STUDENTS' PORTFOLIO ASSESSMENT IN MATHEMATICS FOR GRADES 10th TO 12th. THE CASE OF E-PORTFOLIO.

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ABSTRACT

In this paper, we will present in brief ways of assessment and the use of student portfolio as an alternative assessment approach. We will present the use of portfolios worldwide and especially at Mathematics program of International Baccalaureate. Furthermore, we will focus on that assessment which refers to the use of e-portfolios and we will present two assignments from International Baccalaureate program. We will propose research questions for the use of portfolios and e-portfolios in Greek educational system as part of student's assessment.

INTRODUCTION

It has long been recognised that assessment can support learning as well as measure it (Black & Wiliam, 2003). Internationally, the role of assessment in supporting and improving learning is impacting on curriculum and policy developments (Klenowski, 2004). This shift in assessment frameworks from those that emphasize standardized, norm-referenced testing programmes to those that involve more classroom-based assessment reflect the understanding that assessment needs to align more with student-centred curriculum based on constructivist learning theories (Serafini, 2001). This assessment approach is sometimes called an "assessment culture" (Dochy, 2001).
This culture has the following characteristics:
- strong emphasis on the integration of assessment IN instruction;
- An active students' participation who shares responsibility in the process, practices self evaluation, reflection and collaboration, and conducts a continuous dialogue with the teacher. Students participate in the development of the criteria and the standards for evaluating their performance;

- both the product and process are being assessed;
- the assessment takes many forms;
- usually there is no time pressure, and a variety of tools that are used in real life for performing similar tasks are permitted;
- the tasks are often interesting, meaningful, authentic, challenging and engaging, involving investigations of various kinds;
- students document their reflections in a journal and use portfolios to keep track of their academic/vocational growth;
- reporting practices shift from a single score to a profile, i.e. from quantification to a portrayal (Birenbaum, 1996).

The previous characteristics, seems that can be covered effectively with portfolios, which we will be analysed in next paragraph. The value of portfolios as an assessment tool is thoroughly researched and their use in education is well documented (Woodward, 2000).

PORTFOLIO DEFINITION

Judith Arter & Vicki Spandel (1992) define a student portfolio as:

"A purposeful collection of student work that tells the story of the student's efforts, progress, or achievement in (a) given area(s). This collection must include student participation in selection of portfolio content; the guidelines for selection; the criteria judging merit; and evidence of student self-reflection".

This definition supports the view that assessment should be continuous, capture a rich array of what students know and can do, involve realistic contexts, communicate to students and others what is valued, portray the processes by which work is accomplished, and be integrated with instruction (Arter & Spandel, 1992).

There are many types of portfolios, prepared for different purposes and using various resources. With regard to the use and application of portfolios to the educational environment, portfolios are structured to cover different needs from the educational process. Thus, it is supported that, portfolios (Mason, Pegler & Weller, 2004) are those that:

- Offer a rich and textured view of a student's learning and development,
- Represent the outcomes of the student's overall progress and practice, with a view to create a personal Curriculum Vitae (CV).
- Create a body of work that represents student's learning over the course of his/her education,
- Provide a valid result of the student's assessment.

Finally, portfolios constitute an accessible information repository, which can ensure the student's as well as the teacher's assessment and progress/attitude. Student's and teacher's self-assessment (Valli & Rennert-Ariev, 2002) provides the possibility of improvement of the educational practice.

As presented in next figure, portfolios may include a varied material.
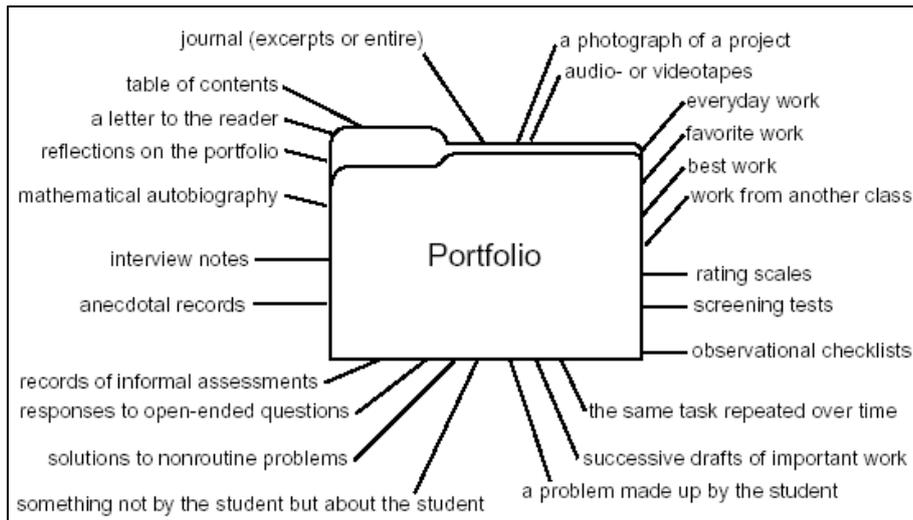
Figure 1. Possible items in a mathematical portfolio (Kuhs, 1994).

THE USE OF PORTFOLIOS WORLDWIDE

Across Organisation for Economic Cooperation and Development (OECD) countries, student mathematical portfolios are used as a form of assessment. On average across OECD countries, 43 per cent of school principals report that student portfolios are used at least three times per year to assess 15-year-olds and in Denmark, Iceland, Japan, Mexico, Spain and the partner country Brazil this applies to between 75 and 96 per cent (Mullis, Gonzalez & Chrostowski, 2004). In New Zealand, secondary schools use portfolios as a form of assessment in mathematics. Twenty percent (20%) year's marks for the depended upon a file of materials produced and selected by each student. Moreover in Kentucky State they used in grades 4, 8 and 12 the portfolio as a form of assessment in mathematics. Finally, in the International Baccalaureate Diploma Programme (International Baccalaureate Organization, 2001), -which is offered in more than 1300 schools in over 110 countries (44 in UK of which 21 are state, approximately 10 in Greece which all are private schools) at the curriculum for Mathematical Methods Standard Level (MMSL), Mathematics High Level (MHL) and Further Mathematics SL (FMSL)- it is used portfolio of three parts of work as an internal assessment. The three parts include mathematical Investigation (Type I), Extended Closed-Problem Solving (Type II) and Mathematical Modelling (Type III).

THE USE OF PORTFOLIOS IN GREECE

Portfolio is proposed as an assessment method both in the compulsory (Grades 1 to 9) and upper secondary or Lyceum (Grades 10 to 12) education.

The Greek Educational Assessment Law for Lyceum: "Student Assessment in General Lyceum", (Official Government Gazette, 2006) includes a clause about student portfolios. This clause mentions, "*...portfolios include evidences that contribute the student educational assessment, which cannot be gathered form other methods of assessment. The portfolio may include: a) tasks, which are not part of the daily educational practice, b) report about activities that students have involved, c) copies of awards and honours in cultural, social and athletic domain, d) questioners of student self-assessment and e) Observations and proposals relative to some courses. Each student that wishes to include in his portfolio new elements, can submit them to his/her teacher*". Moreover the new Cross-Thematic Curriculum Framework (CCTF) for the compulsory education mentions the student's portfolio as an assessment technique (Official Government Gazette, 2003).

Regardless the previous two laws, it seems that Greek teachers do not use portfolios for students' assessment (Mullis et al., 2004; OECD, 2005). As Simon & Forgette-Giroux (2000) underlie: "*Despite the favourable outlook* (of portfolios), *it may nevertheless remain a passing fad due to the lack of a conceptual content selection framework and difficulties surrounding its implementation within the classroom setting*".

THE IMPLEMENTATION OF PORTFOLIOS

According to Simon & Forgette-Giroux (2000), portfolio assessment has been shown to have considerable potential in terms of its use in the evaluation of higher-order, cross-curricular skills. Moreover, the IBO (2001) use student portfolios as a part of the student final mark in mathematics. This assessment constitutes twenty percent of student mark. According to IBO (2001) student portfolio can be "*a collection of three pieces of work assigned by the teacher and completed by the student during the course. The assignments must be based on different areas of the syllabus and represent all three activities: mathematical investigation; extended closed-problem solving and mathematical modelling*". The portfolio is internally assessed by the teacher and externally moderated by the IBO. IBO (2001, p. 45-47) mentions: "*The purpose of the portfolio is to provide candidates with opportunities to be rewarded for mathematics carried out under ordinary conditions, that is, without the time limitations and stress associated with written examinations. Consequently the emphasis should be on good mathematical writing and thoughtful reflection. The portfolio is also intended to provide candidates with opportunities to increase their understanding of mathematical concepts and processes. It is hoped that, in this way, candidates will benefit from these activities and find them both stimulating and rewarding. The specific purposes of portfolio work are to:*

- *develop students' personal insight into the nature of mathematics and to develop their ability to ask their own questions about mathematics*
- *provide opportunities for candidates to complete extended pieces of work in mathematics without the time constraints of an examination*

- *enable candidates to develop individual skills and techniques, and to allow them to experience the satisfaction of applying mathematical processes on their own*
- *provide candidates with the opportunity to experience for themselves the beauty, power and usefulness of mathematics*
- *provide candidates with the opportunity to discover, use and appreciate the power of a calculator/computer as a tool for doing mathematics*
- *enable candidates to develop qualities of patience and persistence, and to reflect on the significance of the results they obtain*
- *provide opportunities for candidates to show, with confidence, what they know and can do*" (IBO 2001, p. 45-47)

As IBO (2001, p. 52) state "*each piece of work in the portfolio should be assessed against the following four criteria:*
A   Use of notation and terminology
B   Communication
C   Mathematical content
D   Results and conclusions
In addition, at least one assignment in each portfolio should include work which is appropriate to be assessed against the criterion:
E   Making conjectures
And at least one assignment in each portfolio should include work which is appropriate to be assessed against the criterion:
F   Use of technology"

The achievement levels concerning the previous criteria are:

Criterion A: use of notation and terminology,
- 0   The candidate does not use appropriate notation and terminology.
- 1   The candidate uses some appropriate notation and/or terminology.
- 2   The candidate uses appropriate notation and terminology in a consistent manner and does so throughout the activity.

Criterion B: communication
- 0   The candidate neither provides explanations nor uses appropriate forms of representation (e.g. symbols, tables, graphs, diagrams).
- 1   The candidate attempts to provide explanations and uses some appropriate forms of representation (e.g. symbols, tables, graphs, diagrams).
- 2   The candidate provides adequate explanations/arguments, and communicates them using appropriate forms of representation (e.g. symbols, tables, graphs, diagrams).
- 3   The candidate provides complete, coherent explanations/arguments, and communicates them clearly using appropriate forms of representation (e.g. symbols, tables, graphs, diagrams).

Criterion C: mathematical content

0   The candidate recognizes no mathematical concepts, which are relevant to the activity.
1   The candidate recognizes a mathematical concept or selects a mathematical strategy, which is relevant to the activity.
2   The candidate recognizes a mathematical concept and attempts to use a mathematical strategy, which is relevant to the activity and consistent with the level of the programme.
3   The candidate recognizes a mathematical concept and uses a mathematical strategy, which is relevant to the activity and consistent with the level of the programme, and makes few errors in applying mathematical techniques.
4   The candidate recognizes a mathematical concept, successfully uses a mathematical strategy, which is relevant to the activity and consistent with the level of the programme, and applies mathematical techniques correctly throughout the activity.
5   The candidate displays work distinguished by precision, insight and a sophisticated level of mathematical understanding.

Criterion D: results or conclusions
0   The candidate draws no conclusions or gives unreasonable or irrelevant results.
1   The candidate draws partial conclusions or demonstrates some consideration of the significance or the reasonableness of results.
2   The candidate draws adequate conclusions or demonstrates some understanding of the significance and reasonableness of results.
3   The candidate draws full and relevant conclusions or demonstrates complete understanding of the significance, reasonableness or possible limitations of results.

Criterion E: making conjectures
0   The candidate demonstrates no awareness of patterns or structures.
1   The candidate recognizes patterns and/or structures.
2   The candidate recognizes patterns and/or structures and attempts to draw inductive generalizations.
3   The candidate recognizes patterns and/or structures, successfully draws inductive generalizations, and attempts to provide formal justifications.
4   The candidate recognizes patterns and/or structures, successfully draws inductive generalizations and justifies (or disproves) the generalizations by means of formal arguments.

Criterion F: use of technology
0   The candidate does not use a calculator or computer beyond routine calculations.
1   The candidate attempts to use a calculator or computer in a manner, which could enhance the development of the activity.
2   The candidate makes limited use of a calculator or computer in a manner, which does enhance the development of the activity.

3   The candidate makes full and resourceful use of a calculator or a computer in a manner, which significantly enhances the development of the activity (IBO, 2001, p. 55-57).

A research question that arises is if the previous well-define portfolio (Content, Criteria Assessment and Achievement Level) may be part of the final student mark, especially in grades 10th to 12th. This curriculum change may happens if a well prepared program of in-service teachers' training takes place to each one of the approximately 1500 Lyceum schools. In appendix I and II we present two portfolio assessment assignments from the IBO (2001).

E-PORTFOLIOS, THE FUTURE

One drawback to portfolios is the actual collection, storage and organization of the materials, particularly when they are being collected for course or programme assessment (Lockledge & Weinmann, 2001). An obvious solution is to convert the portfolios to a digital media, creating a digital or e-portfolio.

"E-portfolio is a collection of authentic and diverse evidence, drawn from a larger archive, that represents what a person or organization has learned over time, on which the person or organization has reflected, designed for presentation to one or more audiences for a particular rhetorical purpose" (National Learning Infrastructure Initiative, 2003).

ICT provides a link between learning, teaching and assessment. In school, ICT is used to support learning. Currently, we have assessment practices where students use ICT tools:

- Graphing Calculators,
- Computer Algebra Systems and educational software,
- Text-processor, spreadsheet, presentations software, Internet,

as an integral part of learning, and are then restricted to paper and pencil when their 'knowledge' is assessed or e-assessment only through multiple-choice, matching and true-false items.

E-portfolios have two positive consequences: students are introduced to modern technologies and ICT is utilised in teaching practice. In addition, it is incumbent upon ICT and, consequently, upon e-portfolios to support teachers who would attempt to attain particular educational objectives, but come up against difficulties in achieving them through compatible teaching methods. NCTM (2000) supports that: "*through the use of technological tools, students might justify more general subjects, modelise and solve complicated problems, which could not be solved in the past*".

E-portfolios are separated into two basic categories. In the first category, there are the technological tools of general use, text processor, web pages, multimedia tools and so forth. In the second category, there are the adapted systems that include servers, programming and databases.

The following figure presents an implementation of e-portfolios:

Figure 2. EUropean CErtificate of Basic Skills (EUCEBS), Tosh (2004)

E-portfolios allow students and teachers to collect and organise their files with many and multiple means (acoustical, visual, graphical, text). Web pages and contacts are used to organise the material and the data are connected on the bases of predetermined models. We have to ensure that each portfolio will be based on learner outcomes that use national, state, and local standards, and are associated with evaluation rubrics (Barrett, 2000).

One of the reasons that lead to the use of e-portfolios is that they are easily accessed; through them, the results of educational activities can be easily supervised. Moreover, copies are easily produced; there is portability; they occupy limited disk space; and the student is at the centre of the educational process. In the case of portfolios using databases through Internet connection, the teacher, the guardian and the student can obtain a direct access and send comments on some work or on the content of the file electronically. Per regular time intervals, they can commend on the quality of the file and on its best and worst points.

For e-portfolios to be developed, a new culture is required as far as it concerns so much teachers' and students' education what for teachers' and students' support; further research into the precise planning of e-portfolios, a planning which should correspond with the one that supports "paper and pencil" portfolios; a training specialised in the use of information, communication and technology; the appropriate methodology in order for the student to respond to what he is asked and not only to what he/she can give; and teachers' further training. To sum up, issues of software and content security, connectivity, grouping, deployment and

portability should be clarified before any use of e-portfolios (Chionidou-Moskofoglou, Doukakis & Lappa, 2005).

CONCLUSION

In this presentation we argued that:
1. Greek Law proposes the use of portfolio for student assessment.
2. Greek Organisation of Teacher Training (O.EP.EK.) is currently running a research study for students' portfolio assessment.
3. The experience of International Baccalaureate's portfolio, suggests us that portfolio "*provide students with opportunities to be rewarded for mathematics carried out under ordinary conditions, that is, without the time limitations and stress associated with written examinations. Consequently the emphasis should be on good mathematical writing and thoughtful reflection. The portfolio is also intended to provide candidates with opportunities to increase their understanding of mathematical concepts and processes. It is hoped that, in this way, candidates will benefit from these activities and find them both stimulating and rewarding*" (IBO, 2001 p. 47).
4. E-portfolios appear to be a useful research challenge, as some teachers are trying to embed ICT in every day teaching and assessment practices. The use of e-portfolios will take place if they will constitute a supportive, dynamic, formative and pleasant assessment environment, which has the potential to follow the students throughout their life giving meaning to their own mathematical knowledge.

As a result, we put the following research questions:
- In which ways would all the various techniques (qualitative and quantitative) be used in an e-portfolio assessment?
- How will the e-portfolio, using all various (qualitative and quantitative) techniques, give a valid and reliable assessment of students' knowledge?
- What is the relation between students' learning and knowing mathematics and e-portfolios?

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APPENDIX I: International Baccalaureate Portfolio Assignment

Type II - Extended Closed Problem Solving
The decibel scale IBO (2001)

Work done on this assignment will be assessed against criteria A. B, C and D. While the use of a graphic display calculator may be helpful, the use of technology is not specifically required, nor will it be assessed.

The **intensity** I of a sound wave is measured in watts per metre squared (Wm^{-2}). The lowest intensity that the average human ear can detect, i.e. the threshold of hearing, is denoted by I_0 where, $I_0 = 1 \times 10^{-12}$ Wm^{-2}. The loudness of sound, i.e. its

intensity level β, is measured in decibels (dB), where $\beta = 10\log_{10}\dfrac{I}{I_o}$.

1. Find the intensity of ordinary conversation which has an intensity level of 65 dB.
2. The sound inside an automobile travelling at 90 kmh-1 has an intensity level of 75 dB. Find the intensity of this sound source in Wm-2.
3. Copy and complete the table below.

| Source of Sound	Intensity Level (dB)	Intensity (Wm^{-2})
Jet plane at 30m	140	
Threshold of pain		1
Loud indoor rock concert	120	
Siren at 30m		1×10^{-2}
Busy street traffic	70	
Quiet radio		1×10^{-8}
Whisper	20	

4. Describe the relationship between an increase in intensity and the corresponding increase in intensity level.

5. Using the given formula, $\beta = 10\log_{10}\dfrac{I}{I_o}$ show that this relationship holds true for any increase in intensity.

6. (a) Sketch the graph of β as a function of I. (b) Determine the intensity of a sound wave whose intensity level is (i) 6 dB; (ii) 12 dB; (iii) 18 dB. (c) How many times more intense would the 18 dB sound seem compared to the 6 dB sound?

7. A dog's threshold of hearing is 1×10^{-13} Wm^{-2}. Discuss the following points.
    (a) How does the graph change? Why does it change? (b) How does the relationship described in part 4 change? Why does it change? (c) When you and your dog cross a busy street does the noise seem equally loud to both of you? Explain your answer.

APPENDIX II: International Baccalaureate Portfolio Assignment

Type III - Mathematical Modelling
Design of a Ship's Propeller Blade IBO (2001)

Work done on this assignment will be assessed against criteria A, B, C, D and F. You are therefore expected to use α graphic display calculator/computer for this assignment.

A new design for a ship's propeller blade requires that it has a flat shape similar to the one in the diagram below.
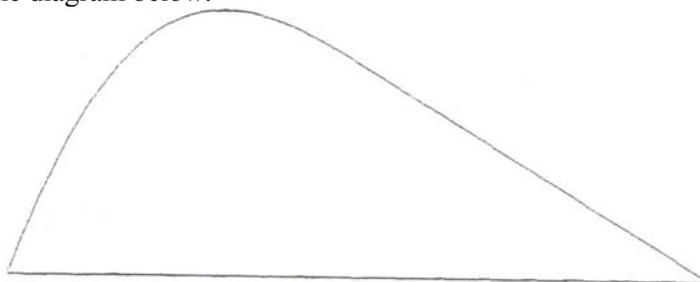
For construction purposes, we need to set up the mathematical functions that describe the profile of the propeller blade.

The curved side of the propeller blade is made up of three functions denoted by $P(x)$, $Q(x)$, and $R(x)$, where x is defined as the horizontal distance along the drive shaft to which the propeller blade will be attached. This drive shaft will have a radius of 30 cm. In total eight blades will be attached to the drive shaft to form the final configuration of the propeller.

The conditions required are as follows:

(i) $P(2) = 3$;   (ii) $P(3) = Q(3) = 7$;   (iii) $Q(12) = 12$;

(iv) $P'(3) = Q'(3)$;   (v) $P''(3) = Q''(3)$; (vi) $P''(2) = Q''(12) = 0$.

Note that 1 unit represents 10 cm.

$P(x)$ describes the curved side of the propeller blade between 20 cm and 30 cm, $Q(x)$ describes it for 30 cm to 120 cm, and $R(x)$ describes it between 120 cm and 210 cm.

Through research work the design engineers have found that the functions $P(x)$ and $Q(x)$ are cubic, while $R(x)$ is linear. Condition (i) ensures that the curved part of the propeller blade starts at the correct location. Condition (ii) will guarantee that the two parts meet, conditions (iv) and (v) ensure smoothness at the joining point of $P(x)$ and $Q(x)$, and condition (vi) ensures smoothness at the ends of each part.

1. Using the conditions given, set up a system of simultaneous equations that will enable you to find the functions $P(x)$ and $Q(x)$.
2. Using suitable technology as a tool, solve this system of equations to find the functions $P(x)$ and $Q(x)$.
3. Given that $R(x)$ must continue the smoothness of $Q(x)$ find its equation.
4. Find the total area of one blade of the propeller.