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Methodology for Spatial-Visual Literacy (MSVL) in Heritage Education: Application to Teacher Training and Interdisciplinary Perspectives

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Abstract

Modern Conservation of Cultural Heritage (CCH) is an interdisciplinary field, comprising arts, crafts, architecture, humanities, IT (Information Technology) and STEM (Science, Technology, Engineering, Mathematics). Several decades of extended research have shown the importance of spatial skills and spatial literacy for success in STEM.

A major part of cultural heritage is visual, and three-dimensional. A sufficient level of spatial understanding and spatial skills is needed to understand, study and preserve cultural heritage. Visualization is especially helpful in teaching and learning the interdisciplinary CCH. However, the necessity of developing spatial visual literacy, and acquisition of relevant theoretical knowledge by experts and educators in CCH has not yet been commonly accepted.

This paper outlines an innovative Methodology for developing Spatial Visual Literacy (MSVL) - a crucial tool for CCH and heritage education, - and selected perspectives of its feasibility and applicability to teacher training and also wider interdisciplinary uses.

The paper addresses selected lessons from application of some elements of the Methodology as part of previous research and educational scenarios for different objectives and target audiences, from high-school, undergraduate, PhD students, to experts from different areas of expertise within the CCH, to facilitate its uses for teacher training in heritage education.

Key words

Heritage education; conservation of cultural heritage; Methodology for the development of Spatial Visual Literacy (MSVL); spatial ability

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Metodología para la Alfabetización Espacial-Visual (MSVL) en Educación Patrimonial: Aplicación en la formación docente y perspectivas interdisciplinarias

Resumen

La Conservación del Patrimonio Cultural (CCH) es un campo interdisciplinario, que comprende artes, artesanía, arquitectura, humanidades, TICs (Tecnología de la información) y STEM (Ciencia, Tecnología, Ingeniería, Matemáticas). Varias décadas de investigación han demostrado la importancia tanto de de las habilidades espaciales, como de la alfabetización espacial para el éxito en STEM.

Una parte importante del patrimonio cultural es visual y tridimensional. Se necesita un nivel suficiente de comprensión espacial, así como habilidades espaciales para poder comprender, estudiar y preservar el patrimonio cultural. La visualización, es especialmente útil para enseñar y aprender el patrimonio desde un punto de vista interdisciplinar. Sin embargo, aún no se ha aceptado por parte de expertos y educadores en patrimonnio la necesidad de desarrollar la alfabetización visual espacial y la adquisición de conocimientos teóricos relevantes sobre la misma.

Este trabajo presenta una metodología innovadora para desarrollar la alfabetización visual espacial (MSVL, por sus siglas en inglés), una herramienta crucial para la conservación y la educación del patrimonio, y perspectivas seleccionadas de su factibilidad y aplicabilidad a la capacitación docente, así como usos interdisciplinarios más amplios.

El documento aborda una selección de ejemplos de aplicación de algunos elementos de la Metodología como parte de investigaciones previas y escenarios educativos con diferentes objetivos y audiencias distintas, desde estudiantes de secundaria, bachillerato o doctorado, hasta expertos de diferentes áreas de experiencia dentro de la conservación del patrimonio, buscando facilitar su uso en la formación docente en educación patrimonial.

Palabras clave

Educación patrimonialo; conservación del patrimonio cultural; Metodología para el desarrollo de la alfabetización visual espacial (MSVL); habilidad espacial

Introduction

Spatial-visual literacy and heritage education

Different terms are used by diverse researchers in various areas for the related skills and processes: spatial-visual skills, spatial ability, spatial visualization, spatial reasoning, visual-spatial literacy and visual thinking. For several decades, these skills have received much attention from researchers and educators in different areas of knowledge. In humanities, this interest has been extended far beyond its primarily-visual areas like history of visual arts, to, e.g.: literature, social sciences (Swedberg 2016; Grieseking 2013). Over fifty years of wide research have demonstrated the importance of spatial skills for success in STEM, and examined the impact of visualisation in education (Newcombe 2010; Sorby 2009). At the same time, interpretation of terminology, definition of targets of application of these skills, and of the expected outcomes of their acquisition and learning, differ in diverse areas of knowledge. In education, especially in humanities and arts, the development and application of visual literacy is often reduced to studying and interpretation of two-dimensional images.

The ability to *understand* spatial interrelationship of simple and complex nature would be a powerful visual-spatial instrument for researchers in humanities and arts and engineers alike. It would enhance their understanding of real and virtual three-dimensional objects, and enable them to analyse complex three-dimensional images, to "see" imaginary objects, to manipulate them spatially in one's mind. Furthermore, and ability to *create* three-dimensional images would make these processes of mental three-dimensional analysis and development easier and more flexible. Combining the process of three-dimensional analysis with simultaneous freehand sketching would provide powerful educational Visual-Spatial Tools for teachers, regardless of their teaching area. Multi-compatibility of these tools with diverse areas of knowledge would add value to heritage education, due to a multi- and interdisciplinary character of conservation (preservation) of cultural heritage. Furthermore, because of the visual character of the major part of cultural heritage, educators could also use those tools for analysing and explaining cultural heritage to their students (Lobovikov-Katz 2009; Lobovikov-Katz et al. 2012; 2014).

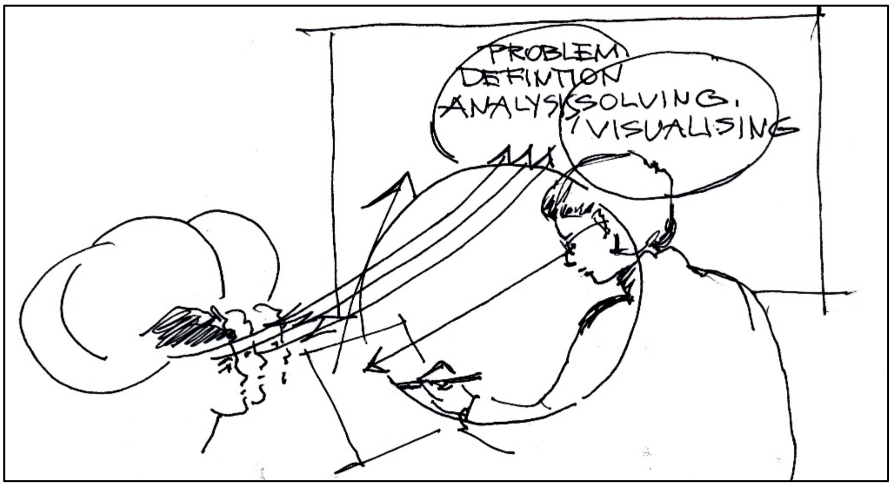

Figure 1. Use of mind-eye-hand system for the development of understanding and solving problems ©Anna Lobovikov-Katz

However, the acquisition of these tools has not been widely pursued because, in spite of the research, the development of spatial skills and spatial literacy has not been seen as a prerequisite for educators in general, and heritage educators in particular. Also, the process of developing spatial skills and acquiring the necessary theoretical knowledge has been traditionally considered as time consuming. Furthermore, the scope of theoretical subjects supporting these skills has been gradually reduced or eliminated from universities curricula. All these put the development of visual-spatial literacy out of reach of future educators.

Related subjects and processes

There are mathematics- and arts-related visual subjects and both areas of visual disciplines have the same theoretical basis. Besides their direct educational value, these disciplines are well-known for their contribution to the development of spatial-visual ability of students. Fig. 2 visualises the analysis of overall development of spatial ability among architectural undergraduates within a one semester course in descriptive geometry, which I gave at the Technion. Spatial ability was measured by MCT (Mental Cutting Test) (Tsutsumi 2004; Nemeth 2007), at the beginning, and at the end of the semester. Bar graph in Fig. 2 presents groups of answers similar to that used by Nemeth (Nemeth 2007). It shows that spatial ability measured by MCT generally improved among the students, with the percentage of low performance decreased (students who answered correctly no more than 1 to 9 questions of 25 in the beginning of the semester), and the percentage of higher performance increased through semester. This specific experiment did not focus on personal improvements of each student. Overall results demonstrate the contribution of learning descriptive geometry to the development of students's spatial ability.

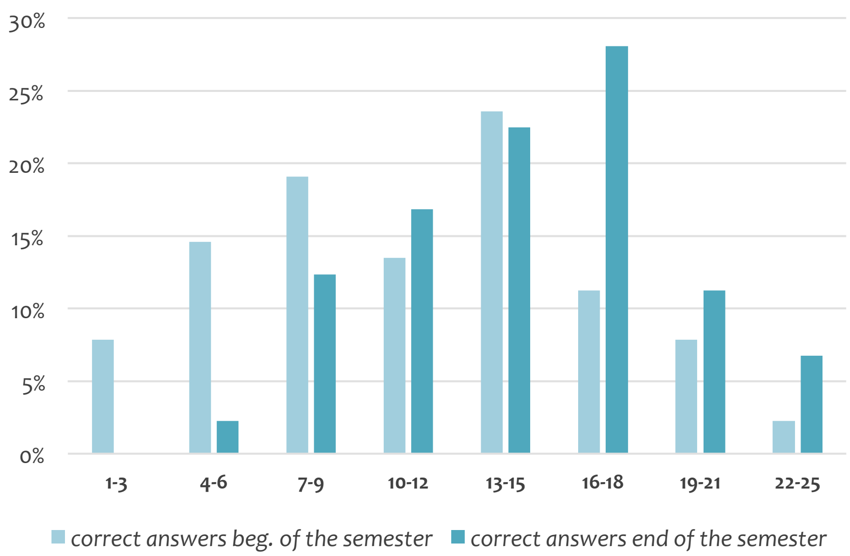

Figure 2. The development of spatial ability as measured by MCT (Mental Cutting Test). Correct answers (of total 25 questions of the test) at the beginning and at the end of the course. Vertical axis relates to the percentage of participants (about 100 students participated in the course). ©Anna Lobovikov-Katz

In spite of their educational value, the scope of mathematics- and arts-related visual disciplines has significantly changed in recent decades. Core math-related visual disciplines are descriptive geometry and perspective (Croft 2005; Crowley 1987), the former being traditionally associated with engineering and architecture. Students and experts in arts and humanities are deprived of learning this subject. On the other hand, engineers are not taught any artistic disciplines (e.g. freehand drawing and painting). General or humanities and arts studies, often provided to the students of technological faculties, sometimes incorporate a limited number of hours in art-related subjects in STEM curricula. However, often only a minority of students learn them. Furthermore, art classes in highly-ranked technological universities are often perceived both by students and teachers as merely a relaxing environment when compared to their major demanding area of studies, and therefore are not meant to provide a significant theoretical basis in art-related skills. The only fortunate exception seems to be architecture which is supposed to have courses in the entire complex of visual subjects: descriptive geometry, perspective, drawing, sketching in monochrome and colour. This, historically, was the situation in architectural education. However, following the impressive achievements in CAD (computer-aided design), virtual and mixed reality, gradually more and more hours in the architectural curricula have been added for these innovative disciplines, usually, at the expense of descriptive geometry, perspective, and freehand courses. Similar processes are taking place also in engineering studies.

While freehand arts-related disciplines are often considered as outdated and old fashioned by some of the major users of these disciplines, e.g. architects, who often trade them for CAD, an inverse development has been occurring among those who are responsible for CAD development and relevant research in computer science. The IT community has been expressing more and more interest in the use of freehand sketch as a natural and easy way of expressing ideas, for a freehand input in CAD (Kazmi et al. 2014; Olsen et al. 2008; Kondo 2009; Olsen et al. 2009). However, it might happen that soon only a very limited number of experts will still possess the skill of freehand sketching. Along with these tendencies, a targeted development of spatial skills among the students (e.g. Spatial Visualization Course, The Cockrell School of Engineering, The University of Texas at Austin, USA) is a rare phenomenon.

Through more than twenty years of research in heritage conservation and heritage education (Lobovikov-Katz 2000; 2006 ; Lobovikov-Katz et al. 2018), as well as of educating students and young experts from diverse areas of expertise in a wide spectrum of visual subjects, including descriptive geometry, perspective, freehand drawing and painting in different techniques, I have noticed that the maximum effect of the teaching-learning process can best be reached when students are introduced to the entire complex of visual disciplines. This inclusive approach to teaching these disciplines allows deeper understanding of different subjects and of their inter-relationship, and is a time saving learning experience through teaching shortcuts. Finally, this has resulted in the formulation of an innovative Methodology for the development of Spatial and Visual Literacy (MSVL). While the proposed Methodology is beneficial to different types of audiences, this paper focuses on outlining its structure, components and feasibility with a view to teacher training and heritage education.

Methodology for the development of Spatial and Visual Literacy (MSVL)

MSVL – Outline

MSVL, as proposed in this paper - combines an Integrated Approach (IA) to teaching the theoretical basis of core visual disciplines with Rapid Learning Methodology in Freehand Sketching (RALEMEFS). IA integrates selected core elements of precise basic visual disciplines. Rapid Learning Methodology in Freehand Sketching (RALEMEFS) provides learners with a flexible system of rules and tools for avoiding mistakes and self-guiding progress in freehand drawing. While RALEMEFS focuses only on the development of the actual sketching ability, the MSVL has a wider scope. The core elements of the combined application of RALEMEFS and the newly formulated IA were first tested in 2016 (Lobovikov-Katz 2016a). Since then they underwent further development and consolidation. This paper is the first presentation of the combined Methodology for the development of Spatial and Visual Literacy (MSVL):

$$[MSVL] = [IA] + [RALEMEFS]$$

MSVL has three main objectives:

1) To provide an integrated theoretical basis of the main rules and principles of the core visual subjects;
2) To develop basic skills in free-hand sketching, as based on "1", and on the methodology "RALEMEFS";
3) To contribute to the development of spatial skills and spatial reasoning through the above "1" and "2".

By the completion of their training, teachers will have developed the understanding of the theoretical basis of diverse types of images and their transformations which will better equip them for dealing with the changing computer-aided applications. At the same time, they will develop a basic freehand sketching ability. (1+2+3) will equip them (the teachers) with a tool useful for sharpening their own understanding of diverse subjects, and for visualizing their knowledge to their students. Such an aid will be helpful for easy analysing and visually explaining the structures of complicated subjects. This knowledge and skills will be useful for showing complicated correlations between diverse factors and components of systems at high levels of complexity, relevant to cultural heritage, its conservation, and beyond.

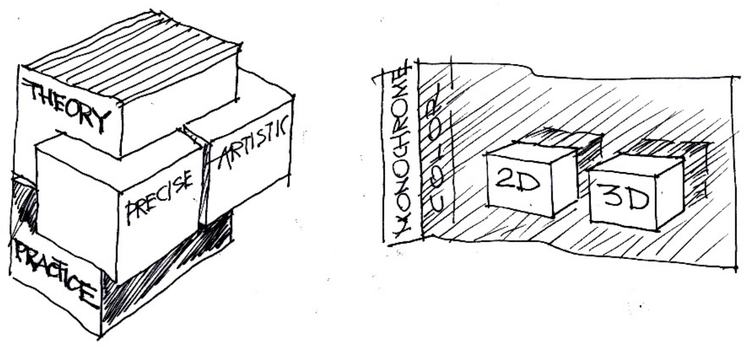

Figure 3. Precise/artistic/theory/practice core approach of MSVL and exemplification of 2D/3D objects versus colour/ monochrome description. ©Anna Lobovikov-Katz

Methodology (MSVL) - WHAT: content and components

MSVL uses the unique Integrated Approach (IA) to introduce the theory of visual disciplines, and it combines the acquisition of the theoretical basis with the development of practical ability with the use of Rapid Learning Methodology in Freehand Sketching (RALEMEFS). Freehand sketching applications are based on theoretical knowledge, and at the same time, help to achieve a better understanding of complicated theoretical principles and rules, while contributing to the ease of learning the latter. MSVL introduces the core theoretical basis of precise and artistic visual disciplines. Its main components are presented schematically in Fig 4.

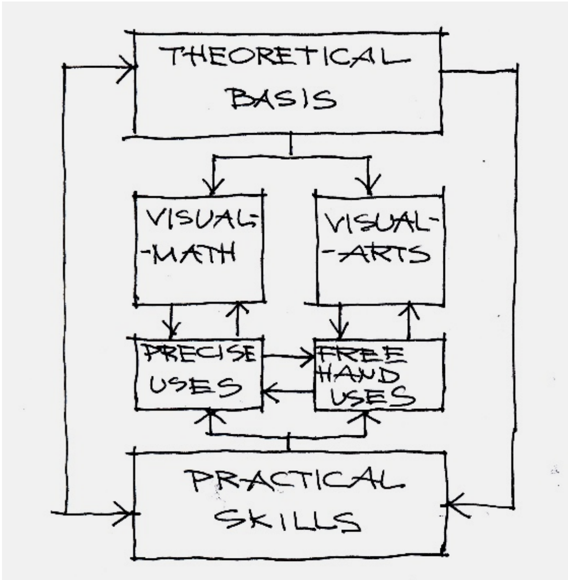

Figure 4. Core structure of MSVL: theoretical basis (IA) and practical skills (RALEMEFS), taught and developed with regard to math-related and arts-related visual subjects, through precise and freehand applications. ©Anna Lobovikov-Katz

IA was formulated through simultaneous teaching of precise and artistic visual disciplines: descriptive geometry, perspective, freehand drawing (monochrome and colour) and painting. For the combined teaching structure of basic visual disciplines, it was necessary to review the main thematic components of these disciplines, and to split them into their basic elements. Some cross-cutting didactical solutions were applied through the relevant courses. One of the main principles used in this educational construction, was the use of spatial transitions between three-dimensional objects and their transformations, and their two-dimensional definitions. This inter-relationship between three-dimensional (3D) and two-dimensional (2D) representation was applied in several layers.

The *first layer* deals with images (2D) of spatial (3D) objects on a flat surface. Understanding this interrelationship is a challenging exercise for a beginner. Why does a three-dimensional object look in a certain way on its flat image, what should be our point of view of a real three-dimensional object in order to create a specific image? Answers to these and other similar questions need some spatial ability and theoretical knowledge.

The *second layer* is the use of 2D-3D inter-relationship in teaching the rules and principles of a theoretical mechanism of e.g. descriptive geometry or perspective, and building the cross-paths in learning the specific topics of these disciplines. The aim of IA is to show the students how flat images are the result of transformations and of the application of rules in the theoretical three-dimensional space as relevant to diverse types of projection systems and projections, e.g. orthographic, axonometric, or perspective. At the same time, it is important to explain that diverse themes cut through diverse types of projections. For example, the construction of shadows in orthographic, axonometric or perspective images, is commonly taught as a separate set of principles in each single type of projection. However, the construction of shadows follows unique rules. If understood in their three-dimensional theoretical space, these rules can be then "translated" into a specific language for each type of projection. This saves teaching the same topic over again in its three different applications. The development of this spatial understanding also prepares the trainees for subsequent effective self-learning after the completion of their studies.

Methodology (MSVL) - HOW: the "technology" of teaching/learning process

The practical component of MSVL, - RALEMEFS (the Rapid Learning Methodology in Freehand Sketching), provides a clear structure of basic rules and recommendations which guide learners through their studies and help them avoid mistakes. RALEMEFS appeals to high intellectual capabilities, including the ability to analyse typical of adult learners, to compensate for their previous lack of freehand sketching skills. Since RALEMEFS allows for very fast progress for the learners who actually apply it in their actual sketching, it can be used already while learning with MSVL. Freehand sketching exercises are interwoven with the process of learning the theoretical basis of MSVL - IA (Fig. 5, 6). This helps to reinforce the theoretical knowledge, while making its acquisition easier, more "user-friendly". Freehand sketching can be used for visualizing different spatial rules so as to better understand them, and also to practice their application. In teacher education and training, this interwoven shuttle use of freehand sketch in the tissue of the core theoretical subjects, serves as a model for their optional active application of MSVL in their teaching.

In teaching theoretical bases with IA, the themes cross-cutting through several different types of projections and areas (e.g. axonometry and perspective) are introduced in their theoretical three-dimensional scope, and then exemplified through their application in different types of projections and images.

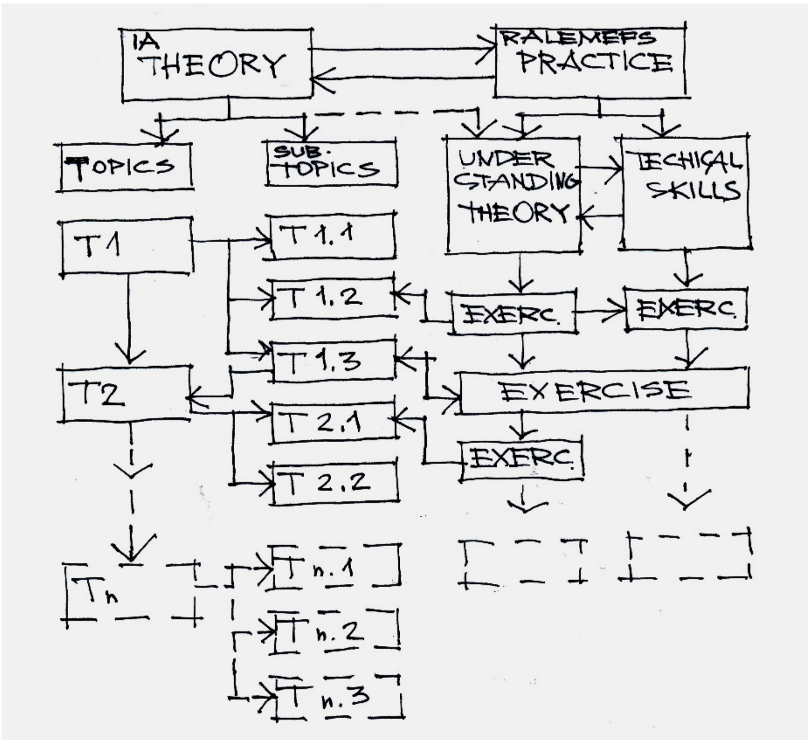

Figure 5. The MSVL teaching "technology" – theory-practice interaction and "shuttle" use of freehand sketching ©Anna Lobovikov-Katz

Artistic visual subjects, including freehand drawing (sketching) and painting, are based on math-related principles. Since the Italian Renaissance, the mathematical development and its expression in painting were interrelated, while sometimes paintings were seen as mere exercises for the mathematical development (Alberti 1935, 2011; Vasari 1960). Teaching the theoretical basis of math-related visual disciplines builds a solid foundation for further development of freehand sketching ability of the learners.

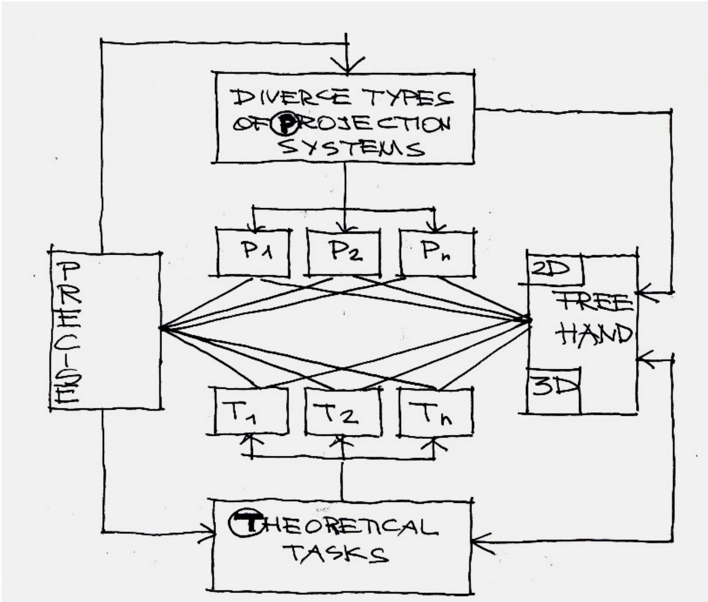

Figure 6. MSVL Teaching process interaction: theory, practice, precise, artistic (freehand) teaching components, e.g. various **T**heoretical tasks (**T**) could be solved in diverse Types of **P**rojection systems (**P**), through precise / freehand methods / techniques. ©Anna Lobovikov-Katz

Selected aspects of application MSVL to teacher training

The ways and the levels of teachers' application of the results of their learning with MSVL

There are different ways, and different levels of application by teachers of the results of their learning with MSVL, of their knowledge and understanding of basic theoretical subjects, and of practical skills developed in the course of teacher training.

Two Ways: Direct and Indirect use. Knowledge, understanding and skills developed by teachers as a result of their learning with MSVL, can be applied in two ways in their teaching:

1) Direct - teaching visual subjects
2) Indirect - teaching any subject.

The *indirect* application has a remarkably wider impact than the *direct* one, because of the vast number of different disciplines which will benefit from it. At the same time, it is the most challengeable for teachers' education. Teachers who are not linked directly to the teaching of visual subjects - the precise math-related and the free-hand-artistic ones alike, - most probably do not have any previous experience in these areas.

Two Levels: Level 1 and Level 2. Two levels of the methodology application can be distinguished: Level 1: "product", and Level 2: "technology". On Level 1, teachers merely apply the "product" acquired as a result of their learning with MSVL, to the benefit of their teaching. They can use their knowledge and understanding of the theoretical basis of visual disciplines, and use their ability of freehand sketching, to explain and visually present different subjects and topics of disciplines to their students.

On the more advanced Level 2 ("technology"), teachers may try to share their spatial and visual knowledge and skills with students, in order to encourage and guide the latter how they, in turn, can apply visualisation in their learning. To enable Level 2 application by teachers, specifically adapted MSVL programs and visual manuals should be developed. Teachers should be given expert assistance through the initial period of Level 2 application.

Lessons from application of selected methodological elements of MSVL

Overview. MSVL is a result of redesigning and putting together several methods developed and applied over periods of time. This section of the paper examines the application of some of these elements to different types of audience, undertaken in different frameworks, with different objectives, processes and results. Target audiences included undergraduate students, MSc and PhD students and young researchers and experts from different areas of CH conservation. These involved homogeneous audiences, i.e. students that studied together on a daily basis as an organic class e.g. as part of a university program, and a heterogeneous audience, which had been brought together for a one-time learning experience. Homogeneous audiences mostly included university undergraduate students, and, in a few cases, high-school students. Both precise and RALEMEFS elements were introduced to both types of audience.

Multi-disciplinary and heterogeneous audience – Short introduction to IA and RALEMEFS. Since one of the main benefits of MSVL is its application to teacher training for non-visual fields, it is especially important to examine the feasibility of this application. Here we look at the case of a heterogeneous audience - an international group of young experts, MSc and PhD students which included representatives from the following areas: history, archaeology, architecture, art history, sociology, cultural heritage, conservation of cultural heritage, civil engineering, building pathology, chemistry, electrical engineering, economics, and management. All participants were involved with conservation of cultural heritage, but for some of them this involvement was of a limited scope. This training experiment was undertaken in the form of two sessions on "Understanding cultural heritage through sketching – rapid learning methodology". This was part of the Training School, organized partly by the European Cooperation in Science and Technology (COST) in the framework of the COST Action i2MHB (Innovation in Intelligent Management of Heritage Buildings) and the Fundación Santa María la Real del Patrimonio Histórico on its premises in Aguilar de Campoo, in 2016 in Spain. The main focus of these two sessions was a rapid introduction of freehand sketching methodology, and its subsequent targeted application to the analysis of a historic heritage site (the exercise took place at the Monastery of Santa Maria la Real). However, this was also the first testing of a short version of IA. Some results of this teaching experiment were presented in 2016 (Lobovikov-Katz 2016a; Lobovikov-Katz et al. 2016b). During the sessions, the participants showed a good understanding of a very compact introduction to the selected core elements of IA. At the end of the sessions the participants filled in a questionnaire. Summarizing their experience during the sessions, with regard to sketching ability, half of the participants who had no or very little experience in sketching wrote that "everybody can learn to draw“ (Lobovikov-Katz 2016a). The fast development of a very basic sketching ability was facilitated, besides the use of RALEMEFS, by a very brief introduction to the main terms, definitions and theoretical mechanisms of major types of projections, incl. parallel and central projections - i.e., the elements of IA.

Figure 7. Exemplifying application of experimental elements of IA and introduction to RALEMEFS at two 2-hours sessions in the framework of the COST Action i2MHB Training School in Spain, 2016.

Cross-cutting topics as part of IA. Another experimental application of the elements of IA was made in the framework of a two-semester course of descriptive geometry and perspective, at the NB School of Design and Education in Haifa, Israel, the Department of Architecture. The combined structure of the course, which included both descriptive geometry and perspective, allowed for an integrated introduction of the topics cross-cutting through different parts of the course. First, the students were introduced to a three-dimensional theoretical mechanism. After understanding how this worked in the "theoretical geometrical space", they learned to use this mechanism in diverse types of projection systems and different types of projections, e.g. three-dimensional perspective or axonometric sketches, plans and façades. The understanding that a two-dimensional image is defined through three-dimensional theoretical transformations and rules, allowed for a deeper understanding of these subjects by students.

2D-3D didactical challenges in the contemporary learning environments. Special thought should be given to how two-dimensional and three-dimensional teaching information is presented and to their interrelationship and transformations. This includes e-learning, distance learning and blended learning (Lobovikov-Katz 2017). Though virtual and mixed reality are part of modern reality, including education in general, and heritage education in particular (Hazan and Lobovikov-Katz, 2017 ; Lobovikov-Katz 2015), it seems that for some time it will not yet be accessible to all. Furthermore, 2D-3D transformations should not be excluded from teaching practice, because their understanding is one of the most powerful tools in the development of spatial reason and spatial visualisation (Stachel 2013). Development of methodologies and technologies for combining freehand sketching in teaching with the application of sketch-based modelling is a promising perspective in heritage education, including teacher training.

Modular approach. The experience of EU Project in heritage education "ELAICH" (Educational Linkage Approach in Cultural Heritage) (Lobovikov-Katz et al. 2014,), as well as early teaching experiments which served as a methodological foundation of this project (Lobovikov-Katz 2008;2009), showed that a modular approach can be of an added value in teaching visual subjects. This was found to be especially helpful in the presence of the following factors when:

1) The target audience lacks basic knowledge and skills on the subject being taught
2) The target audience is heterogeneous with regard to the participants' level of knowledge and their main learning areas
3) The subject being taught is interdisciplinary / multidisciplinary.

A modular approach in course design allows for a flexible accessibility of the methodology in question to different types of audience. For example, in ELAICH, an online platform was designed as a tree, where the trunk and the main branches of a "tree" of learning comprised a core basic course, while "secondary branches" provided a more advanced and extended learning of specific topics "on demand" from a learner who could decide which branch to explore. Of course, learning the advanced topics was conditional and accessible only on completion of the underlying basic ones. Such didactically solid and yet flexible modular learning system allows for an adjustable course duration, and it also allows learners to extend their learning around the topics of their specific interests.

Conclusions

MSVL has three main benefits / values. The first benefit of using MSVL is time saving which lies in its non-digital character: while digital technologies change all the time, and require time for keeping up to date with the innovations throughout every teacher's career, MSVL does not require re-learning. MSVL is based on a solid theoretical basis which will always stay with the teachers after the initial training. At the same time, the skills and knowledge acquired and developed by them through learning with MSVL, will assist them in their continuous learning of computer-aided applications, through their common visual elements and theoretical foundations.

The main value of MSVL is that it provides teachers with a new ability, a set of skills which they can use in educating their students. And, finally, MSVL, including RALEMEFS, provides teachers with a self-learning instrument, which they can use to further extend the acquired theoretical knowledge and understanding, and for the continuous development of practical skills. The development of spatial understanding of a 3D theoretical origin of basic mathematics-related visual disciplines, like descriptive geometry or perspective, provides the learners with a tool useful also for their future learning of theoretical subjects after the completion of their studies. Thus, a theoretical 3D awareness along with a practical ability, will have a long-term impact on teachers after their initial training with the help of the Methodology for the development of Visual and Spatial Literacy - MSVL.

The development of dedicated modular educational programs for teachers will allow for putting this methodology into practice of teacher training, and through the subsequent education activity of the teachers - MSVL graduates, will contribute to the development of basic spatial-visual literacy among their students.

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