LEARNING FOR PLACEMENT. FOSTERING INNOVATION IN THE CONSTRUCTION SECTOR THROUGH PUBLIC-PRIVATE PARTNERSHIP IN THE EMILIA-ROMAGNA REGION

Marcello BALZANI
Laboratory TekneHub, University of Ferrara, Clust-ER Construction,Emilia-Romagna High Technologies Network,Italy
marcello.balzani@unife.it

Fabiana RACO
Laboratory TekneHub,University of Ferrara ,Italy
fabiana.raco@unife.it

Theo ZAFFAGNINI
Department of Architecture, Laboratory TekneHub , University of Ferrara, Italy
theo.zaffagnini@unife.it

ABSTRACT
The Fourth Industrial Revolution increasingly deals with the application of new abilities, skills and workforce strategy as well as the introduction of new integrated technologies to support both productivity and innovation. The current research project carried out in collaboration between TekneHub, a research laboratory of the Emilia-Romagna High Technology Network, the Department of Architecture (DA) of the University of Ferrara and national and international public and private parties has focused on knowledge updating in the construction sector. The study was based on the application of both collaborative *Integrated Project Delivery Methods* (IPD) and *Value-Chain Analysis (VCA)*, which allow the most effective learning strategies to be identified in relation to industry needs, academia capability and placement requirements. Managerial knowledge and data based decision-making are certainly emerging as key findings in order to drive the Framework of Qualifications for higher education towards more contemporary and effective results.

Keywords: Construction management / Innovation management / Integrated Project Delivery Method (IPD) / Skills for Innovation in Higher Education.

INTRODUCTION
To ensure that new opportunities for increasing the productivity and the competitiveness of the construction sector determine a Fourth Industrial Revolution, it is not enough to introduce new technologies, such as automation in production processes and Internet of Things (IoT), or Advanced Materials.
At both national and European level, the construction industry has to deal with the inadequacy of job organization and skills in key areas, such as managerial knowledge, basic financial knowledge (ERA SGHRM, 2011) and data based decision-making, that are becoming even more crucial to make a new level of productivity effective. The upgrading of skills would allow the industry to "significantly contribute to job creation, by increasing its activity in some very promising areas such as the renovation of buildings" (EC, 2012, p.2).
Due to its slow innovation adoption, at both technological and organizational level, and the lack of collaborative work, associated with a variety of site-based project sizes, the construction sector has always been characterized by insufficient sharing of best practices among all the players and stakeholders involved, as often experienced in the Italian setting. Consequently, huge waste is still observed along the construction value chain.
"One reason for the industry's poor productivity record is that it still relies mainly on paper" (McKinsey, 2016, p.7). Moreover, the fact that the construction industry invests less than 1% of net sales in R&D (EC, 2016) must be taken into account in order to understand the lack of innovation and technological progress.
For this reason, thanks to the reforms of the UK Government, the European States have recently undertaken actions to enable the development of a digital and automated production environment. In fact, since 2014 several codes and standards have become law and are being implemented. These include the sets of rules which refer to the adoption of Building Information Modeling tools; a set of ICT integrated tools for collaborative design and management.
The first results of an ongoing research project can be found below, which aims both to measure the impact of digitization and automation in the construction sector and the reflections (effects) on the higher education system in the Emilia-Romagna Region, which is part of a national industrial cluster, strictly linked with the European market.

Considering the complexity of the players involved throughout the industry, the research project was based on the application of both collaborative *Integrated Project Delivery Methods* (IPD) and *Value-Chain Analysis* (VCA) to access, through quantitative and qualitative analysis, the correspondence between industry needs and public sector capability offering adequate higher education solutions to address placement opportunities.
The first results of the research project show that an integrated and collaborative approach to the upgrading of higher education solutions, helps to identify more effective strategies, in order to support the introduction of new skills and technologies in the construction sector.

THE STUDY: SKILLS FOR CONSTRUCTION INDUSTRY DIGITIZATION

Despite the increasing demand of digitized processes in the construction industry, "the sector is among the least digitized" (McKinsey, 2016, p.2). While the construction process is becoming more complex due to the amount of specialized knowledge that is necessary to effectively put a project in place, cost and schedule overruns are the norm.
This research study considers knowledge and Information Management (IM) as assets which are fundamental for the efficient and effective delivery of a project and which lead, if well managed, to better outcomes, including:
1. Increasing collaboration;
2. Improving the quality of data-decision making;
3. Enhancing the speed of decision-making;
4. Reducing duplication of effort;
5. Increasing business resilience.

The aim of the project is to investigate the quality of the regional higher education offer in order to verify the presence of knowledge areas such as the capacity to manage big data, creative thinking, complex problem solving and the risk management approach which have been identified as drivers for making the new industrial revolution effective.
In fact, according to *The Future of Job Report* "in many industries and countries, the most in-demand occupations or specialties did not exist 10 or even five years ago" (WEF, 2016, p.1) and one job type is mentioned, among others, across all industries and geographies: data analysts. In this new scenario, the skills set is expected to change rapidly according to industry needs so the "exposure to industry and other relevant employment sectors" (PIDT, 2011) becomes crucial right from the early stages of education, with particular reference to levels five to eight of the European Qualification Framework. It should be stressed that "the term industry is used in the widest sense, including all fields of future workplaces and public engagement, from industry to business, government, NGOs, charities and cultural institutions (e.g. musea)" (ERA SGHRM, 2011).
The finding of the study sample was based, first, on the definition of the target involved. In this study, higher education courses such as bachelor higher national diploma, bachelor, master and doctorate courses for architects and engineers were considered as main areas of the research. (Figure 1)

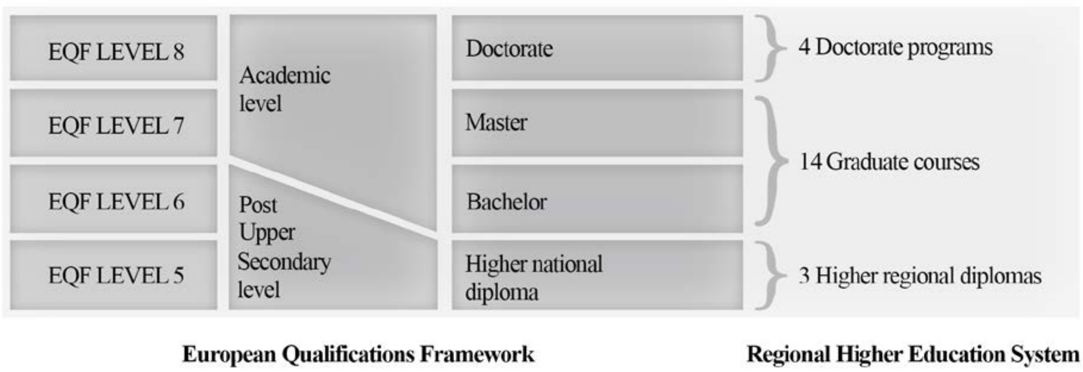

Figure 1: European Qualifications Framework and regional higher education system. Research domain.
Secondly, criteria such as the representativeness from the territorial point of view were considered. In fact, higher education courses for the construction sector as well as continuing education and on the job training activities are an integral part of the regional education system.
However, despite this scenario there is currently no common data set of information, either at regional or national level, which could allow the most effective strategies to be identified in order to meet the new placement opportunities. A long-term fallout of the study is certainly providing the regional sector with a comprehensive database of information regarding the quality of supply and demand of professionals in the construction sector.
This purpose can only be pursued thanks to strong cooperation between the public and private players involved.

In fact, the research project is carried out in collaboration between the regional "Association Construction Clust-ER", which is regional a public-private initiative, the TekneHub centre, a research laboratory of the Emilia-Romagna High Technology Network, the Department of Architecture (DA) of the University of Ferrara and other regional, national and international public and private parties. (Figure 2)

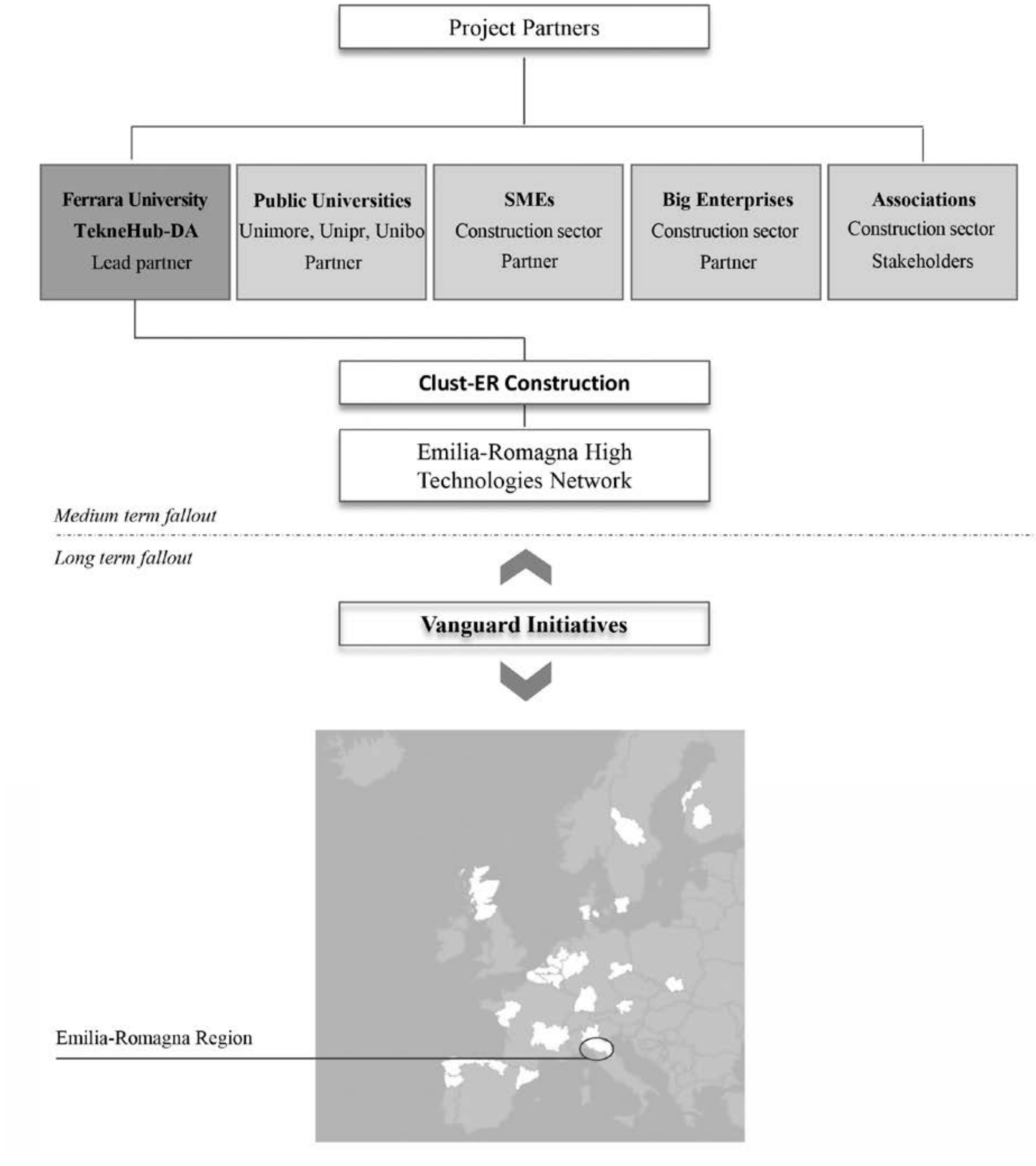

Figure 2: Projects partners. All the actors and stakeholders were involved at the early stage of the project

METHODOLOGY

As stated so far, the construction value chain is characterized by complexity, uncertainty, a fragmented supply chain, and short-term thinking which are obstacles for long-term innovation and learning (Oesterreich, Teuteberg, 2016, p. 123). However, Europe's Construction Value Chain (CVC) is a key industry, which accounts for 7% of European GDP, gross domestic product, and employs 11 million people.

Industry 4.0 requires, on the other hand, shared data-based knowledge which can only be reached through comprehensive data mining, data analysis and a risk management based approach along the entire value chain. As a result, the ability to manage this quantity of data became of crucial importance.

Subsequently, the research questions are as follows.
Research question 1: What impact does Industry 4.0 have on the regional higher education system in terms of updating skills and competencies? (RQ 1)
Research question 2: Are regional and national Qualification Frameworks consistent with the needs of the current construction industry? (RQ 2)
Research question 3: Which teaching methods are suitable with reference to the target of the end users involved? (RQ 3)
Research question 4: Which new research areas are supposed to be of great importance for the future of the regional construction sector? (RQ 4)
During the initial stages of the research, intensive brainstorming activity was conducted with all the stakeholders involved and, within the IPD methodology, the research indicator sets were defined, such as:
- The target of students/end users involved;
- The set of skills and competencies related to the digitization process of the construction industry;
- The regional and National Qualifications Framework;
- The European Qualification Framework.

Furthermore, for the purpose of answering research question 1, the whole set of higher regional diploma, graduate, postgraduate and doctorate courses is undergoing analysis with respect to the following parameters:
- Basic project management knowledge;
- Advanced project management knowledge applied to specific subjects, areas and phases of the value chain;
- Basic risk management knowledge;
- Advanced risk management knowledge applied to specific subjects, areas and phases of the value chain;
- Data mining based knowledge;
- Ability to manage data interoperability;
- Competencies in terms of human resource management;
- Transferable skills (ERA SGHRM, 2011);
- Skills from the knowledge based economy such as communication, entrepreneurship, IPR, ethics and standardization (ERA SGHRM, 2011).

To answer research questions 2 and 3, four pilot projects have been put in place and are under evaluation, such as: Post-graduate courses in the field of digitization (target: BIM manager and BIM coordinator for public and private sectors); (Adoption of) Specific PhD training paths in the field of collaborative design and management; Program of lectures in the field of digitization (target: professional development and continuous improvement)
Research in the field of BIM impact on design quality and process management (partners involved: private and public players). Meanwhile, the three main regional construction value chains have been taken under evaluation in relation to RQ 1, 2 and 3 in order to answer to question 4.

RESULTS AND LONG TERM FALLOUT

The introduction of digitization tools and methods could represent a great opportunity for improving the productivity of the construction sector. However, significant updating of skills is needed as well as ways of sharing professionals' knowledge among all the players in the construction sector.
With reference to the construction industry, the regional higher education system is characterized by:
- 3 higher regional diplomas;
- 14 graduate courses;
- 4 doctorate programs. (Figure 3)

Despite the high level of quality of the regional training offer, since 2006 the University of Ferrara has been the top University among national graduate courses in architecture (CENSIS, 2017). The research project made it possible to verify a lack of digital collaboration based knowledge issues within the courses, as mentioned before. The analysis of the regional education system also demonstrated the almost total lack of project management based knowledge even within five years courses.
In fact, there are huge numbers of courses in areas such as digital representation, virtual modeling for architectures and engineering, integrated ICT technologies for survey, 3D survey, GIS and high quality doctoral research on BIM, Big-Data management, 3D Printing tools for architecture and Artificial Intelligence tools and so on. On the other hand, the teaching of collaborative work tools and methods has not been introduced yet.

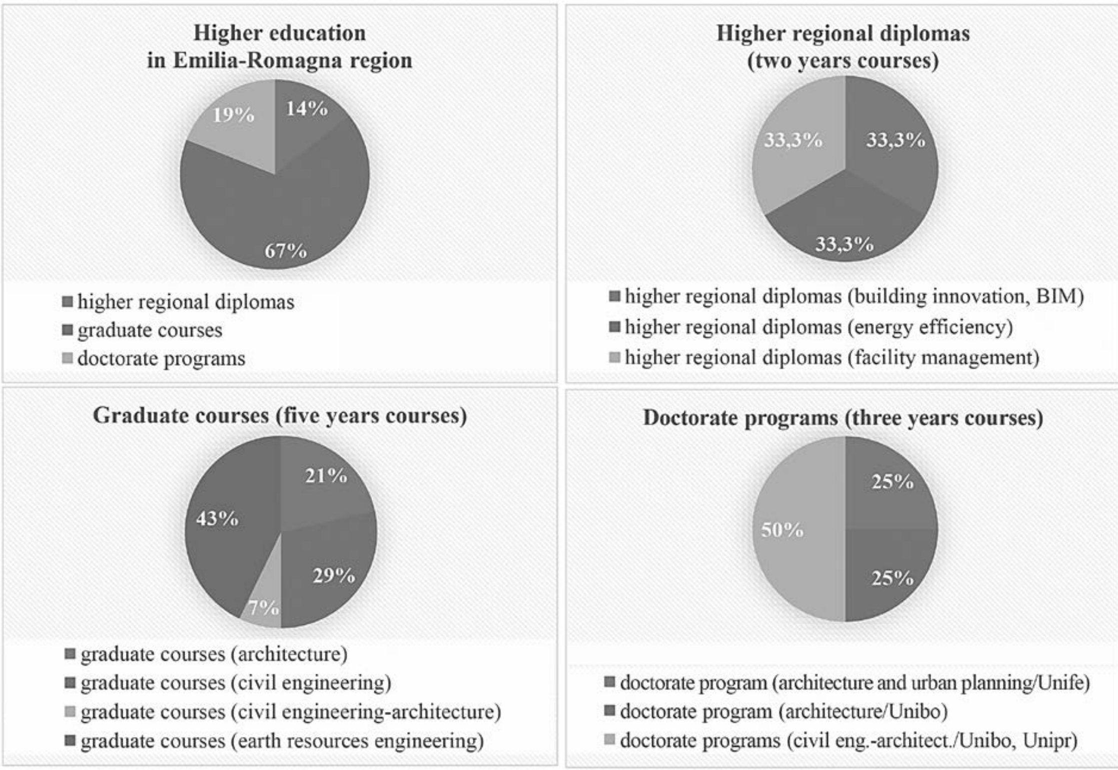

Figure 3: Emilia-Romagna higher education system.

However, with reference to the New Italian Procurement Code the following knowledge areas also need to be considered in order to achieve construction sector digitization:
- Strengthening the digitization of surveying and diagnostic processes;
- Supporting Public Procurement through data based decision-making processes;
- Developing a New Project Management approach for the construction sector (IM, Information Management and BIM, Building Information Modeling).

Furthermore, especially in the field of managerial knowledge and data-based decision making the lack of basic knowledge in master's courses is observed. This sort of difficulty can be properly managed through the introduction of project management knowledge at the beginning of five year courses. As a result, it would be possible to adopt more effective strategies, such as an inductive approach and on the job training, in post-graduate courses.

In conclusion, while the most important medium-term fallout is updating the National Qualification Framework there are other main goals to be achieved within three to five years:
1. Updating existing training courses, in specific areas, with reference to the new qualifications identified;
2. Scheduling the adoption of specific training methods (deductive training activities, on the job training etc.) to be applied in order to rapidly reach the expected target.
3. Updating bachelor, master, PhD programs (managerial knowledge, data based decision-making methods and tools, risk management, skills to enhance interactions between academia and Industry, awareness of financial tools)
4. Making post-graduate courses more effective (inductive approach, on the job training, etc.)
5. Strengthening the partnership between the public and private sector in the field of digitization in the construction industry.

REFERENCES

CENSIS, (2017), *La classifica delle Università italiane,* [On-line].
Available: http://www.censis.it/17?shadow_pubblicazione=120573

Decreto Legislativo 18 aprile 2016, n. 50, [On-line]. Available:
http://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazione

Gazzetta=2016-04-19&atto.codiceRedazionale=16G00062

ERA Steering Group Human Resources and Mobility (ERA SGHRM) (2011), *Using the Principles for Innovative Doctoral Training as a Tool for Guiding Reforms of Doctoral Education in Europe* (pp. 1-9).

European Commission (EC, 2013), *Entrepreneurship 2020 Action Plan* (pp. 1-33). Brussels, BE: European Commission. Available: http://ec.europa.eu/growth/smes/promoting-entrepreneurship/action-plan/

European Commission (EC, 2016), *The 2016 EU Industrial R&D Investment Scoreboard EU* (pp. 1-107). Seville, ES: European Commission.

European Parliament and Council (2014), DIRECTIVE 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC.

Oesterreich, T. D., Teuteberg, F. (2016). *Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry*, in Computers in Industry 83, (pp. 121-139). Osnabrück, DE: Elsevier

Agarwal, R., Chandrasekaran, S., Sridhar, M., (2016), *Imagining construction's digital future* (pp. 1-14). Singapore: McKinsey&Company

Wiseman, J., Roe, P., Parry, E. (2016), *Skills and Training in the Construction Industry 2016* (pp. 1-123). Birmingham, UK: Construction Industry Training Board (CITB)

World Economic Forum (WEF, 2016), *The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution* (pp. 1-12). Cologny/Geneva, CH: World Economic Forum

LEARNING GEOMETRY THROUGH MATHEMATICAL MODELLING: AN EXAMPLE WITH GEOGEBRA

Maria Giovanna FRASSIA
Department of Mathematics and Computer Science
University of Calabria
Italia
frassia@mat.unical.it

Annarosa SERPE
Department of Mathematics and Computer Science
University of Calabria
Italia
annarosa.serpe@unical.it

ABSTRACT
This paper is in line with the critical thinking and reflection process on the role of mathematical modelling with the use of technology in mathematics education. After some considerations about the teaching - learning of Geometry in Italian secondary schools and the analysis of the theoretical framework inherent mathematical modelling, the paper will illustrate a practical, coherent example of a classroom activity. Starting from a real object, the activity develops into mathematical modelling - that explores meaningful properties and concepts - which allows the simulation of a computer prototype in the dynamic geometry environment GeoGebra.

INTRODUCTION

Mathematical modelling is one of the topics in mathematics education, which has been the object of debate particularly in the last few decades. In classroom practice all over the world, however, modelling still has a far less prominent role than is desirable. The main reason for the gap between the goals of the educational debate and everyday school practice is that modelling is difficult both for students and for teachers. Today more than ever before, the teaching and learning of Mathematics play a crucial role in shaping thinking and reasoning as well as impacting on the whole personality. That is why we firmly believe mathematical modelling ought to be included in an updated mathematics secondary school curriculum as a sound basis for further education.
The International Commission on Mathematical Instruction (ICMI) has been promoting discussion on this topic at international level for some time (Blum et al., 2007; Stillman, 2013 and 2015; and many others), stressing - among other things - that teaching Mathematics must take into consideration not just the cultural role of the subject (which is generally accepted), or the reasons which consistently reinforce it in an ever - changing society, but also how school education is structured, with its procedures, trends as well as its restrictions.
Teaching while keeping in mind the mathematics-real world binomial signifies promoting active learning in class, turning studying into a process of discovery, thus aiding the understanding of mathematical concepts (Niss, 2003); moreover, it means providing the learners with the chance of cognitively reconstructing mathematical structures which echo and enhance students' natural cognitive structures, especially perceptive-motor ones (Gallese, & Lakoff, 2005).
For instance, in the teaching of Geometry the use of the Dynamic Geometry Software (DGS) continually opens up new didactic perspectives because it privileges the constructive aspect of the subject while at the same time maintaining the same degree of deductive accuracy, clarity of hypothesis and consequences pertaining to the discipline (Hannafin et al., 2001; Hohenwarter et al., 2008; Leikin et al., 2013). Thanks to the DGS, the graphic - constructive phase - both before the acquisition of some concepts and geometric properties, and afterwards as verification and/or in-depth analysis - greatly helps didactics, as it lends itself both to visualization and exemplification and/or exploration.
The real world stimulates both the connection with "significant geometric properties" (Enriques, 1921), and their simulation by means of modern technological tools. Indeed, it ought to be remembered that Geometry originated as modelling of the physical world and its surroundings. In the Italian school, the teaching of geometry has progressively endorsed the formal aspect of the subject, "de-contaminated"- so to speak - of even the smallest figural and constructive element. On the contrary it has been appropriately and explicitly claimed that 'geometrical concepts should not overlook the dual conceptual and figural aspect' (Fischbein, 1993), therefore it is advisable to incorporate both into everyday teaching, else geometry teaching will fail to contribute to informed learning. This paper illustrates an example of mathematical modelling in secondary school with the aid of the DGS GeoGebra.

THEORETICAL FRAMEWORK

The inclusion of modelling in school Mathematics curricula is crucial for the development of problem solving skills, and promotes a reflection on the relationship between Mathematics and sensible reality (Gallegos, & Rivera., 2015).
A real problem offers a learning opportunity in three dimensions (Wedelin, & Adawi, 2015):

- Familiarity with real-world problems:

