„CONTEMPORARY APPROACH TO THE DEVELOPMENT OF SPATIAL COMPREHENSION THROUGH AUGMENTED REALITY CONTENT“

Erasmus+

DEVELOPMENT OF TEACHING MATERIALS METHODOLOGY

Prof. Manuel Contero
Universitat Politècnica de València, Spain

SPACAR
No. 2019-1-LT01-KA202-060471

This project is funded with the support of the European Commission.

Agenda

- Context
- Spatial Ability
- Measuring Spatial Abilities
- Pedagogical Framework
  - Design principles
  - Taxonomy of exercises
- Format of Exercises
- Validation Framework

No. 2019-1-LT01-KA202-060471

Context – Project Summary

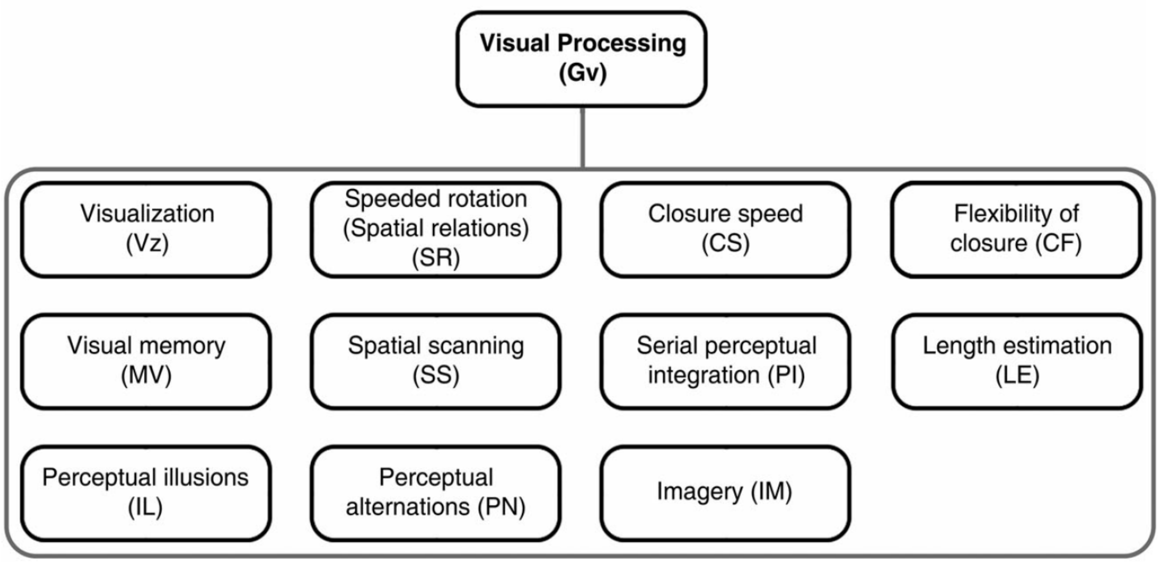
- The objective of the project is to develop the didactic toolkit which include set of practical exercises with 3D objects prepared for the use into AR environment.

- The didactic toolkit is specified for vocational schools, colleges and universities where the graphical engineering subjects are compulsory.

- The didactic toolkit will allow:
    - To develop spatial skills of students of vocational schools and higher schools
    - To obtain practical experience in solving graphic exercises
    - To enhance the quality of graphic education

Spatial Ability

The Cattell-Horn-Carroll Model (CHC) model of intelligence defines **Visual Processing (Gv)** as the ability to make use of simulated mental imagery (often in conjunction with currently perceived images) to solve problems

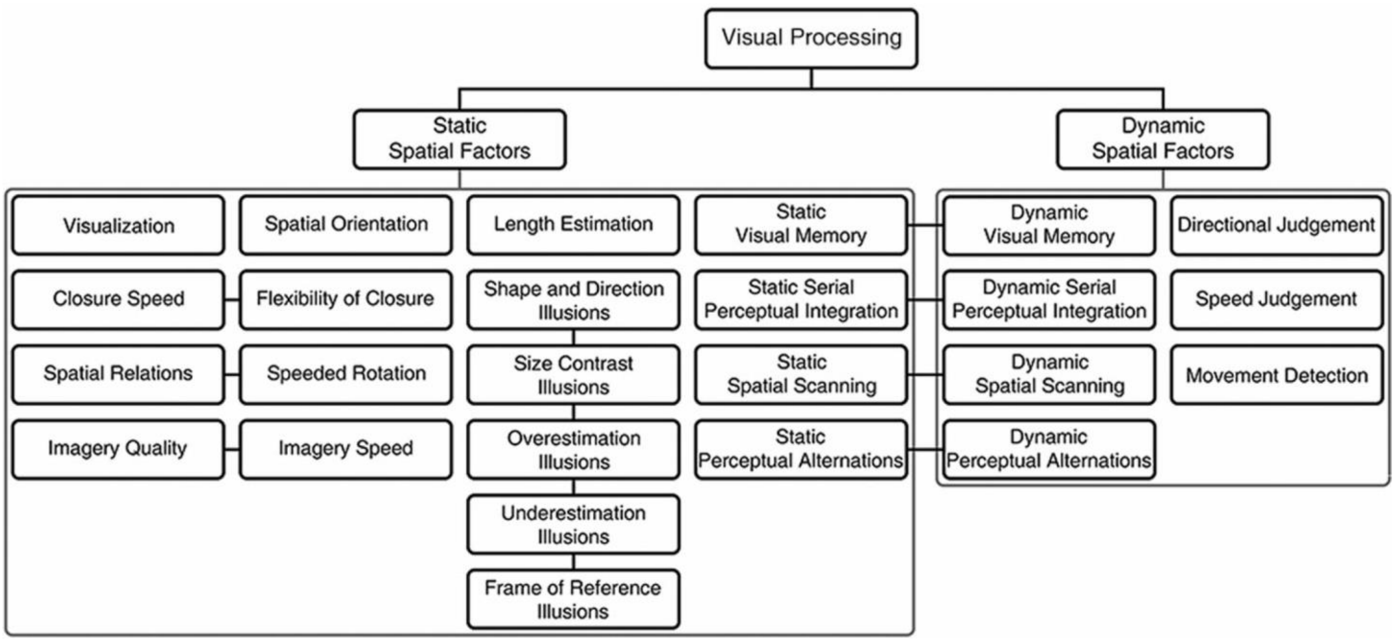


Factor structure in the domain of visual processing (Buckley et al., 2019)

No. 2019-1-LT01-KA202-060471

Spatial Ability: Complexity

The Cattell-Horn-Carroll Model (CHC) only includes some of the subfactors proposed by researchers in the spatial ability field



Extended subfactor structure in the domain of visual processing (Buckley et al., 2019)

No. 2019-1-LT01-KA202-060471

Spatial ability: subfactors related to the SPACAR project

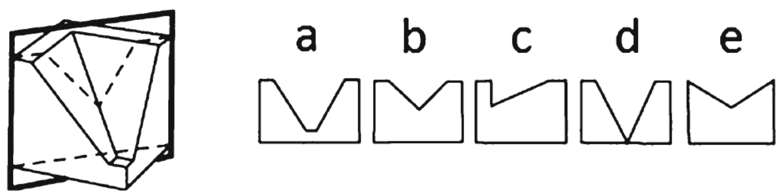
Subfactor	Definition
Visualisation	The ability to perceive complex patterns and mentally simulate how they might look when transformed (e.g. rotated, changed in size, partially obscured)
Speeded rotation	The ability to solve problems quickly by using mental rotation of simple images
Closure speed	The ability to quickly identify a familiar and meaningful visual object from incomplete (e.g. vague, partially obscured, disconnected) visual stimuli, without knowing in advance what the object is
Visual memory	The ability to remember complex images over short periods of time (less than 30 seconds)
Spatial scanning	The ability to visualise a path out of a maze or a field with many obstacles
Spatial relations	The ability to solve problems by using mental rotation of complex images in a relatively untimed situation
Spatial orientation	The comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented, and an ability to determine spatial orientation with respect to one's body (McGee, 1979)
Imagery quality	The ability to generate a mental image, add and/or subtract detail from the image, rotate, maintain, and transform the image in specified ways (Burton & Fogarty, 2003)
Imagery speed	The efficiency of those processes involved in the generation, maintenance, and transformation of mental representations (Burton & Fogarty, 2003)

No. 2019-1-LT01-KA202-060471

Measuring Spatial Abilities

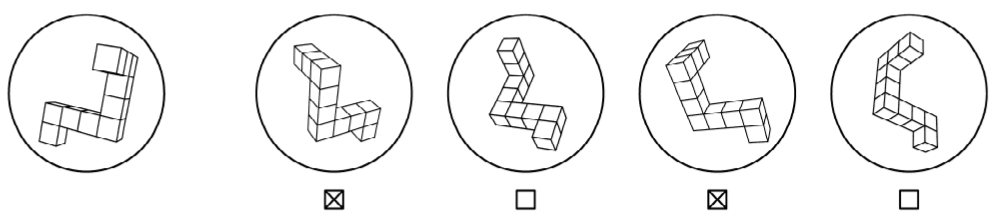
Mental Cutting Test (CEEB, 1939)

The subject must choose the correct figure that represents the resulting section:



Mental Rotation Test (Vandenberg & Kuse, 1978)

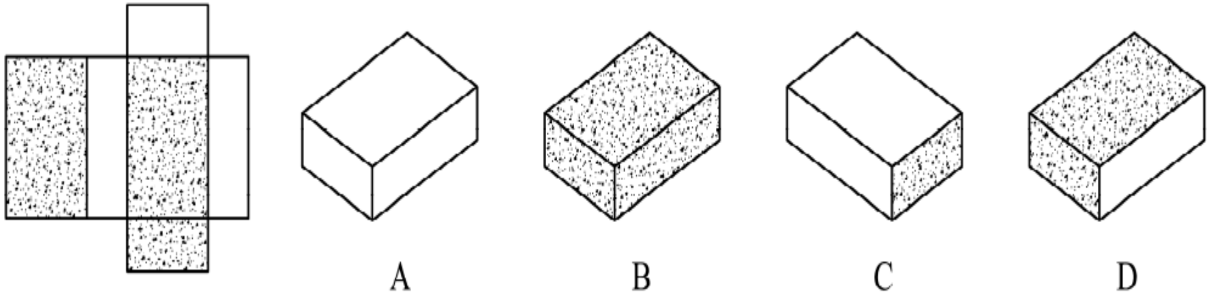
Each item consists of five stimuli, which include a target that consists of three-dimensional cubes and four alternatives (two correct alternatives and two incorrect alternatives)



No. 2019-1-LT01-KA202-060471

Measuring Spatial Abilities

Differential Aptitude Test: Space Relations (Bennet et al., 1956)
the task is to select an appropriate 3D object among four alternatives that would be obtained from folding the given unfolded shape

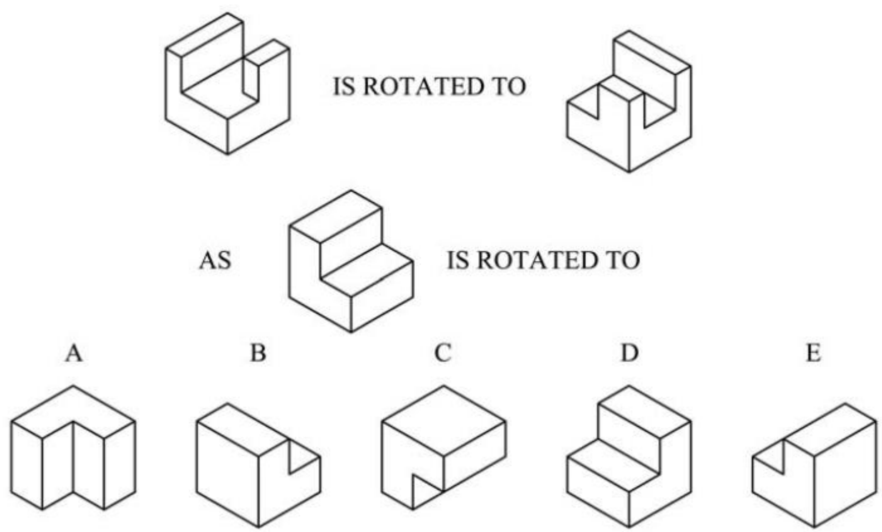


No. 2019-1-LT01-KA202-060471

Measuring Spatial Abilities

Purdue Spatial Visualization Test: Rotations (Guay, 1977)

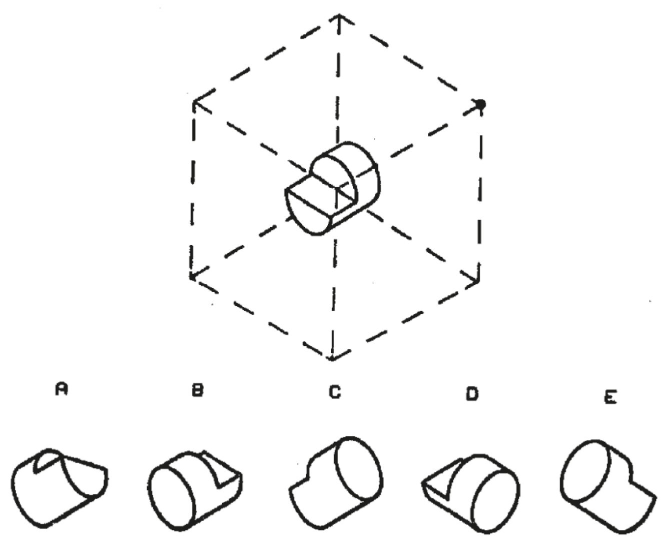
A set of five choices a presented that show a rotated version of a second object. Subjects have to select that choice where the second object would be rotated by the same amount in space as the first object was.



No. 2019-1-LT01-KA202-060471

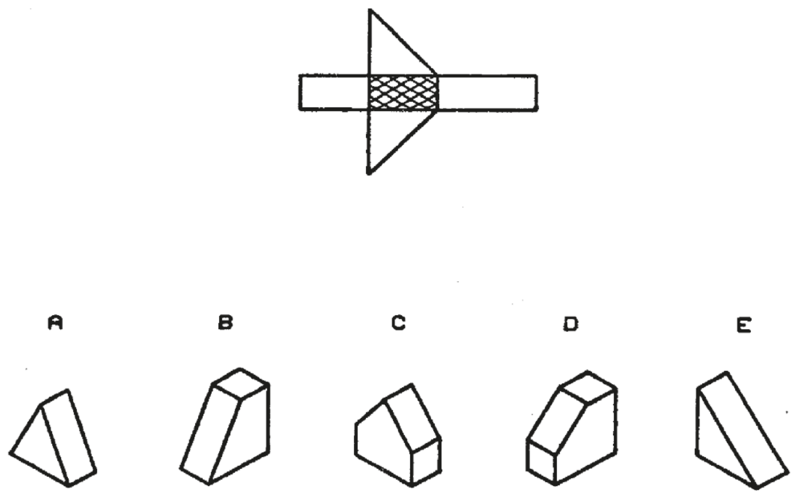
Measuring Spatial Abilities

Purdue Spatial Visualization Test: Visualization (Guay, 1977)
Participants must visualize an object framed in a clear box from a specific corner marked with a dot. Five alternatives are offered. Just one is correct.



Measuring Spatial Abilities

Purdue Spatial Visualization Test: Development (Guay, 1977)
Participants must choose between 5 options, which is the object, presented by its axonometric projection, whose development is shown. Just one alternative is correct.

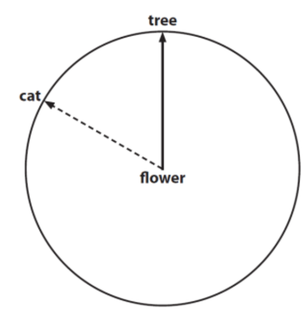


No. 2019-1-LT01-KA202-060471

Measuring Spatial Abilities

Spatial Orientation Test (Hegarty & Waller, 2005)

Seven objects are drawn on the top half sheet of paper corresponding to each item. Participants are asked to imagine being at the position of one object (the station point) facing another object and then are asked to indicate the direction to a third object (target)



No. 2019-1-LT01-KA202-060471

Pedagogical Framework

Based on the original Bloom‘s taxonomy (Bloom et al., 1956) in the cognitive domain

Levels	Description	Keywords	Sample questions
1. Knowledge	Exhibits memory of previously learned material by recalling fundamental terms, facts, methods, procedures, concepts	cite, define, identify, label, list, match, name, recognise, reproduce, select, state	1. List the main types of projection methods 2. Match the right symbol with the corresponding projection method
2. Comprehension	Understand the uses and implications of given Information (terms, facts, methods, procedures, concepts)	classify, convert, describe, distinguish between, explain, extend, give examples, illustrate, interpret, paraphrase, summarise, translate	1. In the first angle projection method, the view seen from left is placed on (a) Above front view (b) Right of front view (c) Above top view (d) Below front view
3. Application	Use strategies, concepts, principles, and theories in concrete situations. Solve problems. Practice theory	apply, arrange, calculate, carry out, construct, demonstrate, discover, execute, implement, modify, operate, predict, prepare, produce, relate, show, solve, use	1. For each row shown, select the pictorial view of the object that will produce the orthographic views that are given

Bloom’s taxonomy in engineering technical drawing (Violante et al., 2020)

No. 2019-1-LT01-KA202-060471

Pedagogical Framework

Based on the original Bloom's taxonomy (Bloom et al., 1956) in the cognitive domain

Levels	Description	Keywords	Sample questions
4. Analysis	Breaking information into its component elements to explore relationships	analyse, associate, determine, diagram, differentiate, discriminate, distinguish, compare, estimate, infer, order, outline, point out, separate, subdivide	Compare 1st angle method of projection and 3rd angle method of projection
5. Synthesis	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions	combine, compile, compose, construct, create, design, develop, devise, formulate, integrate, invent, modify, organise, plan, produce, propose, rearrange, reorganise, revise, rewrite	Formulate the right number of views needed to fully describe an object in 1st angle method of projection
6. Evaluation	Judge the value of ideas, materials and methods by developing and applying standards and criteria	appraise, assess, check, conclude, contrast, criticise, evaluate, hypothesise, judge, justify, support, test	Check if projections of the drawing, provided in the figures, have been used in an appropriate way

Bloom's taxonomy in engineering technical drawing (Violante et al., 2020)

No. 2019-1-LT01-KA202-060471

Pedagogical Framework: design principles

The intellectual output of the project (exercises) will follow the next principles:

- Main goal of the exercises is improving spatial abilities on students using these resources.
- Exercises will operate on Bloom's levels 2-6 and will be provided to students according to their "prior" knowledge.
- Exercises will provide a progression on difficulty. For each Bloom's level will be developed sets of exercises with a growing level of difficulty. An objective metric, such as the complexity of the geometry involved in the exercise should be used to measure the level of difficulty.
- Exercises will be provided to students in a progressive way, beginning will Bloom's level 2 and finishing with level 6.
- As far as possible, sketching activities should will be integrated as part of the exercises, considering that they also contribute to develop spatial abilities (Mohler & Miller, 2008).
- Tasks in the spatial ability tests used in the validation study described in section 6 of this document should not be included in any of the exercises.

No. 2019-1-LT01-KA202-060471

Pedagogical Framework: taxonomy of exercises

Examples of activities organized according to their cognitive level in the Bloom's taxonomy:

Comprehension level (2)

Some activities suitable for this level are:

- Identification of surfaces and vertexes in both orthographic and axonometric views of a three-dimensional virtual object provided as an input.
- Identification of orthographic views from a virtual three-dimensional model used as input.
- Identification of the geometry of a solid of revolution defined by section, axis and angle.
- Identification of the result of a Boolean operation applied to several objects.
- Isometric sketching of block-structured objects defined by a codification (Connolly et al., 2009).

No. 2019-1-LT01-KA202-060471

Pedagogical Framework: taxonomy of exercises

Examples of activities organized according to their cognitive level in the Bloom's taxonomy:

Application level (3), some activities suitable for this level are:

- Creation of orthographic views (with and without hidden line representation) from perspective: object of growing difficulty level: block-based, single and double inclined planes, cylindric surfaces.
- Identification of the rotated version of an object (chain of rotations).
- Identification and sketching of a symmetrical version of an object.

Analysis level (4), some activities suitable for this level are:

- Part identification and numbering in assembly drawing.
- Prism identification when used as building blocks in parts.
- Identification of developments of objects.

No. 2019-1-LT01-KA202-060471

Pedagogical Framework: taxonomy of exercises

Examples of activities organized according to their cognitive level in the Bloom's taxonomy:

Synthesis level (5), some activities suitable for this level are:

- Definition of the constructive solid geometry (CSG) steps to build a 3D model.
- Creation of perspectives from orthographic views.
- Interpretation of topographic maps.
- Identification of an object from its development.
- Creation of the BIM model of a building or infrastructure project using its drawings as an input.

Evaluation level (6), some activities suitable for this level are:

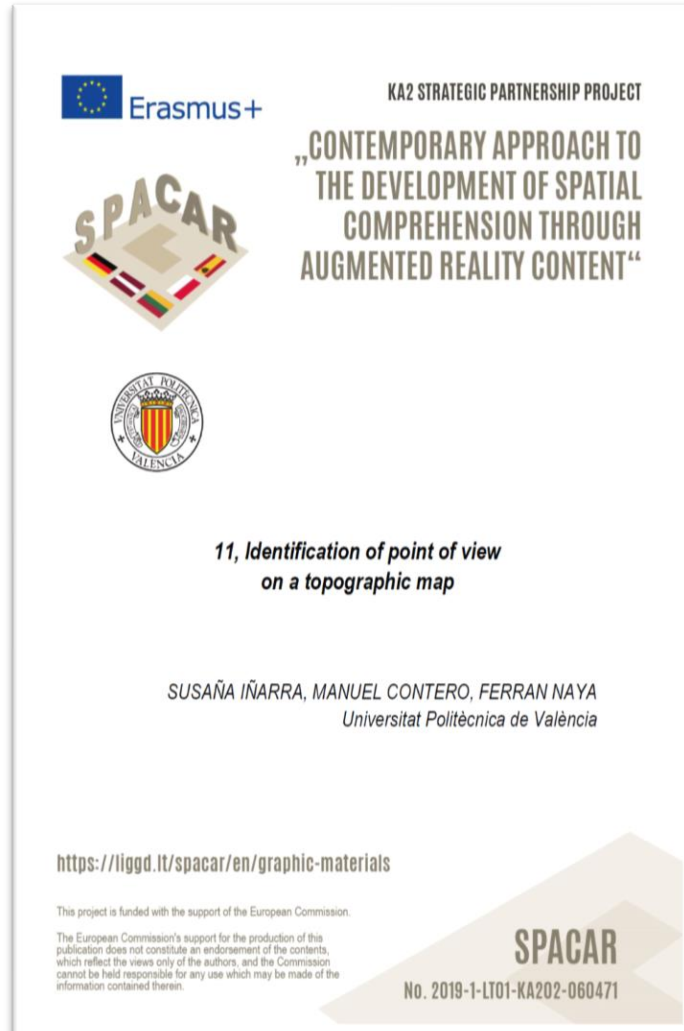
- Assembly part compatibility on exploded views.
- Feasibility of a CSG tree to represent a model.
- Assessment of correctness of the number y content of cuts, sections and views to define an object.

No. 2019-1-LT01-KA202-060471

Definition of Exercises - Template

Content:

- Intellectual output identification.
- Exercise identification/number.
- Title.
- Description.
- Digital files (3D models in OBJ and FBX formats)
- Result → Open ended & test format
- Prior knowledge required to solve the exercise.
- Description of the augmented reality content.



Erasmus+

KA2 STRATEGIC PARTNERSHIP PROJECT

„CONTEMPORARY APPROACH TO THE DEVELOPMENT OF SPATIAL COMPREHENSION THROUGH AUGMENTED REALITY CONTENT“

11, Identification of point of view on a topographic map

SUSAÑA IÑARRA, MANUEL CONTERO, FERRAN NAYA
Universitat Politècnica de València

https://liggd.lt/spacar/en/graphic-materials

This project is funded with the support of the European Commission.

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

SPACAR

No. 2019-1-LT01-KA202-060471

Intellectual Output: 5

Exercise number: 11

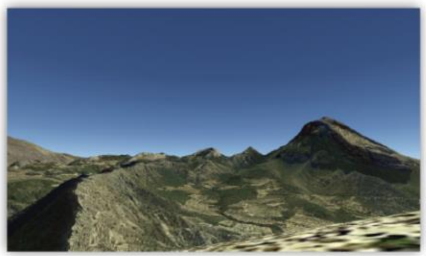
Title: Identification of point of view on a topographic map

Description: Imagine you are on top of a mountain and you see the landscape presented in the image. You must identify what is your position on the corresponding topographic map. Select the response that indicates where and which direction you think you are located.

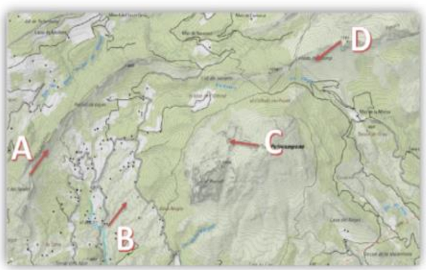
Digital files:

IO5-11.zip contains the files:

IO5-11-a.png: Image file corresponding the landscape view

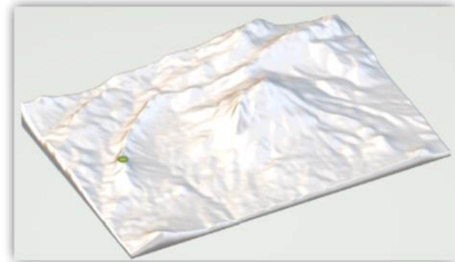


IO5-11-b.png: Image file corresponding the topographic map



No. 2019-1-LT01-KA202-060471

IO5-11-c.fbx: digital elevation model format corresponding to the area covered by the topographic map. The green area represents the solution of the exercise



Result: The correct answer is A. This location is represented by a green area on the 3D digital model.

Augmented reality content: A 3D model of the terrain with the solution of the exercise.

Prior knowledge: Reading of topographic maps.

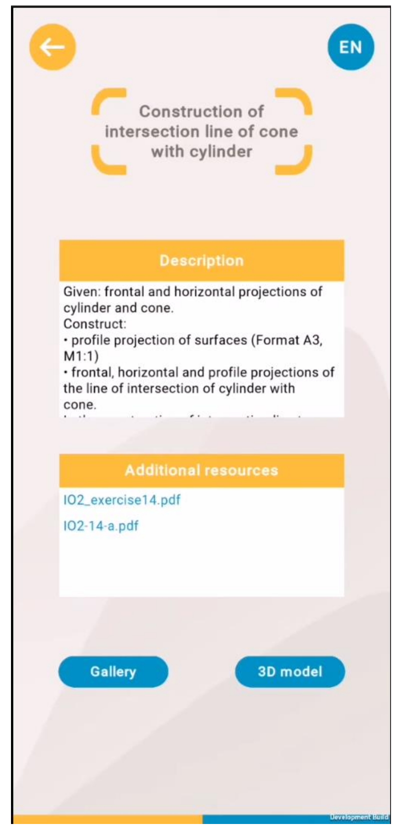
No. 2019-1-LT01-KA202-060471

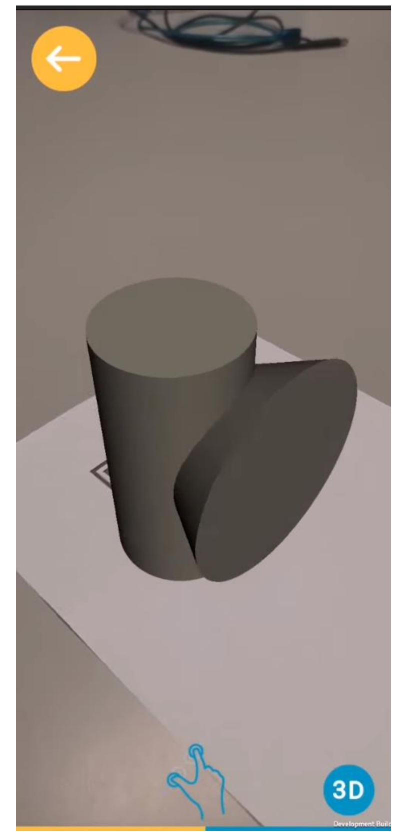
The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

No. 2019-1-LT01-KA202-060471

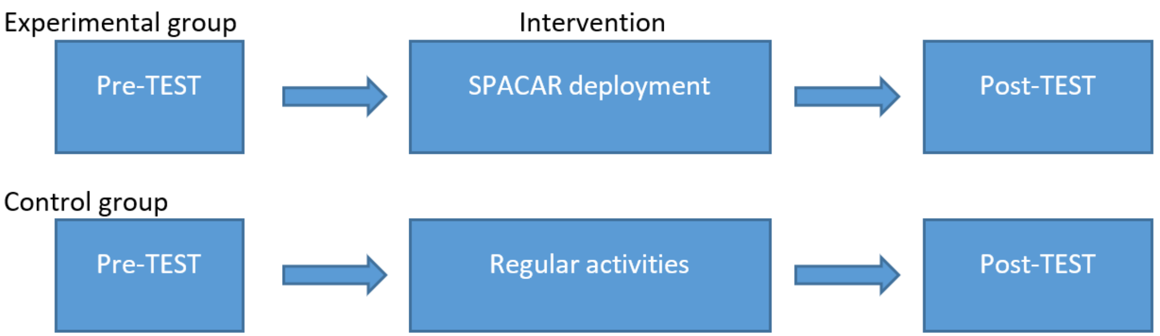
Implementation

- Final design of exercises will depend on constraints imposed by the app implementation.
- A working prototype is needed to evaluate the feasibility of the designed exercises:
  - 3D object size
  - Image size
  - Length of texts





Validation Framework – Spatial ability



- Quasi-experimental design using:
  - Revised Purdue Spatial Visualization Tests: Rotations (Revised PSVT: R)
  - Differential Aptitude Test: Space Relations (DAT: SR)
  - Spatial Orientation Test (SOT)
- To analyze the impact on students' motivation, it is recommended to conduct the Instructional Materials Motivation Survey (IMMS)
- To evaluate usability on augment reality app (experimental group) it is recommended to use the Handheld Augmented Reality Usability Scale (HARUS)

No. 2019-1-LT01-KA202-060471

„CONTEMPORARY APPROACH TO THE DEVELOPMENT OF SPATIAL COMPREHENSION THROUGH AUGMENTED REALITY CONTENT“

DEVELOPMENT OF TEACHING MATERIALS METHODOLOGY

Prof. Manuel Contero
Universitat Politècnica de València, Spain

SPACAR

No. 2019-1-LT01-KA202-060471

This project is funded with the support of the European Commission.