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CHALLENGES OF "TEACHING AND LEARNING" IN TECHNICAL DRAWING COURSE: A COMPARISON OF ARCHITECTURAL AND CIVIL ENGINEERING EDUCATION

Hande Aladağ and Hande Düzgün Bekdaş

Yıldız Technical University, Turkey

Technical drawing is the act and discipline of composing drawings that visually communicate how something functions or is constructed. It is essential for expressing ideas in architectural and civil engineering (CE) education. In architectural education, technical drawing is used for communicating the all aspects of a shape/design and detail drawings whereas in CE education it is used for capturing all the geometric features of a product/component with an end goal of conveying all the required information that will allow a manufacturer to produce that component. In both educations, technical drawing course aims to improve the drawing and presentation techniques by gaining skills on 2 and 3 dimensional perception and to teach students how to communicate on a common ground within the framework of certain drawing techniques. In technical drawing course, students learn how to use a visual language (symbols, perspectives, units of measurement, notation systems, visual styles, and page layout) to ensure that the drawing is unambiguous and relatively easy to understand. However, teaching and learning strategies can have different implications for technical drawing course in the architectural and CE education. Besides, learning levels, cognitive development and spatial visualization skills of students can affect academic success in technical drawing course along with those teaching and learning strategies. In this context, the study aims to present the challenges in technical drawing course in architectural and CE education depending on those variables. Also, discussion of improvement techniques and methods that can be applied to technical drawing course from the learning and teaching point of view constitutes another aim of the study.

Keywords: Architectural education, CE education, Technical drawing course, Teaching and learning.

Introduction

Technical drawing is the act and discipline of composing drawings that visually communicate how something functions or is constructed. Technical drawing contains all the information needed in a certain scale production and assembly of structural elements and the rules to be drawn within the process. Technical drawing is a way of communication between people who see technical drawing education. Therefore, it is essential for expressing ideas in architectural and civil engineering (CE) education. In architectural education, technical drawing is used for communicating the all aspects of a shape/design and detail drawings whereas in CE education it is used for capturing all the geometric features of a product/component with an end goal of conveying all the required information that will allow a manufacturer to produce that component. In both educations, technical drawing course aims to improve the drawing and presentation techniques by gaining skills on 2D and 3D perception & expression and to teach students how to communicate on a common ground within the framework of certain drawing techniques. In technical drawing course, students learn how to use a visual language (symbols, perspectives, units of measurement, notation systems, visual styles, and page layout) to ensure that the drawing is unambiguous and relatively easy to understand. However, teaching and learning strategies can have different implications for technical drawing course in the architectural and CE education regarding the obstacles faced in technical drawing course by architectural and CE students. In this sense, the study aims to present the obstacles faced in technical drawing course by architectural and CE students. Therefore, in the study challenges and obstacles faced in technical drawing course by architectural and CE students were determined by comprehensive literature review and focus group discussions. Then determined parameters ranked by using Simple Multi-Attribute Ranking Technique (SMART) which is a basic ranking technique method. In addition, the findings of the study will contribute to educators to develop innovative applications (improvement techniques and methods) in technical drawing course which also constitutes another aim of the study.

Predictors of Academic Success in Technical Drawing Course in Architectural and CE Education

In architectural and CE educations, technical drawing course aims to improve the drawing and presentation techniques by gaining skills on 2D and 3D perception & expression and to teach students how to communicate on a common ground within the framework of certain drawing techniques. In technical drawing course, students learn how to use a visual language to ensure that the drawing is unambiguous and relatively easy to understand. Students enrolled in architecture and civil engineering are required to enroll in a course in technical drawing during their first semester (15 weeks).

In Yildiz Technical University, general curriculum of 15-week technical drawing course in architectural education consists of the definition of architectural tools and using principles, projection concepts, scale, preliminary project technique, rules of dimensioning, methods of line weighting, vertical circulation elements, settlement plans and sections, descriptive geometry: projection concepts, projections of points, lines, planes and various objects and their relations with each other and axonometric perspectives with the objective of developing skills in architectural design through 2D and 3D geometrical architectural elements (descriptive geometry) by using architectural drawing and presentation techniques. Architecture students enroll in two hours of lecture and four hours of practice per week (with 6 ECTS credits). Each course includes theoretical lectures and then one or two drawing practices related to the subject and also a homework assignment. During the practice work, each student is required to complete the drawing and to turn it in before leaving for the day. In the practice hours, instructors assist the students when they needed on their work. During the semester, for all the practices, homeworks and midterm exams students are required to complete works by manual drawing. And also visualization of the specific issues is enhanced by working on the hand-held models. The grades of the semester constitute of all these applications, homework assignments and also two midterm and one final exam.

On the other hand in Yildiz Technical University, general curriculum of 15-week technical drawing course in CE education consists of description of technical drawing and descriptive geometry, procedures of projection, types of projection, perspective, creation of epure, positions and projections of points and lines, projection drawings of 3D geometrical objects, types of lines and line weights, scale, rules of dimensioning, methods of line weighting, horizontal and vertical interfaces, description of AutoCAD and its commands. The course is 3-credits (local credit) with two hours of lecture and two hours of computer lab each week (with 4 ECTS credits). During the lab hours, students work on assignments with the instructor circulating as needed to assist the students. During the lab hours, mini-lectures about theoretical knowledge about construction elements and technology are delivered by the instructor during the first 20-30 minutes of lab session. In addition, the students get 3–5 homework assignments per semester where they must apply principles from the course material to a given problem. The students draw the example problems and solutions using instruments and spatial visualization is enhanced by the use of hand-held models and by computerized models for visualization of the specific problems. The lectures also include instructions in solving the problems using CAD packages. For their homework assignments, students work manually and by using a CAD package. During each lecture session, a specific theoretical topic is delivered and simple tasks are solved as example problems. After the lecture, problems are assigned that students must solve in the lab session. During the lab, each student is required to complete the assignment and to turn it in before leaving for the day. Students have two mid-term exams during the semester. For the midterm exam students are required to complete assignments by manual drawing and for the final exam in the course, students are required to complete assignments by CAD packages (2 hours).

As it can be seen in the course contents, differentiation of the curriculum technical drawing course in architectural and CE educations emerge different strengths and weaknesses which can create different impacts on the challenges and obstacles in technical drawing course in architectural and CE educations. Table 1 shows strengths and weaknesses of technical drawing course in architectural and CE educations.

Table 1. Strengths and weaknesses of technical drawing course in architectural and CE educations

Strengths of Technical Drawing Course in Architectural Education	• Students enroll on technical drawing as a first course in their first semester. After following semesters, they enroll on computer aided design course separately. • "Hand-eye-brain coordination" is the basis of the course. • Sketching and making models are the normal modes of graphical communication. • Therefore, there is a great deal of "hands-on" problem solving and sketching, illustrates the role of sketching and drawing in the development of spatial abilities • Each week, 4-hour practice is performed in the classroom and during these practice hours instructors assist the students when they needed on their work. • The course is mostly based on mutual communication (instructor feedbacks for homeworks & practice works)
Strengths of Technical Drawing Course in CE Education	• Class sizes are relatively small (around 20-30) and the instructor circulates among students during the lab session, answering questions and reinforcing topics as needed from the mini-lecture. • During the lab hours, students work on assignments with the instructor circulating as needed to assist the students. • The course is mostly based on mutual communication (instructor feedbacks for homeworks & practice works)
Weaknesses of Technical Drawing Course in Architectural Education	• Students are taken to the school with the central examination system and it is not enough for an education based on visual perception and design. • Class sizes are high (around 50-60) and not enough time for sufficient instructor feedbacks • Students use drawing materials for the first time (mostly they have never experienced before) • The first semester of the first year is difficult in terms of understanding/solving a language that affects all professional education for the students. • Students have to understand and express the structural elements they have never seen. At this point, extensive support of the structural information lessons is needed. • The course has a very intensive program designed to train in one semester. Descriptive geometry course which used to be a separate course have also been integrated into this course. • Classrooms are physically insufficient (comfort conditions-lighting, air conditioning, technological possibilities)

Table 1. Strengths and weaknesses of technical drawing course in architectural and CE educations (Continued)

Weaknesses of Technical Drawing Course in CE Education	• Practice in the classroom is limited to just 2-hour session per week • Classrooms are physically insufficient (comfort conditions-lighting, air conditioning, technological possibilities.) • Students use drawing materials for the first time (mostly they have never experienced before) • The first semester of the first year is difficult in terms of understanding/solving a language that affects all professional education for the students. • Students have to understand and express the structural elements they have never seen. At this point, extensive support of the structural information lessons is needed. • The course has a very intensive program designed to train in one semester. Descriptive geometry course which used to be a separate course have also been integrated into this course. • Contains also general overview on CAD packages.

Since technical drawing course aims to improve the drawing and presentation techniques by gaining skills on 2 and 3 dimensional perceptions in both educations, different challenges and obstacles can be occurring in architectural and CE education due to the implication of the course. However along with the course context, learning levels, cognitive development, spatial visualization skills of students and etc. are some of the common criteria that can affect academic success in technical drawing course. Detailed explanations for those criteria can be found below.

- **Learning Levels of Students:** Students learn in many ways: by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing and drawing analogies and building mathematical models; steadily and in fits and starts. In this context, students can be categorized as Sensing and Intuitive Learners, Visual and Auditory Learners, Inductive and Deductive Learners, Active and Reflective Learners, Sequential and Global Learners (Felder and Silverman 1988).
- **Teaching Methods of Instructors:** Teaching methods also vary. Some instructors lecture, others demonstrate or discuss; some focus on principles and others on applications; some emphasize memory and others understanding. In order to gather academic success in technical drawing course, improving corresponding teaching styles is equally important. How much a given student learns in a class is governed in part by that student's native ability and prior preparation but also by the compatibility of his or her learning style and the instructor's teaching style. As Felder and Silverman (1988) indicated mismatches in learning styles of students and teaching styles of lecturers lead poor student performance, low test grades, unresponsive or hostile classes, poor attendance and dropouts. In the context of technical drawing course, many or most students are expected to be visual, sensing, inductive, and active.
- **Cognitive Development:** It is a field of study focusing on development in terms of information processing, conceptual resources, perceptual skill, and other aspects of brain development and cognitive. In other words, cognitive development is the emergence of the ability to think and understand. Cognitive development can also be called intellectual development. In technical drawing course this criterion refers to understanding, thinking skills, spatial awareness, visualization skills and relationship of views of projection.
- **Knowledge Development:** In technical drawing course, this criterion refers to the application of basics of conventions, standards, layouts, drawing types, measurement and scale.
- **Psychomotor Development:** In technical drawing course this criterion refers to coordination, control, accuracy, neatness and general discipline.

- **Student Attitude for New Technologies:** Researchers clearly indicates that today's students are accustomed to managing technologies like the Internet, 3D video games, mobile phones, MP3 players, and other gadgets. Asking such students to perform classical paper-and-pencil exercises can be counterproductive-particularly if it is wanted to offer voluntary remedial courses to improve spatial visualization deficiencies. It is highlighted that it will be difficult to maintain freshman students' attention in such a course, and they often abandon it before it ends (Contero et al., 2005). Thus, student attitude for new technologies can be considered as an important success criterion in technical drawing course.
- **Affective Behaviors:** In technical drawing course this criterion refers to motivation and enjoyment. It can be suggested that the more motivation and enjoyment of student increase, the more participation to the course and the academic success will increase.
- **Instructor feedback:** It's an important and effective method for both teaching and learning in drawing course. Lecturers should check and correct students' work for each lesson and give them back for reviews.
- **Spatial Visualization Skills of Students:** Spatial skills have been shown to play a significant role in performance in engineering graphics and architectural design courses**.** Researches have proposed three major factors for categorizing spatial abilities: spatial relations, spatial visualization, and spatial orientation (Contero et al., 2005). Spatial visualization is defined as, "the ability to mentally manipulate, rotate, twist, or invert pictorially presented stimulus objects (Alias et al., 2002). According to Piagetian theory, an individual acquires spatial visualization ability through three distinct stages of development. These stages are; 1) learning topological spatial visualization in order to discern an object's topological relationship with other objects; 2) projective representation in order to conceive what an object will look like from different perspectives; 3) combining projective abilities with the concept of measurement (Sorby and Baartmans, 2000). This multi-faceted ability helps civil engineers and architectures to conceptualize links between reality and the abstract model of that reality. Spatial visualization ability has also been found to be essential to a student's success in some engineering & architecture related subjects such as calculus, mathematics, engineering & architectural drawing (Alias, et al., 2002). Also it is found that a person's spatial ability is the primary factor that explains differences in performance in fully utilizing computer-based technology. Previous researches determine some sub-criteria that affects spatial visualization skills of students. These criteria are explained below:
    - **Experience:** Spatial experiences - acquired through life experiences or formal education - have been suggested to contribute to differences in spatial visualization ability. Deno (1995) finds that spatial experiences in non-academic subjects are correlated to spatial visualization ability in engineering & architecture students. For example, playing with construction block type of toys such as LegosTM, Lincoln LogsTM, Erector SetsTM is found to be a good predictor. In conclusion, the findings from previous studies support the hypothesis that spatial visualization ability is affected by spatial experiences and the effect could be on overall or some aspects of the ability depending on the types of experiences (Alias et al, 2002).
    - **Gender:** Metragia et al. (2011) also investigated the relationship between previous experience in design-related courses (like drafting, mechanical drawing, CAD, and art) and found out that previous experience in design courses were gender-biased (i.e., average scores for women on these variables were significantly lower than for men on these two predictors). This means that men were more likely than women to have participated in those activities that were found to be helpful in the development of spatial skills (i.e., play with construction toys and previous drafting course). However, in contradiction with these research findings, some researchers found out that no clear relationship between gender and spatial visualization ability exist (Alias et al., 2002; Adanez and Valenco, 2004).
    - **Aptitude:** Studies have also indicated some form of relationship between aptitude (general intelligence) and spatial visualization ability (Alias et al., 2002). Spatial visualization is an

aptitude that could be improved with training and Technical Drawing courses are an efficient way of doing this (Adanez and Valenco, 2004).

- **Attendance:** However, spatial visualization considered as an aptitude, it is believed that spatial visualization skills can be improved through practice (Adanez and Valenco, 2004; Sorby, 2009). In this sense, researches shows that who had a high frequency of class attendance had significantly higher gains in spatial visualization (Leopold et al, 2001).
- **Level of commitment to completing the required homework assignments:** High personal commitment to completing homework assignments had significantly higher gains in spatial visualization (Leopold et al, 2001).

On the other hand, some researches shows that the predictors which were not significant for success in spatial visualization were 1) age, 2) right vs. left handedness, 3) previous experience in high school geometry courses, 4) playing video games, 5) previous work experience involving spatial skills, and 6) participation in sports which involved placing an object in a specific location (e.g., basketball, hockey, etc.) skills (Metragia et. Al, 2011). In conclusion, if a student is not capable of visualizing, they are going to find it difficult to follow and understand the rest of the content in the course. However, learning deficiencies and difficulties triggers high failure rate in drawing courses (Garmendia et al, 2007). Therefore, visualization skills of the student should be improved by efficient teaching methods. The improvement of visualization ability of engineering & architecture students would also be an important benefit because of its influence on job and academic success. The effect on visualization ability of an indirect, sizable, and long training will be more permanent and general. Therefore, Technical Drawing could be one of the more efficient training methods (Adanez and Valenco, 2004; Olkun, 2003) by providing a context in which spatial ability can be improved through practicing conventions.

Research Methodology and Data Collection

In the study with the aim of presenting the challenges and obstacles in technical drawing course in architectural and CE education, focus group discussions were carried out with twenty architecture and twenty civil engineering students separately. The focus group as an exploratory technique that involves collecting data through a dynamic and interactive group discussion led by a moderator (the researcher), has long been one of the most widely adopted qualitative research methods (Chan, et al, 2012). However, unlike individual interviews, the focus group provides added dimension of the interactions among members by communicating with one another, exchanging ideas and comments on each other's experiences or points of view (Kitzinger, 1994). Thus, it is claimed that focus groups enable researchers to study and understand a particular topic from the perspective of the group participants themselves (Wilbeck, et al, 2007). The focus group discussion which usually lasts between 60 and 90 minutes, is normally audio- and/or video-taped, and then transcribed and analyzed (Barbour and Kitzinger, 1999; Morgan, 1988).

In the study, through the focus group discussions a total number of 20 architecture and a total number 20 civil engineering students who completed their first year were selected. Before starting the group discussion, the moderator introduced the aim of the study, the function of the focus group discussion, and the ground rules and confidentiality of the discussion. Firstly participants were asked; 1) to discuss the challenges and obstacles in technical drawing course, 2) to identify the parameters that affects their academic success in technical drawing course. After the main discussion, common keywords and phrases were identified such that the data could be summarized and categorized, allowing an overall picture of the various ideas raised by different participants to emerge. After then, respondents were asked to review and rate the final contextual analyses results in terms of their significant level. Gather data was analyzed with SMART which is a multi-attribute decision making approach.

Data Analyses

SMART is a basic ranking technique that uses the simple additive weight method to obtain total values as the ranking index by handling data under each criterion (Chai et al, 2013). This method conveniently converts importance weights into actual numbers. Major advantages of SMART, are that it is simple to use and it actually allows for any type of weight assignment techniques (Velasquez and Hester, 2013). In SMART, weights are derived using direct numerical ratio judgments of the relative importance of attributes. Participants, first rank-order the attributes in importance and assign an arbitrary importance to the least important attribute. Then they judge how much more important each of the remaining attributes is in relation to the least important and assign weights. Finally, the ratio weights are normalized (Wang and Yang, 1998). In this study, data was collected separately from a total number of 20 architecture students and a total number of 20 civil engineering students in order to rank the determined predictors of academic success in technical drawing course in architectural and CE educations. According to the SMART analyses results, predictors of academic success in technical drawing course in architectural and CE education and their significant level are shown in the Table 2 and Table 3.

Table 2. Significant level of predictors of academic success in technical drawing course in architectural education

Criteria	Importance Level	Rank
C1. Familiarity with drawing tools and equipment	0.046941	15
C2. Spatial visualization skills	0.074153	3
C3. Psychomotor skills	0.060844	11
C4. Drawing/expression technique skill	0.061916	10
C5. Preliminary preparation (number of homework assignments)	0.057580	12
C6. Duration of lecture (in terms of the sufficiency of recitation sessions)	0.067500	7
C7. Class size (number of students)	0.049968	14
C8. One-to-one rectification (individual student-teacher attention)	0.073033	4
C9. Course content (intensity of the course content)	0.065394	8
C10. Course content (quality of the course content)	0.070836	5
C11. Attendance	0.063698	9
C12. Affective behaviors (motivation and enjoyment of the student)	0.067550	6
C13. Lack of theoretical knowledge about construction elements and technology	0.051885	13
C14. Attitude for using new technology	0.032898	16
C15. Received feedbacks about homework assignments and practices during/after the lecture sessions.	0.080253	1
C16. Cognitive development methods (perspective drawing, model, sketch etc.)	0.075551	2

Table 3. Significant level of predictors of academic success in technical drawing course in CE education

Criteria	Importance Level	Rank
C1. Familiarity with drawing tools and equipment	0.057422	12
C2. Spatial visualization skills	0.066808	4
C3. Psychomotor skills	0.048916	16
C4. Drawing/expression technique skill	0.062836	8

C5. Preliminary preparation (number of homework assignments)	0.055404	14
C6. Duration of lecture (in terms of the sufficiency of recitation sessions)	0.059713	11
C7. Class size (number of students)	0.076025	1
C8. One-to-one rectification (individual student-teacher attention)	0.057422	13
C9. Course content (intensity of the course content)	0.062356	9
C10. Course content (quality of the course content)	0.06447	6
C11. Attendance	0.063579	7
C12. Affective behaviors (motivation and enjoyment of the student)	0.072968	3
C13. Lack of theoretical knowledge about construction elements and technology	0.052335	15
C14. Attitude for using new technology	0.065434	5
C15. Received feedbacks about homework assignments and practices during/after the lecture sessions.	0.073071	2
C16. Cognitive development methods (perspective drawing, model, sketch etc.)	0.061243	10

Discussion of Results

According to the SMART analyses results, a comparison for the rankings of predictors of academic success in technical drawing course in architectural and CE education is shown in the Table 4.

Table 4. Comparison for the ranking of predictors of academic success in technical drawing course in architectural and CE education

	Architectural Education	**CE Education**
Criteria	**Rank**	**Rank**
C1. Familiarity with drawing tools and equipment	15	12
C2. Spatial visualization skills	3	4
C3. Psychomotor skills	11	16
C4. Drawing/expression technique skill	10	8
C5. Preliminary preparation (number of homework assignments)	12	14
C6. Duration of lecture (in terms of the sufficiency of recitation sessions)	7	11
C7. Class size (number of students)	14	1
C8. One-to-one rectification (individual student-teacher attention)	4	13
C9. Course content (intensity of the course content)	8	9
C10. Course content (quality of the course content)	5	6
C11. Attendance	9	7
C12. Affective behaviors (motivation and enjoyment of the student)	6	3
C13. Lack of theoretical knowledge about construction elements and technology	13	15
C14. Attitude for using new technology	16	5
C15. Received feedbacks about homework assignments and practices during/after the lecture sessions.	1	2
C16. Cognitive development methods (perspective drawing, model, sketch etc.)	2	10

According to the SMART analyses results;

- "Receiving feedbacks about homework assignments and practices during/after the lecture sessions (C15)" along with "cognitive development methods (C16)" were found out as the prominent predictors of academic success in technical drawing course in architectural education.
- "Class size (C7)" along with "received feedbacks about homework assignments and practices during/after the lecture sessions (C15)" found out as the prominent predictors of academic success in technical drawing course in CE education.
- In this context, "receiving feedbacks about homework assignments and practices during/after the lecture sessions (C15)" can be considered as one of the important predictor both in architectural and CE education.
- In both architectural and CE educations, "familiarity with drawing tools and equipment (C1)" and "lack of theoretical knowledge about construction elements and technology (C13)" were found as the least important predictors of academic success in technical drawing course. However, in technical drawing course students have to understand and express the structural elements they have never seen. At this point, extensive support of the structural information about construction elements and technology is extremely needed.
- In both courses, students seem to pay more attention to "spatial visualization skills (C2)" than "psychomotor skills (C3)".
- In both architectural and CE educations, "attendance (C11)", "duration of lecture (C6)" and "course content in terms of intensity of the course content (C9)" were found out as moderately important predictors in academic success.
- In addition, it's found out that "cognitive development methods (C16)" is more important for architectural students than the CE students whereas "attitude for using new technologies (C14)" is more important according to the CE students. Technical drawing course in architectural education uses the classic graphical architectural language. Taken into account that there are 2 compulsory courses in which architectural presentation techniques (2 and 3 dimensional) are taught in the digital environment, digital technology is not included in this course in architectural education. So that the "hand-eye-brain coordination" that forms the basis of architectural education is developing much more in this course. On the contrary, CE students take lectures including instructions in solving the problems using CAD packages. For their homework assignments, students work manually and by using a CAD package. For this reason, "attitude for using new technologies (C14)" become more prominent for CE students rather than architectural students.

Innovative Applications in Technical Drawing Course

In both architectural and CE educations, technical drawing course aims to improve the drawing and presentation techniques by gaining skills on 2 and 3 dimensional perception and to teach students how to communicate on a common ground within the framework of certain drawing techniques. However, teaching and learning strategies can have different implications for technical drawing course in the architectural and CE education due to the challenges and obstacles faced in both educations. As it should be, these teaching and learning strategies should provide solutions to the obstacles faced in technical drawing course in the context of spatial visualization skills, learning levels and course context. There is wide consensus when considering that appropriate knowledge of the students' difficulties in the learning process can help to identify the procedures which must be explicitly demonstrated and the appropriate teaching sequence (Middleton 2005). Therefore, academia should develop and implement a course to help students improve their ability to visualize in three dimensions with a matching teaching styles to students' learning styles. Thus, it will be possible to improve student success and retention.

Especially in engineering & architectural education; static views of concepts, theories and ideas with little or no explanation or focus on interpreting the spatial data, almost assuming that the student will be able to make the mental leap, piecing together the spatial puzzle are frequently presented (Mohler, 2001).

Thereby developing a teaching strategy which deals with the learning difficulties by focusing on visualization problem-solving processes can foster success of the course. In this context some suggestions about education and training for improving technical drawing course are given below.

- **Integrated curriculum:** As it is seen in the SMART analysis results, spatial visualization is an import issue that affect the academic success of students in technical drawing course. If spatial visualization ability is accepted as being important to problem solving and learning in engineering & architecture, educators need to place more emphasis on the development of these skills in their students. For this reason, developing a course which would help "low visualizers" overcome their deficiencies in 2 and 3 dimensional spatial visualization and which would help them become more successful in their engineering & architectural studies should be academy's priority (Sorby and Baartmans, 2000). It is also stated that perception and mental imagery can be developed through various applications, which include modelling and sketching, representing objects in three dimensional models, working from three-dimensional models to represent their different dimensions on paper, as well as experience in working with different perspectives of objects and models as represented on paper or on the computer screen. In this context, topics and activities such as hands on construction activities, paper and pencil activities, Sketching isometric pictorials from coded plans, sketching multi-view drawing of simple objects, paper folding activities, combining objects by cutting, joining or intersecting and computer activities should be integrated as cognitive development methods in order to increase spatial visualization ability of students (Sorby and Baartmans, 2000; Sorby, 2009). Remedial lessons should also be made available to those who have poor spatial visualization ability as normally practiced with those who are weak in the mathematical and analytical skills (Alias, et al., 2002).
- **Dual Approach:** Contero, et al., (2005) discuss the importance of visualization skills in engineering & architecture education and propose a dual approach to helping students improve their spatial abilities. They also suggested that using Web resources and sketch-based modeling tools in intensive remedial courses are viable valid strategies for ensuring that students obtain a minimum spatial abilities level. The approach is based on computer graphics applications, and uses both Web-based graphics applications and a sketch-based modeling system. By combining these approaches, they suggested that it would be possible to capture students' attention and foster two important engineering & architectural skills: freehand sketching and an understanding of the relationship between orthographic and axonometric views. From an educational viewpoint, exploiting this appeal can be highly productive
- **Predicting success of students in technical drawing from visualization test scores:** Majority think that analysis of shapes from two or more views, which are based on visualization processes and mental imagination, have a high idiosyncratic component: there are people who can visualize and others who cannot. In this respect, it is not clear where the specific difficulties lie and which procedures should be taught. However taken into account that visualizing objects is a systematic process which can be taught and learnt (Adanez and Valenco, 2004; Sorby, 2009), identifying the spatial visualization skill at an early stage can be considered as a prior for satisfactory teaching–learning. In literature it is underlined that there is a necessity to improve the teaching methodologies considering the difficulties of first-year engineering & architecture students toward learning technical drawing and the importance of spatial aptitude in the profession (Adanez and Velasco, 2002). It is also determined that identifying students' start learning level is an other important issue and the possibility to evaluate the beginning level of students, is a must to improve a technical drawing course design (Metraglia, et. al., 2011). Therefore, in order to effectively plan the didactic process, it is necessary to detect as early as possible those students who require more attention and support. Thus, a visualization psychometric test that could facilitate an early diagnosis concerning the academic performance of technical drawing students can be applied. In this context, the Purdue Spatial Visualization Test: Rotations (PSVT:R) can be applied to test a person's ability at the second stage of spatial development. In this way, it would

be possible to identify the various preparation levels of the students, it would be easier to design useful technical drawing courses, for instance dividing the classroom into sections related to the level of preparation.

- **Student numbers:** The number of students is a defining variable: with a little number of students it's better to make practical exercises by using 3D CAD software, while managing a large number of students usually takes the professors to teach the traditional technique "by hand", so with pencils, rulers, compasses and so on (Metraglia, et. al., 2011).
- **Certification system:** Metraglia, et al. (2011) suggested that the variety of curriculums, ways of teaching and learning "on the job" makes hard to define a person's technical drawing skills and each person's skills are different one from another because of education and experience. In this context, they underline the necessity of a certification system to in order to validate a Technical Drawing learning level in national and international contexts by adopting European Qualifications Framework (EQF). In this sense, context arrangements might be done in order to validate possible shared recognized certifications.

Conclusion

Today, when change and innovation set the agenda, architectural and CE educations should be the environment where emphasis is placed on some permanent and fundamental principles. Drawings are the first steps in the process of making (Dernie, 2010). Considering that the Technical drawing is the act and discipline of composing drawings, the most important part of the course should be "to give what, how and how much" for the students. Even if the methods and contents are changed, both courses' aim is to improve the perception and thinking on the basis of learning and to teach the drawing technique. In this context, this study aims to identify the challenges of "teaching and learning" in technical drawing course. Hence it presents predictors of academic success in technical drawing course that may contain challenges in terms of teaching and learning. It also presents a comparison about the ranking of predictors of academic success in technical drawing course in architectural and CE education by using SMART ranking technique. The findings of this study provide a glance into candidates' views and perceptions of technical drawing courses and of the values students carry with them into technical drawing courses. This study also underlines the complementary relationship between traditional and computer generated techniques in both architectural and civil engineering education. According to the study, "receiving feedbacks about homework assignments and practices during/after the lecture sessions" is one of the important academic success predictor both in architectural and CE education.

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