps conceptuals importants: (a) la percepció ecològica, segons l'aproximació de J. J. Gibson (1966); i (b) el model d'aprenentatge cognitiu, segons la descripció de Collins, Brown, and Newman (1989).

Pel que fa al primer camp conceptual, el nostre enfocament teòric implica un organisme –l'usuari musical– el qual fa front a un entorn –el món sonor– que tracta de copsar mitjançant mapes cognitius. L'usuari musical extrau 'pistes' del material sonor i les organitza de la forma menys exigent des del punt de vista cognitiu.

Quant al segon camp conceptual, els principis que hem seguit per al disseny del nostre entorn d'aprenentatge han estat: (a) donar suport constructiu i acumulatiu per a tots els estudiants; (b) fomentar l'autocontrol dels processos d'aprenentatge; (c) incorporar els processos d'adquisició en contextos autèntics; (d) adaptar el suport educatiu; i (e) integrar l'adquisició de (meta) habilitats cognitives dins de l'àmbit de la matèria. En aquest context, el concepte *scaffolding* és de gran importància, ja que permet l'estudiant d'assolir aprenentatges que altrament estarien fora del seu abast.

Objectiu i abast de l'estudi

Aquest estudi pretén examinar els efectes d'un entorn d'aprenentatge tecnològic sobre la CMR d'estudiants de música a l'ESO.

Distingim tres hipòtesis, expressades de forma alternativa:

H1 La nostra primera hipòtesi va ser que el programa experimental tindria un efecte global positiu en la CMR dels estudiants.

H2 La nostra segona hipòtesi va ser que l'efecte positiu del programa experimental seria durador.

H3 També vam hipotetitzar que els estudiants del grup experimental avaluarien l'entorn d'aprenentatge de manera més positiva que els estudiants del grup control.

A més de les hipòtesis anteriors, també vam plantejar tres preguntes addicionals:

1. El programa experimental va ser igualment eficaç per a estudiants amb nivells diferents d'experiència musical?
2. El programa experimental va ser igualment eficaç per als sis criteris representacionals estudiats?
3. El programa experimental va ser igualment eficaç per als tres paràmetres musicals utilitzats?

Importància de l'estudi

Estudis recents han suggerit que la música pot ser un àmbit molt prometedor per a l'explicació de la CMR dels estudiants (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 709) i han reclamat la necessitat de més recerca en el context d'estudis experimentals amb intervenció (Verschaffel, Reybrouck, Jans, et al., 2010, p. 500). El nostre estudi modestament adreça aquestes propostes i se situa en un entorn educatiu real, és a dir una aula de música en un institut públic d'ESO (IES). Amb aquest punt de partida pretenem transcendir la mera especulació teòrica i contribuir a la millora en l'educació, segons les dues premisses que vam declarar abans.

Revisió de literatura

D'ençà que va sorgir la psicologia de la música a les primeries dels anys vuitanta com un ens autònom dins la psicologia cognitiva, els investigadors interessats en la representació musical han centrat els seus esforços en dos camps concrets: (a) la categorització de les representacions de fragments sonors fetes per xiquets (Bamberger, 1980, 1982; Carmon & Elkoshi, 2010; Elkoshi, 2002, 2007, 2014; Reybrouck et al., 2009; Tan & Kelly, 2004; Upitis, 1987, 1990; Verschaffel, Reybrouck, Janssens, et al., 2010); i (b) l'estudi de sistemes simbòlics inventats com a alternativa a la notació tradicional (S. R. Cohen, 1985; Davidson & Colley, 1987; Davidson & Scripp, 1988; Elkoshi, 2004a; Gromko, 1994, 1995; Gromko & Poorman, 1998; Gromko & Russell, 2002; Lee, 2013; K. C. Smith et al., 1994; Tan, Wakefield, et al., 2009; Walker, 1978, 1981a, 1981b, 1987).

A més, han sorgit d'altres aproximacions, com ara l'estudi de la representació gràfica de la música relacionada amb el color (Elkoshi, 2004b), el moviment (Fung & Gromko, 2001; Sadek, 1987), i la forma (Küssner & Leech-Wilkinson, 2013; Küssner, 2013). Però la clau de volta de la nostra investigació és l'enfocament metarepresentational de la representació gràfica de música per part de xiquets (Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Gil et al., in press), després de les experiències de diSessa en l'àmbit de les matemàtiques i de la ciència.

Aquesta revisió de literatura és del tipus *integrador*, atès que presenta conclusions globals d'un nombre d'estudis separats en el temps, però que adrecen hipòtesis relacionades o idèntiques (Cooper, 1989, p. 13). El nostre enfocament combina tres formats comuns per organitzar la informació: (a) la literatura ha estat organitzada *conceptualment* a fi de explorar els temes principals del camp; (b) *metodològicament* es destaquen les afinitats entre els estudis que pertanyen a un mateix tema; (c) hom segueix un criteri *cronològic* d'ordenació.

Per tal de seleccionar la literatura més apropiada als nostres interessos de recerca, hem tingut en compte els següents criteris:

Data de publicació La revisió abasta des de 1978 a avui dia. No té sentit buscar estudis anteriors, principalment a causa de dues raons: (a) com Deutsch (2013, p. xiii) reconeix, el 1982 pocs teòrics de la música reconeixien la importància de la recerca empírica; i (b) metodològicament, no pot esperar-se un disseny de recerca sòlid abans de la publicació del llibre "Quasi-experimentació" (Cook & D. T. Campbell, 1979).

Metodologia S'han seleccionat estudis realitzats en un àmbit educatiu, on els estudiants han estat requerits de representar fragments sonors o de triar la representació més apropiada a un estímul sonor determinat, d'entre un nombre de possibilitats.

Disseny de recerca Han estat inclosos estudis descriptius, experimentals i quasi-experimentals amb una mostra gran ($n \geq 30$), mentre que estudis de cas amb mostres petites han estat exclosos.

La nostra estratègia de recerca es fonamenta en sis tècniques suggerides per Bates (1989, p. 412): (a) la *referència clau* va ser l'estudi de Verschaffel, Reybrouck, Jans, et al. (2010), relacionat amb altres tres estudis (Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Janssens, et al., 2010; Reybrouck et al., 2009); (b) la comprobació de notes a peu de pàgina i de llistes de referències ens va permetre de recuperar literatura anterior, incloent d'altres estudis clau (Bamberger, 1980; diSessa & B. L. Sherin, 2000); (c) vam utilitzar la recerca de cites per trobar la literatura més recent relacionada amb el nostre tema d'interès (Elkoshi, 2014; Küssner, 2013; Küssner & Leech-Wilkinson, 2013); (d) la revisió del web de Jeanne Bamberger va per tal d'identificar les seves publicacions va ser una mena d'*exploració d'àrea*; i (e) vam dur a terme cerques temàtiques i d'autors a les bases de dades ERIC® i PsycINFO® mitjançant la plataforma ProQuest®.

Com a resultat de la nostra estratègia de recerca, vam recuperar 68 referències (Bamberger, 1972, 1980, 1982, 1991a, 1991b, 1994, 1996, 1998, 2003, 2005, 2006, 2007a, 2007b, 2010; Bamberger & Brody, 1984; Bamberger &

diSessa, 2004; Barrett, 1991, 1997, 1999, 2000, 2001, 2002, 2005; M. R. Campbell, 1991; Carmon & Elkoshi, 2010; S. R. Cohen, 1985; Davidson & Colley, 1987; Davidson & Scripp, 1988, 1989/1994; Davidson, Scripp, & Welsh, 1988; Davidson & Welsh, 1988; Elkoshi, 2002, 2004a, 2004b, 2007, 2014; Fung & Gromko, 2001; Gil et al., in press; Gromko, 1994, 1995; Gromko & Poorman, 1998; Gromko & Russell, 2002; Hair, 1993; Hargreaves, 1978; Küssner, 2013; Küssner & Leech-Wilkinson, 2013; Lee, 2013; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Janssens, et al., 2010; Reybrouck et al., 2009; van Oers, 1997; Pramling, 2009; Sadek, 1987; K. C. Smith et al., 1994; Tan & Kelly, 2004; Tan, Wakefield, et al., 2009; Upitis, 1987, 1989, 1990, 1993, 1992/2010; Walker, 1978, 1981a, 1981b, 1983, 1985, 1987).

En aplicaciò dels criteris d'inclusió/exclusió van determinar que 29 referències van ser acceptades ($\simeq$ 43%) i 39 referències van ser rebutjades ($\simeq$ 57%).

L'anàlisi de les referències acceptades ens ha permés de distingir quatre temes principals: (a) correspondència entre símbols i sons; (b) categorització de les representacions; (c) atributs de les representacions; i (d) competència metarepresentacional (CMR).

Pel que fa a la correspondència entre símbols i sons, en general els autors destaquen l'arbitrarietat de la notació musical estàndard i la seva manca de relació directa amb els estímuls sonors que simbolitza (Walker, 1978, pp. 21,22,108; Bamberger, 1980, p. 171), malgrat el seu valor mnemotècnic al llarg dels segles (Walker, 1981b, p. 110). Diferents estudis han mostrat que els xiquets fan servir un ventall ampli d'estratègies representacionals (Upitis, 1990, p. 89; Davidson & Scripp, 1988, p. 197; Elkoshi, 2004a, p. 77; Verschaffel, Reybrouck, Jans, et al., 2010, p. 478; Lee, 2013, p. 397; Verschaffel, Reybrouck, Degraeuwe, et al., 2013, p. 695), malgrat no sempre les seves representacions indiquen el seu coneixement ni la seva comprensió dels fenòmens acústics (Bamberger, 1982, p. 223; Elkoshi, 2004a, p. 78).

La recerca sobre la correspondència entre l'entorn auditiu i l'espai visual a través de representació ha produït alguns descobriments interessants: (a) els canvis de freqüència se solen representar al llarg d'un eix vertical, mentre les duracions s'ordenen en un eix horitzontal, i les diferències d'amplitud se relacionen amb variacions en la mida (Walker, 1987, p. 492); (b) malgrat la premissa generalment acceptada que la direcció del discurs musical tendeix a seguir la direcció d'escriptura de la llengua del país (Elkoshi, 2004a, p. 64), els resultats d'un estudi van mostrar abundants estratègies organitzatives (Elkoshi, 2004a, p. 77); i (c) l'entorn auditiu en què els xiquets han estat aculturats pot influir la manera com entenen el món sonor mitjançant la imatgeria mental (Walker, 1987, p. 493).

Quant a la categorització de les representacions, cal destacar la primerenca proposta de Bamberger (1980, p. 172), qui va trobar que els dibuixos de ritmes senzills fets per xiquets es podien classificar dintre dos tipus generals, a saber figural i mètric/formal. Posteriorment, Bamberger va perfeccionar el seu esquema original per tal d'afegir diverses subcategories, la qual cosa seria el punt de partida per a la classificació proposada anys després per Upitis (1987).

Simultàniament, en un estudi longitudinal realitzat al llarg de tres anys al *Project Zero*, Davidson and Scripp (1988) van explorar les representacions de xiquets quan se'ls demanava de representar una cançó inventada. Com a resultat, els dibuixos dels xiquets van ser agrupats en cinc sistemes de símbols, a saber pictòric, abstracte, jeroglífic, text, i elaboració combinada (Davidson & Scripp, 1988, p. 204). Barrett (1997, p. 4) ens recorda les semblances entre les categoritzacions de Bamberger i de Davidson i Scripp, com també Upitis (1992/2010, p. 48).

Més recentment, Elkoshi (2002, 2004a, 2004b, 2007, 2014) ha proposat cinc categories en aplicació d'un mètode propi d'anàlisi morfològica, estructural i conceptual, a saber zero, associació, pictograma, formal i creixement. Pel que sabem, la més recent categorització de representacions informals de xiquets ha estat proposada per Reybrouck et al. (2009) i Verschaffel, Reybrouck, Janssens, et al. (2010). El seu esquema distingeix entre categories que capturen la música de forma global i categories que tracten de reflectir el desenvolupament temporal d'algun(s) paràmetre(s) musicals.

En relació als atributs de les representacions, a part de l'estudi de paràmetres musicals com ara l'altura, la durada o la intensitat, d'altres atributs com ara el moviment i el color han estat objecte d'atenció. En aquest context, Sadek (1987, p. 149) va assenyalar que els subjectes sense formació musical podrien beneficiar-se d'expressar conceptes musicals a través de moviments. D'altra banda, Elkoshi (2004b, p. 6) ha indicat que la relació entre color i música encara no ha estat objecte d'una investigació sistemàtica.

Per últim, pel que fa a la CMR, aquest concepte deu molt a la recerca de Bamberger sobre les representacions espontànies de ritmes per part de xiquets, com els autors explícitament reconeixen (diSessa, Hammer, et al., 1991, p. 122; diSessa & B. L. Sherin, 2000, p. 393; diSessa, 2004, p. 304). Els estudis sobre la CMR en l'àmbit de l'educació musical (Verschaffel, Reybrouck, Jans, et al., 2010; Verschaffel, Reybrouck, Degraeuwe, et al., 2013; Gil et al., in press) identifiquen variables de subjecte (edat i nivell de formació musical) i variables de tasca (classe de material sonor o musical, instruccions i escenaris experimentals). Tanmateix, hi ha un nombre de limitacions que afecten la validesa dels resultats, com ara les característiques dels fragments sonors (Verschaffel, Reybrouck, Jans, et al., 2010, pp. 480,485; Gil et al., in press) i l'escenari on va tenir lloc la recerca (Verschaffel, Reybrouck, Degraeuwe, et al., 2013, pp. 694,701; Gil et al., in press).

A tall de conclusió, apuntem algunes implicacions teòriques, metodològiques i educatives d'aquesta revisió de literatura. A nivell teòric, malgrat l'evidència clara que la representació informal d'estímuls sonors per part de xiquets es relaciona amb l'edat, estudis recents suggereixen la intervenció d'altres factors, com ara la naturalesa de la tasca (Barrett, 2000, p. 45; Barrett, 2001, p. 35; Barrett, 2002, p. 56; Reybrouck et al., 2009, p. 204; Verschaffel, Reybrouck, Janssens, et al., 2010, p. 261). A més, es pensa que els xiquets no segueixen una trajectòria evolutiva contínua pel que fa a les estratègies representacionals, ans el contari, es mouen enrere i endavant entre un ventall de possibilitats (Barrett, 2000, p. 45; Barrett, 2001, pp. 34-35; Barrett, 2002, p. 56; Reybrouck et al., 2009, p. 204).

Metodològicament, al llarg del temps els investigadors han proposat un nombre d'activitats per tal de mesurar la correspondència entre els estímuls sonors i llur representació gràfica, que es poden resumir en quatre branques principals: (a) interpretar i dibuixar; (b) escoltar i dibuixar; (c) imitar i dibuixar; i (d) escoltar i triar entre parelles de dibuixos.

En darrer lloc, les implicacions educatives fan referència a si el sistema de notació musical estàndard és el vehicle més adequat per a la comprensió musical dels xiquets. Molts autors han reclamat sistemes alternatius a l'ús del pentagrama (Paynter, 2008; Schafer, 1977/1994) i els investigadors generalment han destacat els beneficis de les representacions inventades pels xiquets.

Mètodes

Disseny de l'estudi

Es va utilitzar un disseny amb pretest-posttest i grup control, amb assignació aleatòria estratificada de participants a la condició experimental. Entre el pretest i el posttest va tenir lloc una intervenció educativa mitjançant una aula virtual (Moodle), de manera que els estudiants del grup experimental (E) van rebre suport (*scaffolding*) mentre que els del grup control (C) no. Aquest suport va consistir en petites pistes i recordatoris proporcionats pel professor per ajudar els estudiants a realitzar les diferents tasques. A més, al voltant un mes després d'acabada la intervenció, es va realitzar una prova de retenció per tal de mesurar l'efecte durador del programa.

Participants

L'univers d'aquest estudi va ser el conjunt d'estudiants de primer d'ESO (11–12 anys) a Palma (Mallorca, Illes Balears). La mostra es va extreure d'un IES als afores de la ciutat, i va constar de 100 estudiants de l'assignatura Música. Es van excloure vint-i-cinc estudiants per no assistir a dues o més de dues sessions de la intervenció educativa. Com a resultat, la mostra analitzada va consistir en 75 estudiants. Abans del començament de la intervenció, el centre havia distribuït els estudiants en quatre classes, amb diferències significatives quant al nivell acadèmic. Per això, en comptes de respectar aquest escenari acadèmic, vam estratificar els estudiants per la seva experiència musical.

Variables

El disseny de l'estudi pretenia provar fins a quin punt una intervenció educativa milloraria la CMR dels estudiants, mesurada abans i després de tenir lloc. Vam considerar dues variables independents principals o factors, és a dir 'Assignació a la condició experimental' ('Experimental', 'Control'), i 'Temps' ('Pretest','Posttest','Prova de retenció'). Les variables dependents van ser generades per combinació de tres paràmetres sonors (altura, durada i intensitat) i sis criteris representacionals (correcció, compleció, transparència, formalitat, parsimònia i bellesa). Per tant, hi havien 18 variables dependents per cada prova (pretest, posttest i prova de retenció), totes elles de tall qualitatiu i dicotòmic.

Principis ètics

Aquest estudi es va caracteritzar pel fet que l'investigador era també el professor dels estudiants. Aquesta doble responsabilitat ha estat assenyalada com a font potencial de conflictes ètics. Tot seguit fem palesa la nostra conformitat amb els principis ètics descrits per Lankshear and Knobel (2004, p. 103):

Disseny de recerca vàlid

Alguns investigadors han apuntat que l'assignació aleatòria dels participants és inconvenient per raons pràctiques o ètiques (Shadish et al., 2002, p. 502). Certament, aquest estudi no pot ser considerat experimental en un sentit estricte, ja que l'ambient educatiu on va tenir lloc implicava la intervenció de variables estranyes.

Consentiment informat

Vam decidir de no demanar consentiment als estudiants, sinó a la directora del centre (*gatekeeper*), fonamentalment per la naturalesa potencialment coactiva dels professors quan demanen consentiment als seus propis estudiants (Hammack, 1997, p. 257), la qual cosa podria condicionar-los en la seva decisió.

Evitació de l'engany

El fet de no informar els estudiants sobre la recerca podria considerar-se una mena d'engany. A tal efecte, seguint les directrius del BERA (2011, p. 6), vam demanar i obtenir un consentiment del Comitè Ètic de la Universitat de Valencia, la qual cosa certifica la correcció dels procediments que vam dur a terme.

Intrusió minimitzada

La intrusió com a tal no va existir, atès que el professor era també l'investigador. A més, els procediments durant la intervenció educativa, així com els materials posats a l'abast dels estudiants, no implicaven un canvi substancial de la mecànica habitual a l'aula.

Confidencialitat

A fi de conservar l'anonimat dels estudiants, a cada participant se li va assignar un codi generat per la concatenació de les dues darreres lletres dels seus noms i cognoms. A més, s'ha eliminat qualsevol referència a l'IES exacte on la recerca va tenir lloc, tant en aquest informe com en possibles presentacions públiques de l'estudi.

Risc de provocar dany

Atesa la naturalesa de la nostra recerca, no es va provocar cap dany als participants. Podria pensar-se que la intervenció educativa diferenciada per als grups experimental i control podria perjudicar els alumnes d'aquest darrer grup. A fi de subsanar aquest hipotètic dany, tots els estudiants –independentment de la seva assignació– van obtenir la millor qualificació treta per un estudiant al grup experimental.

Respecte

De conformitat amb les directrius educatives, no hi va haver tractament diferenciat als participants, independentment de les seves circumstàncies personals. A més, ningú va ser injustament afavorit o discriminat per la seva actuació en l'experiment.

Instruments

Mesurament de l'aptitud musical

Tot seguit es descriuen sengles instruments per al mesurament de la discriminació auditiva i de l'experiència musical (Hankinson et al., 1999; Pirie, 1999; Edwards et al., 2000):

Prova d'aptitud musical (MAT) Atès el perfil dels estudiants i el temps destinat per a la música a l'IES, vam seleccionar només tres proves de l'instrument original, a saber altura, ritme-durada, i dinàmica. Pel que fa a la fiabilitat dels mesuraments, vam calcular els coeficients ω de McDonald per cadascuna de les tres subescales seleccionades (altura: $\omega = .68$, 95% CI [.46, .86]; durada: $\omega = .36$, 95% CI [.04, .62]; intensitat: $\omega = .35$, 95% CI [.01, .48]).

Qüestionari d'experiència musical (MEQ) L'instrument va consistir en 23 qüestions tipus Likert distribuïdes en cinc subescales: (a) i (b) habilitats generals d'interpretació; (c) autoavaluació de l'habilitat musical; (d) formació musical; (e) hàbits d'escolta. Es van calcular els coeficients ω de McDonald per cadascuna de les cinc subescales (a: $\omega = .65$, 95% CI [.43, .82]; b: $\omega = .59$, 95% CI [.21, .88]; c: $\omega = .81$, 95% CI [.74, .86]; d: $\omega = .81$, 95% CI [.37, .97]; e: $\omega = .57$, 95% CI [.32, .71]).

Mesurament de la CMR

Verschaffel, Reybrouck, Jans, et al. (2010) van dissenyar un instrument per mesurar la CMR dels estudiants, el qual constava de 18 ítems. Per cada ítem hi havia dues representacions contrastants, de manera que una d'elles era més apropiada a un fragment sonor, segons un criteri representacional específic. La nostra versió d'aquest instrument va consistir en la transformació del format original en paper a multimèdia. Es van seguir procediments aleatoris per barrejar els ítems, a fi de garantir que les versions de l'instrument per cada prova (pretest, posttest i prova de retenció) foren paral·leles.

Enquesta sobre l'entorn d'aprenentatge (COLLES)

L'instrument COLLES (Taylor & Maor, 2000) va ser dissenyat a fi de mesurar les percepcions dels estudiants d'un entorn d'aprenentatge tecnològic. Consta de 24 qüestions tipus Likert: (a) rellevància, (b) reflexió, (c) interactivitat, (d) suport del professor, (e) suport dels iguals, i (f) interpretació. Quant a la fiabilitat, es van calcular els coeficients ω de McDonald per cada subescala (a: $\omega = .75$, 95% CI [.62, .84]; b: $\omega = .57$, 95% CI [.35, .70]; c: $\omega = .79$, 95% CI [.66, .86]; d: $\omega = .73$, 95% CI [.56, .83]; e: $\omega = .60$, 95% CI [.43, .70]; f: $\omega = .62$, 95% CI [.39, .73]).

Materials

L'IES on aquest estudi va tenir lloc va proporcionar els materials següents, a excepció de la tauleta tàctil:

Ultraportàtils Vint-i-quatre ultraportàtils Samsung® 10" (Model N145 plus) equipats amb Ubuntu 10.4 (Lucid Lynx) i connexió a la xarxa sense fil de l'IES.

Pissarra digital interactiva (PDI) Hi havia una PDI SMART® de 77" (Model SBM680) a l'aula de música, connectada a un ordinador equipat amb Ubuntu 12.4 (Precise Pangolin) i a dos altaveus de fusta.

Tauleta tàctil Vam emprar una tauleta Trust® de 7.5" amb un bolígraf sense fil ergonòmic, connectada a l'ordinador de l'aula.

Procediments

L'estudi va procedir cronològicament de la manera següent:

Mesurament de l'aptitud musical

L'aptitud musical es va mesurar mitjançant el MAT i el MEQ. Els estudiants van seure a l'aula com de costum i se'ls van proporcionar ultraportàtils per tal de completar les proves.

Pretest

La prova es va dur a terme mitjançant ultraportàtils. Com a mesura de prevenció, es va preparar una versió en paper de la prova, en cas de problemes amb la xarxa inalàmbrica de l'IES.

Intervenció educativa

La intervenció educativa va constar de vuit sessions de 55 minuts cadascuna, repartides en quatre setmanes consecutives, d'acord amb l'horari escolar:

Primera setmana Les sessions primera a tercera van ser de caràcter introductori. El professor va explicar breument els fonaments teòrics i va proporcionar alguns exemples pràctics als estudiants. Cada sessió va concloure amb una tasca de recapitulació a Moodle.

Segona setmana La sessió quarta va consistir en una tasca d'elecció múltiple a Moodle, diferenciada per als grups E i C. Tots els estudiants van tenir 20 minuts per completar la tasca, amb intents il·limitats, però només els integrants del grup E van tenir retroalimentació en les seves respostes.

Tercera setmana La sessió cinquena va ser una mena de recapitulatió dels continguts ja tractats, mentre que la sessió sisena va ser una tasca pràctica en la qual els estudiants van haver de dibuixar una representació adequada a un fragment sonor proposat.

Quarta setmana La sessió setena va tornar a ser una recapitulatió dels continguts ja tractats, mentre que la sessió vuitena incidia sobre la tasca realitzada a la sessió sisena.

Posttest

El posttest va tenir lloc un cop finalitzada la intervenció educativa, i va seguir el mateix procediment que el pretest. Addicionalment, els estudiants van completar una tasca d'elecció múltiple a fi de mesurar el seu nivell d'acord amb els criteris representacionals presents en la prova anterior.

Prova de retenció

Al voltant d'un mes després d'acabar la intervenció educativa, els estudiants van completar una prova de retenció, amb idèntic procediment al posttest.

COLLES

En acabar la prova de retenció, els estudiants van ser convidats a participar en una enquesta sobre la seva experiència en la lliçó, amb l'advertència que aquesta tasca no tindria implicacions acadèmiques. L'escenari va ser semblant a proves anteriors pel que fa a l'ús d'ultraportàtils.

Tractament de dades

Processament

Atès que el programa experimental va fer servir recursos tecnològics exclusivament, totes les dades van ser recollides en format electrònic: (a) puntuacions dels estudiants al pretest, posttest i prova de retenció; (b) puntuacions dels estudiants durant la intervenció educativa; (c) puntuacions dels estudiants a l'enquesta COLLES; (d) dibuixos dels estudiants a la PDI; i (e) dibuixos dels estudiants a la tauleta tàctil.

Anàlisi

L'enfocament estadístic va ser escollit tenint en compte les hipòtesis de recerca i les qüestions, així com la distribució de les variables dependents. Així, per avaluar l'efecte global de la intervenció educativa (H1), i el seu efecte durador (H2), es va dur a terme una anàlisi de variància GEE amb grup (E vs. C), i temps (Pretest vs. Posttest vs. Prova de retenció) com a variables independents, i amb el recompte de respostes més apropiades en cada prova separada com la variable dependent. Quant a H3, a fi d'avaluar la percepció dels estudiants de l'entorn d'aprenentatge, es va calcular l'estadístic χ^2 per cadascun dels sis blocs de qüestions i també per a l'enquesta global.

Pel que fa a la primera qüestió, es va realitzar una anàlisi de variància GEE amb grup (E vs. C), experiència musical (Alta vs. Mitjana vs. Baixa), i temps (Pretest vs. Posttest vs. Prova de retenció) com a variables independents, i amb el recompte de respostes més apropiades en cada prova separada com a variable dependent, per cada condició experimental. En relació a la segona qüestió, vam realitzar una anàlisi de variància GEE amb grup (E vs. C), criteri representacional (Correcció vs. Compleció vs. Transparència vs. Formalitat vs. Parsimònia vs. Bellesa), i temps (Pretest vs. Posttest vs. Prova de retenció) com a variables independents, i amb el recompte de respostes més apropiades en cada prova separada per cada criteri separat com a variable dependent. Finalment, per tal d'avaluar l'efecte del programa experimental per als tres paràmetres musicals, es va realitzar una anàlisi de variància GEE amb grup (E vs. C), paràmetre musical (Altura vs. Durada vs. Intensitat), i temps (Pretest vs. Posttest vs. Prova de retenció) com a variables independents, i amb el recompte de respostes més apropiades en cada prova separada per cada paràmetre musical a variable dependent.

Anàlisi de dades i resultats

Anàlisi descriptiva

La mostra analitzada ($N = 75$) estava formada per 36 xiquets (48%) i 39 xiquetes (52%), distribuïts a l'atzar entre el grup experimental ($n = 41$) i el grup control ($n = 34$). No es van obtenir diferències significatives entre els grups quant al gènere ($\chi^2 = .02, df = 1, p = .882$) i al nivell d'experiència musical ($\chi^2 = .22, df = 2, p = .897$).

Anàlisi inferencial

Efecte global i durador

Pel que fa a la Hipòtesi 1, l'anàlisi GEE va revelar diferències significatives entre el pretest i el posttest amb independència del tractament (Wald $\chi^2(2) = 29.588, p = .000$), la qual cosa implica que tots dos grups es van beneficiar de la intervenció educativa. Per tant, la nostra hipòtesi es va verificar només parcialment. Quant a la Hipòtesi 2, tot i que el grup C va obtenir resultats lleugerament millors que el grup E al pretest, aquest resultat es va invertir al posttest i a la prova de retenció. Per tant, vam acceptar la nostra hipòtesi.

Percepció de l'entorn d'aprenentatge

L'anàlisi de l'enquesta en conjunt va fer palesa una diferència significativa entre els grups ($\chi^2 = 16.45, df = 4, p = .002$). Per tant, vam acceptar la Hipòtesi 3. Tot i això, l'anàlisi particular de cada subescala de l'enquesta ens va alertar de diferències significatives només en les seccions 'pensament reflexiu' ($\chi^2 = 14.24, df = 4, p = .007$) i 'suport del professor' ($\chi^2 = 10.78, df = 4, p = .029$).

Influència de l'experiència musical

L'anàlisi GEE no va revelar cap interacció significativa entre els factors tractament, temps i nivell d'experiència musical. L'únic resultat significatiu atribuïble al tractament va ser la millora entre el pretest i el posttest per als estudiants amb un nivell d'experiència musical baix (Wald $\chi^2 = 4.34, p = .037$). Es van trobar diferències significatives entre el pretest i la prova de retenció, amb independència del tractament, per als estudiants amb un nivell d'experiència musical alt (Wald $\chi^2 = 7.330, p = .007$), mitjà (Wald

$\chi^2 = 4.42, p = .035$), i baix (Wald $\chi^2 = 14.61, p = .000$). Aquest resultat suggereix que tot tres nivells van contribuir a l'esmentat efecte.

Efectes parcials per cada criteri representacional

L'anàlisi GEE va fer palesa una interacció significativa entre els factors tractament, temps i criteri representacional per als criteris formalitat (Wald $\chi^2 = 5.16, p = .023$) i parsimònia (Wald $\chi^2 = 6.14, p = .013$), entre el pretest i la prova de retenció. Quant a la resta de criteris, ambdós grups de tractament van seguir un patró semblant, amb puntuacions força paral·leles.

Efectes parcials per cada paràmetre musical

L'anàlisi GEE no va revelar cap interacció significativa entre els factors tractament, temps i paràmetre musical. Es van trobar diferències significatives per al paràmetre altura, a causa del tractament, entre el pretest i el posttest (Wald $\chi^2 = 4.158, p = .041$), i entre el pretest i la prova de retenció (Wald $\chi^2 = 6.134, p = .013$). Quant al paràmetre durada, tot i que el grup C va obtenir resultats lleugerament millors que el grup E al pretest, aquest resultat es va invertir al posttest i a la prova de retenció. Finalment, en relació al paràmetre intensitat, tots dos grups van seguir un patró semblant, amb puntuacions força paral·leles.

Discussió i conclusions

Interpretació dels resultats

Efecte global i durador

Considerant l'efecte positiu i durador com a mesura global de la intervenció educativa, cal remarcar dues conclusions principals: (a) malgrat no existir una diferència significativa entre els grups de tractament en el posttest, hi ha un innegable valor educatiu del resultat, car la nostra missió com a professors és l'ensenyament a tots per igual; i (b) les diferències significatives obtingudes a causa del tractament entre el pretest i la prova de retenció coincideixen amb l'enfocament de Mayer (2002, p. 226), qui considera la retenció com un dels objectius educatius més importants.

Efecte de l'entorn d'aprenentatge

Cal destacar dues conclusions principals: (a) l'entorn d'aprenentatge va estimluar el pensament reflexiu crític dels estudiants experimentals; i (b) aquests estudiants van reconèixer la funció del professor per fer possible l'aprenentatge en un entorn tecnològic. Pel que fa al primer apartat, malgrat el pensament reflexiu no és una condició suficient per a l'aprenentatge autoregulat, és clarament una condició necessària. Per tant, hem de valorar positivament els suports (*scaffolding*) proporcionats als estudiants experimentals. En relació al segon apartat, sembla que els estudiants van reconèixer el valor dels suports adaptatius que van rebre per part del professor, a banda dels suports fixos presents a l'aula virtual Moodle.

Efecte de l'experiència musical

En general, els nostres resultats són lluny del que podria esperar-se, és a dir, que les puntuacions dels estudiants foren progressivament més elevades segons el seu nivell d'experiència musical anava en augment. En comptes d'això, el nostre estudi fa palesos dos patrons principals: (a) tots els estudiants, independentment del seu nivell d'experiència musical i de la seva assignació al tractament, van millorar després de la intervenció; i (b) els estudiants amb un nivell d'experiència musical alt van seguir millorant a la prova de retenció, mentre que aquells de nivell mitjà i baix van invertir aquesta tendència. Una explicació factible d'aquest fet assenyalaria l'efecte de la formació en notació musical estàndard per als estudiants de nivell alt en el posttest, mentre que els de nivells més baixos, malgrat haver estat menys atents a la intervenció educativa, s'haurien beneficiat de la seva frescor i procedit d'una manera intuïtiva. Durant el període de temps abans de la prova de retenció, els efectes de l'aprenentatge haurien desaparegut de forma més acusada en els estudiants sense l'esmentada formació en notació musical estàndard.

Efectes parcials

De primer, en relació a l'efecte parcial dels sis criteris representacionals, els resultats apunten a una millor comprensió dels criteris epistèmics (correcció, compleció i transparència), que dels no epistèmics (formalitat, parsimònia i bellesa), independentment del tractament. Segon, pel que fa a les diferències significatives trobades a l'anàlisi del paràmetre altura, aquest resultat sembla estar en consonància amb Davidson and Scripp (1988, p. 197) quan apunten que l'altura és el component primari del desenvolupament cognitiu musical dels xiquets a partir dels set anys.

Limitacions de l'estudi

Validesa interna

Atès l'àmbit educatiu on aquest estudi va tenir lloc, amb variables estranyes probablement intervenint, cal tenir presents amenaces a la validesa interna (Shadish et al., 2002, p. 55) com ara la maduració. A més, l'exposició a una prova podria afectar les puntuacions en exposicions subsegüents a aquella prova, la qual cosa podria confondre's amb un efecte del tractament.

Validesa externa

Com Shadish et al. (2002, p. 248) ens recorden, l'assignació aleatòria no implica un mostratge aleatori. El fet d'haver seleccionat la nostra mostra en un centre concret suposa una clara amenaça a la validesa externa. Altrament, hauríem hagut de seleccionar a l'atzar la mostra d'una població global hipotètica, segons un llindar establert, com ara arxipèlag, illa, ciutat o barri.

Validesa de conclusió estadística

En primer lloc, cal remarcar que totes les variables que mesuraven la CMR eren dicotòmiques, la qual cosa podria afeblir la seva relació amb d'altres variables, a causa del seu rang reduït. D'altra banda, pel que fa a la mida de la mostra, vam tenir en compte un estudi pilot (Gil et al., in press) per tal d'obtenir un nombre de participants prou gran com per garantir la significació estadística (Lenth, 2001, p. 187).

Validesa de constructe

L'àmbit educatiu on es va dur a terme l'experiment podria implicar inferències incorrectes sobre els constructes de l'estudi. Primer, les respostes dels participants podrien haver reflectit no només la intervenció educativa, sinó també les seves percepcions de la situació experimental. Segon, el professor podria haver influït en les respostes dels participants, en deixar entreveure les seves expectatives sobre les respostes desitjables.

Implicacions de l'estudi

A nivell teòric, estudis anteriors sobre representació gràfica de música han fet paleses dues conclusions principals: (a) els xiquets fan servir un ventall ampli d'estratègies representacionals (Barrett, 2001, p. 34; Barrett, 2005, p. 127; Elkoshi, 2004a, p. 77; Upitis, 1990, p. 89; Upitis, 1993, p. 52); i (b) el tipus de tasca musical influeix en aquelles estratègies, les quals no semblen seguir un patró evolutiu (Barrett, 2000, p. 45; Barrett, 2002, p. 56; Barrett, 2005, p. 130; Reybrouck et al., 2009, p. 204). En relació al primer apartat, els nostres resultats no semblen corroborar aquesta afirmació. En canvi, el tipus de tasca musical –l'ús d'una tauleta tàctil– sí que podria haver afectat la qualitat de les representacions dels estudiants.

Quant a la metodologia, l'entorn d'aprenentatge tecnològic ens va permetre d'aleatoritzar la mostra sense alterar l'assignació natural dels estudiants a les aules de l'IES, la qual cosa hauria estat força difícil, si no impossible. A més, la tecnologia va tenir el benefici addicional d'actuar com un agent motivacional important per als estudiants (Blumenfeld et al., 2002, p. 484). Entre les limitacions que haurien pogut condicionar la metodologia emprada cal remarcar el fet que la intervenció educativa es va dur a terme en anglès, atès que l'IES participava en un projecte d'immersió lingüística en aquesta llengua (AICLE). Tanmateix, la recollida i anàlisi de dades de tall qualitatiu hauria pogut ajudar a una millor comprensió de l'efecte obtingut a l'estudi.

Finalment, pel que fa a les implicacions educatives, cal insistir que les representacions informals d'estímuls sonors haurien de ser considerades com una part integral del currículum escolar, en comptes de centrar-se en la notació musical estàndard. En aquest sentit, alguns autors recomanen l'ús de representacions lliures (Tan & Kelly, 2004, p. 208), per tal que els estudiants desenvolupen els seus propis sistemes notacionals (Upitis, 1992/2010, p. 10), així com alliberar l'activitat creativa de restriccions normatives (Elkoshi, 2002, p. 210). L'efecte desitjat seria el de transferència a d'altres àmbits, atesa la relació entre els diferents sistemes representacionals (Barrett, 2005, p. 125).

Perspectives de recerca

Tot seguit proposem quatre aspectes que podrien ser objecte d'atenció en futures investigacions: (a) la realització d'experiments amb intervenció, com ara el disseny, implementació i avaluació d'un entorn d'aprenentatge en un escenari educatiu real; (b) l'estudi de les explicacions verbals dels estudiants, per tal de copsar millor la qualitat de les seves representacions; (c) el disseny de fragments sonors amb validesa ecològica, tenint en compte els hàbits d'escolta dels estudiants; i (d) la modificació dels instrument de mesura o la creació de nous, per tal d'augmentar-ne la fiabilitat.

Conclusions

A la vista del que hem exposat, podem extreure les següents conclusions:

1. Un entorn d'aprenentatge tecnològic té una influència global positiva damunt la CMR dels estudiants de primer d'ESO pel que fa a la seva capacitat crítica.

2. Un entorn d'aprenentatge tal té el benefici addicional de millorar la motivació dels estudiants en relació a la representació, sense considerar el dibuix com un afer infantil.

3. Fer que els estudiants representen fragments sonors al llarg de la seva

escolarització millora la seua habilitat representacional, la qual és susceptible de ser transferida a d'altres àmbits.

4. La notació musical estàndard té el seu lloc dins l'educació musical, però aquest lloc no és un fi ell mateix, la qual cosa significa que no ha de substituir les representacions idiosincràtiques dels estudiants.

5. Comprendre com funciona la representació en un sentit general és un procés en el qual l'educació musical ha de participar, i per això cal remarcar la seva funció important en el currículum escolar.