AudioFractions: design , implementation and assesment of a computer program based on a musical metaphor for Elementary mathematical education in Chilean Educative System

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1. Introduction

In the educative domain, music enhances spatial-temporal reasoning skills, which are crucial for learning concepts in proportional reasoning and geometry, areas in which students usually show below-average achievement (Grandin et al. 1998). In the other hand, working with patterns, which are essential to both mathematics and music, enhances the thinking and reasoning skills of children because they must analyze a pattern to figure out its rule, communicate the rule in words, and then predict what comes next in the pattern. To translate a pattern, children keep the same rule but express it using a different medium. For example, a one-two-one-two pattern becomes a skip-hop-skip-hop pattern. Music patterns, such as the repeating melodies or refrains of a song or the beat of a rhythm, prepare children for a variety of number patterns, such as the sequence of odd and even numbers (Johnson and Edelson 2003). Activities integrating music and mathematics have an effect in mathematical reasoning and achievement (Vaughn, 2000) and fraction concepts (Courey et al. (2012). Some reasons argued favoring this integration are: 1) the broad range of significant concepts and skills that can be taught (recognizing, describing, and translating patterns); comparing and ordering the attributes of objects; representing data using pictures and graphs. 2) The value of the integrated activities in areas other than the logical-mathematical. 3) the ease with which even those of us who have a limited musical background can be successful with such activities (Johnson & Edelson, 2003). Therefore, if music is based on mathematical principles, and if an understanding of music requires some understanding of these principles, then it is possible that music education can lead to an improved understanding. Because this and that Music is often taught in isolation from other disciplines, yet the natural connections between the physics of sound and the sounds in nature link these two areas of science and science with music (Carrier et al. 2011), we have carried out this research. Picalab MMSI (*Musi-Matemática Sonora Interactiva,* Interactive Music-Math) is a work on progress focused to design, implement and assess a set of integrated music-mathematics learning modules for Elementary Schools in Chile. Each of these consist in a computer application and a didactic guide following the Theory of Didactic Situations (TDS; Brousseau, 1988). We present here one called AudioFractions.

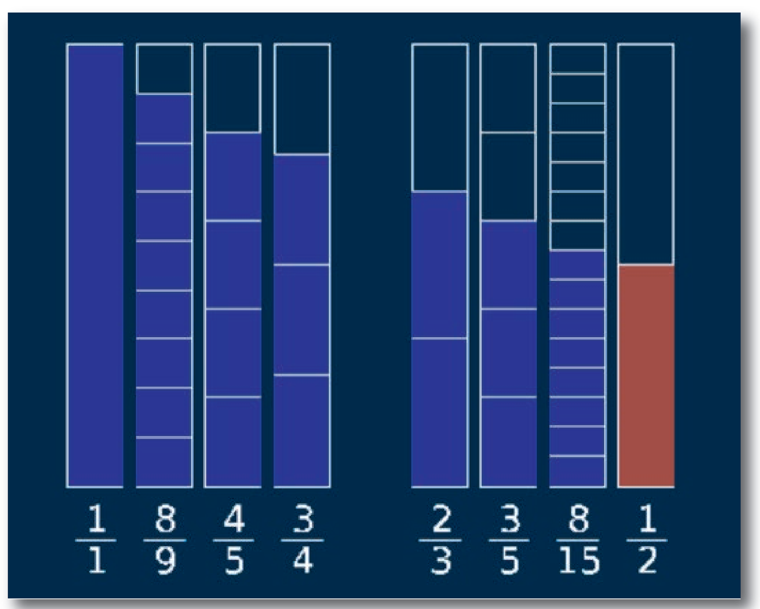
2. Methodology

Three stages were designed: 1): collecting musical methapores related with maths; a multidisciplinary team of teachers, musicians and scientists was invited to propose metaphors embodying connections between music and mathematics. They constituted non functional prototypes, which were organized, simplified and filtered out in order to select the best ones for the implementation stage attending to the Chilean curriculum for maths in Elementary Education. 2) implementing software and its didactic guides; it included a usability test and a pilot test that permited to refine both the MMSI applications and the data collecting instrument. 3) assessing pupils and teachers' perceptions . This was done at several prioritary public schools (schools having pupils with learning difficulties) in Comuna de Peñalolén (Santiago, Chile).

3. Description of AudioFractions

3.1 Level One

AudioFractions deals with rational numbers related with pitch and rhythm. All the activities in the MMSI modules are graded and the learning content is presented according TDS, which propose that the beginning activities must be dedicated to exploration. So, in level one (left), a simple loop is presented to the



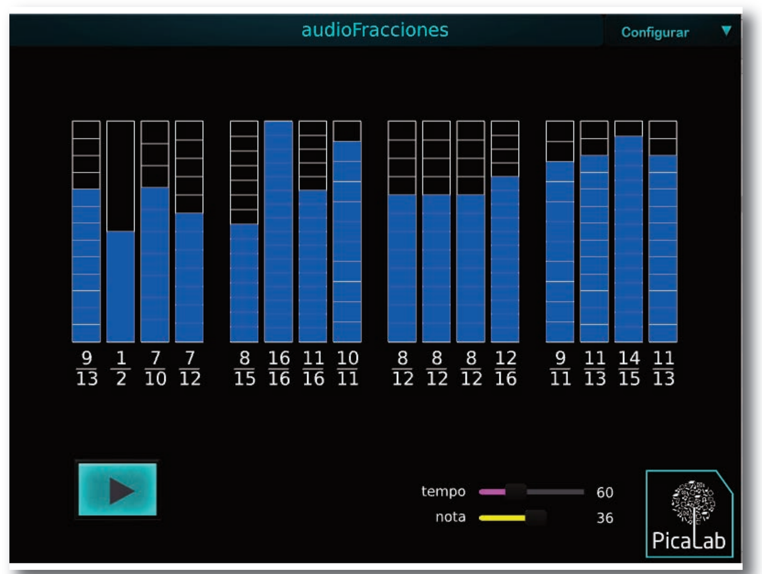
students, where rational numbers must be determined using a vertical bar whose unit represents the fundamental sound. Sound changes according to the selected ratio. Teachers could have the pupils learning relations among musical sound of the scale and the fractions, inviting them to copy the scale used on their computer. Also, teacher could ask pupils use the 16-bars mode in order to build up another scales, practising with different octaves of the same sound (division of fractions) or "writting" short melodic patterns using the corresponding fractions.

3.2 Level Two

The student is left to find the sound that is equivalent to a previously proposed one. Mathematically, the intention is to find a rational number equivalent to given rational number, either based on multiplicative processes (sublevel A) or division processes (sublevel B). This is done with a bar with the representation and another bar that expressed the number or sound (right).

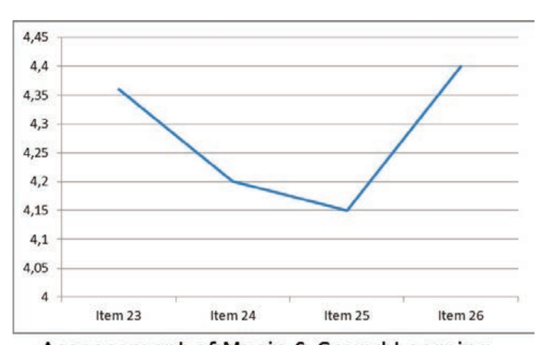
3.3 Level Three

The students pursue a more creative activity by starting from a sound and fraction recorder, and then matching the numerical representations of each bar with a given sound pitch. The student creates and records his own composition as he makes selections of certain rational numbers that correspond to pitches in a musical scale. To develop the rhythmic aspects, the student can also use fractions in order to control the duration of the sounds, including also the possibility of producing silences (right).

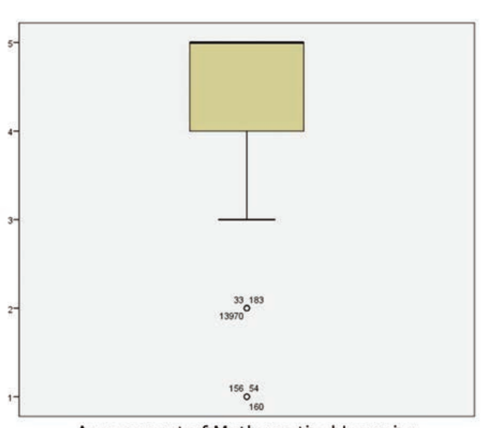


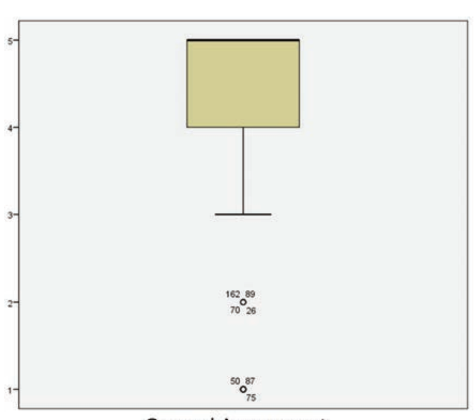
4. Assessment by students

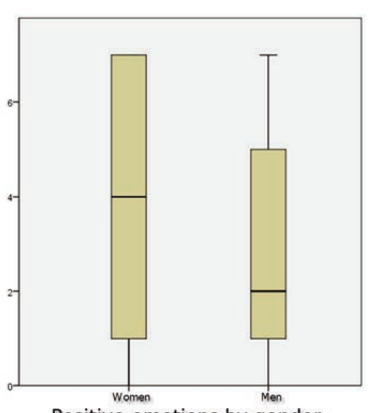
Students assessed AF by means of a validated and reliable questionnaire (Alpha Cronbach=.924) with ordinal five-points-scale to score the agreement/disagreement with proposed statements on the dimensions of evaluation: mathematical learning, musical learning and technical perceptions on the program. Also, students evaluated the emotions they have felt when working with AudioFractions. Results show high scores in each of the dimensions, significant direct correlations between positive emotions and global evaluation, which gives consistency to the quantitative data obtained in the cognitive domain.



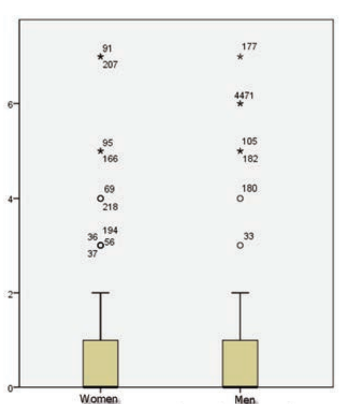
Asssessment of Music & Sound Learning


Assessment of Mathematical Learning

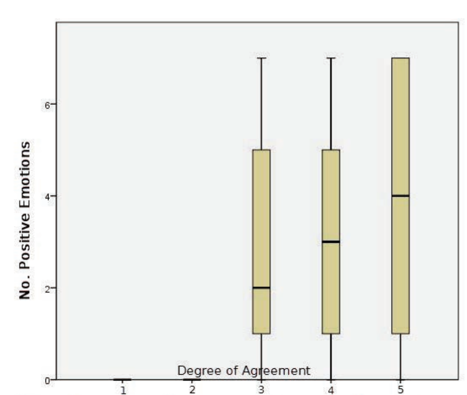

General Assessment



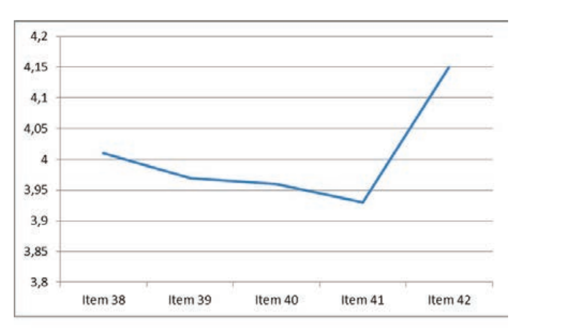
Positive emotions by gender



Negative emotions by gender



Positive emotions and music learning



Technical perceptions on AF

5. Conclusions

Results show an excellent reception at the prioritary schools where were tested. All dimensions of assesment have high average scores with moderate dispersion. Our suggestion is that the use of music contents are very positive for learning mathematics, reinforcing learning each other. In the other hand, affective-emotional assessment data can be interpreted as AudioFractions generating more satisfaction rather the opposite. We suggest that it would be convenient to embody an affective-emotional analysis as an assessment criteria which could complement other ones in the assessment of educative multimedia materials.

Acknowledgements & References

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