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Technological instruments for music learning

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ABSTRACT

An experiment was planned and carried out in order to estimate the variation of musical abilities according to the level of presence of the information technology in teaching and according to time with 11-year-old students. Our conclusions address some paths for further research in this field.

Keywords

Music education, human interfaces, computer music.

INTRODUCTION

Although the first computer applications for music were developed in the late 1950s, a use of this kind of software in regular educational contests was not documented till the 1970s. At the present time, national associations for musical education are regularly distributing manuals about integration of technology in music education practice (see for example Reese, Mc Cord and Walls, 2001). These are usually based on different and unorganized studies, carried out more often by teachers than by specialized researchers. For this reason, research in the field of technological applications for music learning has rarely been accomplished with scientific severity.

This paper reports a scientific experiment aimed at *collecting objective data on the effects of the introduction of new technologies in music learning*. In the first section some information about available music technologies is reported. The second section deals with strategies for introduction of technology in aid of music learning. The third section presents the experiment method and results. The last section addresses for further research.

TECNOLOGIES, INTERFACES, REPRESENTATIONS

Usually, under the name of "new technologies for music" different equipment is grouped together: not only many computer devices, but also electronic devices capable to operate stand-alone or linked to a computer (e.g. human-computer interfaces, MIDI controller or synthesizer keyboards). Sound and music content can be represented (and consequently stored and modified) in several ways, which can be grouped as so:

- symbolic representations (e.g. standard music notation);
- control messages/sequences (e.g. MIDI messages);
- physical representations (in analogue or digital domain);
- other representations (e.g. music programming languages).

Every representation can be displayed in different ways, each one of these points out some details of music material and help to derive some abstraction of it (e.g. time-amplitude signal view allows to see the envelope and so to guess information about loudness).

TECHNOLOGY AND MUSIC EDUCATION

The contribution of technology must not change the goals of music education, but support them. It comes clear that the choice of technologies, interfaces and representations to use has to be done in respect of this principle. So any evaluation of the quality of used tools has to be founded upon the better or worse fulfillment of those goals.

Not only specific educational software is suitable for music learning: a retrospect (Higgins, 1992) of some of the most important studies on effectiveness of music software in educational contexts reports positive implications for every experimentation which used composing software. Kozerski (1988) also underlined that compositional activities offer a better paradigm than music education software.

A classification of the activities which are suitable for school-aged pupils could be drawn on the basis of representations and interfaces which are concerned:

a. analysis and processing at signal (physical) level;
b. analysis and processing at symbolic or control level;
c. computer-aided self learning.

EXPERIMENT

Method

Participants

Before choosing a sample for the experiment, we had to identify the population, of which the sample is a subset and to which we want to extend the results of the experiment. In Italy music education is a consolidate subject for pupils aged 11 to 13, which attend "Scuola Secondaria di I grado". In every one of the three years of this school level, two hours of a class named "Musica" (music) are provided. Since it was not possible to apply the experiment distinctly to the three school years, we chose to define the population as the set of all pupils who attend to the first year of "Scuola Secondaria di I grado".

Unfortunately, some issues made impossible to assume a really random criterion for sample selection: because of school system organization, we could not collect students from different classes or from different schoolhouses. The sample had to be composed starting from existing classes, which are made up of students which undergo the same educational activities, who live in the same area and so have similar cultural backgrounds.

Because of the short time available, we had to limit the sample to two classes: one became the experimental group (EG) and the other the control group (CG). We gained agreement for carrying out the experiment in a "Scuola Secondaria di I grado" located in Osoppo (UD). This school has two first grade classes and a single music teacher. These two classes were randomly assigned to EG and CG, so that the former was class I B (14 pupils) and the latter class I A (13 pupils). The difference in pupils' number has no consequences on results, while non-random sample selection and its narrowness have to be highlighted as limiting factors for experiment effectiveness.

Since the computer laboratory was quite small (there were only 4 workstations available), it was necessary to split the EG in two subgroups (EG1 and EG2), both of seven pupils, selected with a random criterion. The two EGs had computer music lessons separately.

Apparatus

The computer laboratory of the school, completed with some other equipment, included:

- 1 Sony Vaio notebook PC with AMD Athlon XP 1400+ processor, integrated audio interface and external mouse;
- 1 desktop PC with Pentium IV processor, monitor, mouse, keyboard and integrated audio interface;
- 2 desktop PC with Pentium processor, monitor, mouse, keyboard and integrated audio interface;
- 8 headphones (two for each PC) with "y" adapter;
- 1 Apple iMac G5 computer (processor speed 1.6 GHz), with integrated microphone and speakers (used for group activities).

Experimental design

Different kinds of research in music education exist (Kemp, 1992): the choice has to be made on the basis in of research background and goals. For the goal reported in the introduction, we chose experimental research: as regards music education, this is used to verify hypothesis on effectiveness of teaching and to ensure that material and strategies are valid. Experimental research, based on inductive constructions, starts from the assumption that it is possible to predict future behaviors by orderly observing and comparing that behavior in a small representative group.

Before planning the experiment, we explored past studies on this subject, both to avoid the repetition of an activity which had already provided the results we were looking for and to get knowledge of some issues that could arise and possible solutions, and also to put in practice some expedients to make the research more accurate.

The methodology we chose imposes to identify, in the experiment background:

- one or more independent variables, which mark treatment towards the sample (e.g. the use – or the level of use – of an educational instrument towards pupils);
- one or more dependent variables, to measure the effect of the treatment on the sample.

In designing our experiment, the detection of the main independent variable was quite easy: it is the level of presence of technology in the educational activities. In particular, we chose two different values for this variable: a low value, for "standard" music education, in which technology is rarely present, only as auxiliary instrument (e.g. for listening to a record, or karaoke singing); an high value, for preponderance of technological instruments and significant use of them (e.g. for music composing, hard to be included in school classes without computer support).

Control of the independent variable was operated by means of splitting the sample in two subgroups: the former underwent "standard" music education (low level of the variable), the latter attended classes with a significant presence of technology (high level of the variable). Following a widespread terminology, the former group was called control group (CG) and the latter experimental group (EG).

Detection of a suitable dependent variable was more complex. We wanted to measure the level of music learning in the pupils, in order to find possible variations related to the independent variable. So the specific question to which the experiment was about to answer is: do pupils learn better by "standard" music education or by a technology-powered methodology?

As a measure of learning we chose the change in abilities in a fixed period of time. At this point we shifted the time to a second independent variable and we took the measure of abilities as dependent variable: the experiment was to measure differences in musical abilities as a function of the level of presence of technology and time. The measure was taken in two different moments – the start and the end of experimental classes – for both the EGs and the CG.

The problem of detecting a suitable instrument for measuring the dependent variable was only shifted to the problem of evaluating musical abilities. Literature (Shuter-Dyson, 1999; Boyle, 1999; Shuter-Dyson & Gabriel, 1981) provides us with many tests which aim to measure these abilities, together with information for choosing correct instruments and evaluating results.

Firstly, there is no universal agreement on conception of musical ability: is it one single feature or a group of different abilities? Every test measures some specific phenomena and reflects its author's ideas about this issue. Moreover, the tests are often designed for a practical application (e.g. prediction of pupils' succeeding in musical studies): for this reason, most of available tests try to estimate musical aptitude, that is learning capability, while others measure achievement or performance. In any case, it seems that, on the average, tests are effective measurement devices in educational backgrounds (Shuter-Dyson, 1999, p. 629).

In choosing the most suitable test for the experiment we kept in consideration that tests which were validated on a population cannot be applied to another population before verification of its validity and in particular if the two populations speak different languages and the test has been translated (Tafuri, 1985; Anastasi, 1991). In the light of this consideration, the search for a suitable test, validated for Italy, lead us to a single result: the "Test di attitudine musicale" by Valseschini and Dal Ton (Valseschini, 1996). It is made up of two parts: a questionnaire about interest in music and a questionnaire of perception and memorization. As regards reliability, it is reported by the authors of the text, following different criteria: it varies from .7858 to .8549 for the first part and from .7831 to .8132 for the second. Validity is between .6794 and .7133 for the questionnaire about interest (test results were compared to a psychological check and talks for detecting interest) and it is .8767 for perception and memorization questionnaire (results were compared with judgments by music professors). These values are very good, higher than the ones reported for internationally established music ability tests. The Valseschini and Dal Ton appeared so to be a suitable measurement instrument for our experiment.

We also decided to note marks expressed by the school music teacher, to look for possible correlations. The experimental group also underwent an achievement test and a questionnaire about their satisfaction for the activity.

We also thought about extraneous variables which could influence experiment results and made a list:

- behavior and attention of the pupils in classroom;
- pupils' absences;
- motivation of the students towards the tests;
- possible errors in the teacher's judgment.

To limit the influence of these issues we adopted a strict control on pupils' behavior, we noted down absences of the pupils as to find possible correlation with effects of the treatment, we used statistics methods, generally limiting and highlighting random errors.

Procedure

As previously stated, the CG underwent a "standard" music education program, managed by the music teacher of the school. The EGs weekly attended to one hour of "standard" music education program, managed by the music teacher of the school, and one hour of a technology-supported program, by researcher Lorenzo Tempesti. The EGs' less time for standard music activities was considered as part of the independent variable, which represents adopted methodology and so distinguishes between different uses of school time.

We built up a 15 lessons program, which included new technologies as the main instrument for music education. On the basis of previously mentioned literature (Kozerski, 1988) we decided to give preponderance to composing activities, instead of using only standard music learning software. The program consisted of these points:

- Visual loudness analysis with "Audacity" (distributed by Sourceforge, 2002) – waveform view: loudness prediction on the basis of the graph.
- Approach to audio editing with "Audacity": loudness and pitch variation.
- Audio composing: every pupil records some sounds realized with voice or things; these sounds are used to make simple sound compositions.
- Visual pitch analysis with "Vocal Lab" (Laidman & Katsura, 1993) – single and group practice: maintaining voice pitch, loudness variation (the graph does not show any change), intervals, and scales.
- Self-learning of music intervals (pitch) by means of the cd-rom "Musica!" (Ed. La Repubblica, 1997).

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- Pitch and duration control with the piano-roll view in "Logic Fun" (Emagic, 1993): simple exercises, transcription of simple melodies.
- Drums programming: writing and transcription of simple drum parts with "Logic Fun".
- Tempo and loudness (dynamics) in "Logic Fun".
- Computer-aided song analysis ("Smoke on the water") in "Logic Fun".
- Melody transformation with preservation of structure, pitch or rhythm in "Logic Fun".
- Transcription of difficult melodies with "Logic Fun".
- Free composing with "Logic Fun" with only some assigned rules.
- "Question and answer" composing in "Logic Fun".
- Composing games with cd-rom "Rock rap 'n' roll" (Paramount Interactive, 1993).

The CG and the EGs underwent tests on days December 21st, 2004 and May 10th, 2005. The lessons took place weekly between January 1st and May 4th, 2005, with some breaks for holidays or organization issues.

Results

See Tempesti (2005) for complete results tables. Independent variables were named as follows:

- "Interessi": result (max range 17 - 83) of the questionnaire about interest;
- "Memoria": result (errors number, max 49) of the questionnaire of perception and memorization;
- "Voto": school teacher's marks (0-10).

The "I" suffix (e.g. "VotoI") means initial (before treatment) value; "F" means final (after treatment) value.

Before of the analysis, measures were processed:

- "Memoria": number of errors was substituted with percentage of correct answers;
- "Voto": normalization on scale 0-10, since teacher's marks were actually ranged 5.5-10.

Statistical analysis was carried out starting from a t-test on initial values for the variables, in order to verify sample homogeneity (CG and EGs together):

VotoI $t(25) = -.109$, $p = .914$
MemoriaI $t(24) = 1.808$, $p = .083$
InteressiI $t(24) = .580$, $p = .567$

As regards "Interessi" and "Voto", the two groups appear to be homogeneous. "Memoria" shows some differences between them, but they are comparable anyway, since p is more than .05 (Fabbris, 1990).

Then we applied variance analysis on "Memoria", choosing pupils' sex and group (CG or EG) as between factors:

One-way Anova (Memoria) with 2 between factors (sex, group):
sex $F(1, 22) = 0.000$, $p= .993$

Since sex is not significant, it was discarded.

One-way Anova (Memoria) with 1 between factor (group):
group $F(1, 24) = 4.883$, $p = .037$

These result shows some difference between the two groups, which is confirmed regardless of time. In fact, time turns out as a non-significant factor:

time $F(1, 24) = .274$, $p = .605$

The same analysis was applied to variable "Voto":

One-way Anova (Memoria) with 2 between factors (sex, group):

sex $F(1, 23) = 1.117$, $p = .301$

Since sex is not significant, it was discarded.

One-way Anova (Memoria) with 1 between factor (group):
group $F(1, 25) = .034$, $p = .855$

Groups behave more homogeneously than in the case of "Memoria", but time factor appears non-significant anyway:

time $F (1, 25) = .691$, $p = .414$

As regards variable "Interessi", we went on in the same way.

One-way Anova (Memoria) with 2 between factors (sex, group):
sex $F(1, 19) = .46$, $p = .5$

Since sex is not significant, it was discarded.

One-way Anova (Memoria) with 1 between factor (group):
group $F(1, 19) = .03$, $p = .86$

A t-test applied to the two measurements told us that time is not a significant factor:

$t(22) = .41$, $p = .68$

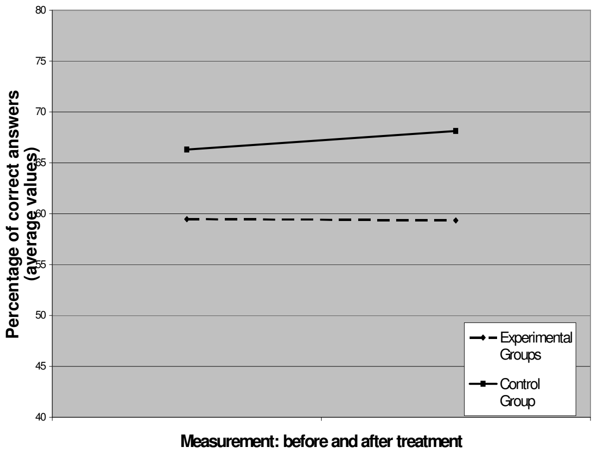

Figure 1. The test of music perception and memorization shows different performance between the two groups, but the treatment has no significant effect.

Seeing that variables "Voto" and "Memoria" behave in a similar way, we calculated correlation between them, for the whole sample, before and after treatment:

VotoI - MemoriaI r(26) = .047, p = .821
VotoF - MemoriaF r(27) = .552, p = .003

We conclude that correlation is significant ($p < .05$) only after treatment.

In order to verify if pupils' achievement is somehow correlated to "Memoria" and "Voto" we went on calculating Pearson's coefficients between them and variable "Profitto", which is the achievement test mark (1 – 10 range):

MemoriaF – Profitto r(14) = .637, p = .014
VotoF – Profitto r(14) = .711, p = .004
MemoriaF – VotoF r(14) = . 563, p = .036

Correlation is significant in all cases ($p < .05$), so we can infer a link between achievement, perception and memorization test, teacher's judgment.

The most important result of this experiment is certainly the non-significance of variable "time": the dependent variable seems not to be influenced by it and thereby treatment does not produce any relevant effect on the EGs. The only effect according to time we detected is the higher correlation between variables "Voto" and "Memoria" after treatment: this fact is probably attributable to the teacher's deeper knowing of the pupils (the first measurement was made only three months after the school year had started) and so a bigger correspondence between his judgment and the pupils' real abilities. This error had been predicted as an extraneous variable and is relevant for the first measurement of variable "Voto".

Another interesting fact is the difference between the EGs and the CG as regards variable "Memoria": the CG made on the average 3 errors less than EGs before treatment, and 4 after treatment. This agrees with the general trend of the two classes: CG was better nearly in every school subject, as stated by the school teachers. Anyway, the difference could not be attributed to a different motivation of the students towards the tests (that was a possible extraneous variable), because pupils belonging to the EGs, who should have been more motivated since they were informed that they were about to attend computer music lessons, got the worst results.

As regards the other extraneous variables, the behavior and attention of the students during classes was better for EG2, which, in effect, carried out an average improvement of 2.5 on "Memoria", against EG1, which obtained a worsening of 2.5.

However, standard deviations for these data are bigger than values themselves, so this correlation becomes less significant. The number of absences does not seem to be linked to results from measurements.

Sample smallness has already been highlighted as a weak point and in this case it does not allow us to understand if the absence of significant phenomena related to time factor is due to specific issues of pupils' included in the EGs or it can lead us to conclude that the level of presence of technology does not produce any effects on variation of musical abilities. Also the short duration of the experimental program could be brought as a reason for that. In the questionnaire about satisfaction, 50% of pupils stated that 15 lessons are not enough (question 12) and 43% wrote that it would be better to have more than one hour a week of this activity (question 11).

Correlation between the achievement test and variables "Voto" and "Memoria", significant for the final measurement, demonstrates that pupils who applied and learned obtained better results. This could lead us to conclude that abilities required to fulfill the achievement test at least partially overlap with those which measurements detect.

We have also to consider the doubt that abilities developed with the technology-supported program are not the same that the chosen test can measure. As we stated before, every test reflects its author's convictions. In the case of the test by Valseschini and Dal Ton, the goal is to predict the possibility of success in music studies. It is difficult to determine to what extent abilities required to become a good musician overlap with those developed by means of activities mainly centered on composing.

The questionnaire on satisfaction highlights that pupils liked this activity: 86% answered they liked it very much or enough (question 1) and the same percentage would like to continue with this activity (question 9). 76% thought the activity had been very or enough useful for improving their musical abilities (question 6) and 79% for improving their abilities with computers (question 8).

CONCLUSIONS

We have already remarked that one of the issues of research in education is that it is often carried out following no scientific methodology and it goes on thanks to comments, class experiences and teachers' stories. Though these are important instruments for facing problems and to host useful discussions, a parallel strictly scientific activity has to exist, to give reliability and universal value to those observations, by means of scientifically undertaken experiments.

The results of the experiment we are here reporting suffer from some limits that we underlined in the previous paragraphs. Anyway, the educational community could presuppose that introducing new technologies in music education does not alter the normal development of musical abilities. Pupils' excitement and interest for this activity is a reason for introducing it, flanking standard activities which include theory, instrumental and vocal performance, etc.

Scientific research in the field of music learning has just started. To achieve palpable and objective results it is necessary to go over present knowledge. In particular, future experiments have to be carried out on extensive samples and by teams of researchers who believe in a strictly scientific behavior. In this respect, research projects aimed to some specific goals are to be considered urgent and significant:

- development of psychology of music and in particular studies on the nature and organization of musical abilities which are needed for composing, performance, analysis, etc.;
- consequent production of specific and affordable tests for detecting and evaluating those abilities;
- unrolling experiments similar to the one we reported, with the adoption of different interfaces, representations and technologies, in order to make a comparison among different methodologies;
- production of technologies and interfaces suitable for music learning, in particular: new musical instruments specifically designed for music learning; powerful but easy-to-use software environments, which provide only functions that the pupil really needs.

To this end, the present availability of free programming libraries and free music software (see for example AGNULA international project at www.agnula.org) is an important factor for improving music education methodologies, also considering that schools computer laboratories need large licensing, which would mean huge costs in the case of commercial software.

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