Serbian Association for Geometry and Graphics

The 7th International Scientific Conference on Geometry and Graphics

moNGeometrija 2020

September 18th - 21st, Belgrade, Serbia

PROCEEDINGS

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ISBN 978-86-6060-046-4

SUGIG

Beograd, 2020.

The 7th International Scientific Conference on Geometry and Graphics

moNGeomatrija2020

Publishers

Serbian Society for Geometry and Graphics (SUGIG)
Faculty of Mechanical Engineering, University of Belgrade

Title of Publication
PROCEEDINGS

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Print
Planeta print, Belgrade

Dean's decision number 13/20 from 20.08.2020.

Number of copies: 80

ISBN 978-86-6060-046-4

The 7th International Scientific Conference on Geometry and Graphics
moNGeomatrija2020

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Serbian Society of Geometry and Graphics (SUGIG)

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CONTENT

TOPIC 4: GEOMETRY, GRAPHICS EDUCATION AND TEACHING METHODOLOGY

CONTENT

THE BENEFITS OFAN ADDITIONAL PRACTICE IN DESCRIPTIVE GEOMETRY COURSE: NON OBLIGATORY WORKSHOP AT THE FACULTY OF CIVIL ENGINEERING IN BELGRADE

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ABSTRACT

At the Faculty of Civil Engineering in Belgrade, in the Descriptive geometry (DG) course, non-obligatory workshops named "facultative task" are held for the three generations of freshman students with the aim to give students the opportunity to get higher final grade on the exam. The content of this workshop was a creative task, performed by a group of three students, offering free choice of a topic, i.e. the geometric structure associated with some real or imagery architectural/art-work object.

After the workshops a questionnaire (composed by the professors at the course) is given to the students, in order to get their response on teaching/learning materials for the DG course and the workshop. During the workshop students performed one of the common tests for testing spatial abilities, named "paper folding".

Based on the results of the questionnairethe investigation of the linkages between:students' final achievements and spatial abilities, as well as students' expectations of their performance on the exam, and how the students' capacity to correctly estimate their grades were associated with expected and final grades, is provided. The goal was to give an evidence that a creative work, performed by a small group of students and self-assessment of their performances are a good way of helping students to maintain motivation and to accomplish their achievement.

The final conclusion is addressed to the benefits of additional workshops employment in the course, which confirmhigherfinal scores-grades, achievement of creative results (facultative tasks) and confirmation of DG knowledge adaption.

Keywords: Descriptive geometry course; workshop; spatial ability test; questionnaire; self-assessment.

INTRODUCTION

The ultimate goal of education is to help students become self-sufficient learners (Karably et al., 2009). Modern teaching methods aim to facilitate this process in order to improve students' learning success. They achieve this by using student-centered learning arrangements but also assign more responsibility to studentsfor their own learning outcome (Beumann et al., 2018).The creation of pedagogical conditions for successful self-independent construction and growth of students' knowledge is of key importance (Voronina et al., 2018)

Students' ways of approaching their studies influence their academic outcomes. Expecting high grades and having the skills to steer learning activities towards assessment demands seem to be important components of academic success (Öhrstedt et al., 2019). However, our knowledge about students' capacity to predict academic achievement is still limited.In the era of fast modern technologies, there is a need to hold students' interest and motivation on a subject matter which requires much attention and deep cognitive actions (Dobelis et al., 2019).

Expecting high grades seems to be an important component for achieving high grades (Dochy, et al.,1999; Hattie 2015). In his comprehensive review of 800 meta-analyses related to education, Hattie (2008) found that self-reported grades (a weak form of self-assessment where students simply predict their own grades and then try to achieve them) were one of the single-most important strategies for improving student achievement. To be able to assess and value their academic outcomes, students need to assess their learning. This requires that students have self-assessment skills.

Self-assessment and goal setting are two strategies employed by educators to assist in the task of developing self-regulated learners. A key type of student self-judgment is self-assessment, which refers to students comparing their learning outcomes with a goal or standard (Labuhn et al., 2010). During self-assessment, students are responsible for interpreting their own results, explaining what the results mean, and determining what actions to take to improve their learning (O'Brian et al., 2010). Self-assessment is important as it complements learning goals and helps students maintain high levels of self-efficacy, including both reflections on and evaluation of one's work; it helps to develop feelings of ownership, and build responsibility for learning (Paris et al., 2001).

LeBlanc et al., (1985) define self-assessment as procedures by which the learners themselves evaluate their skills and knowledge. Harris et al., (1994) regard self-assessment as a self-directed and determined learner setting his/her own assessment criteria, judging his/her learning processes (or product) against these criteria, and making decisions based on these judgments. Self-assessment is more accurately defined as a process by which students 1) monitor and evaluate the quality of their thinking and behavior when learning and 2) identify strategies that improve their understanding and skills. That is, self-assessment occurs when students judge their own work to improve performance as they identify discrepancies between current and desired performances (McMillan et al., 2008; Lee, 2009).

A second component of self-assessment, self-judgment, involves identifying progress toward targeted performance. These judgments give students a meaningful idea of what they know and what they still need to learn (Bruce 2001; McMillan et al., 2008).

Students with high expectations are more likely to persist; those with low expectations often avoid tasks or give up (Brophy, 2004). Positive self-evaluations encourage students to commit more resources to continued study and set higher goals in the future (Schunk, 1995). When involved in assessing their own academic growth, students become more aware of their learning goals and the results of their efforts (Joseph, 2006), thus developing their skills as agents of learning.

It is well established that student engagement depends upon students' self-efficacy beliefs- perceptions of their ability to do well on a specific task, and the value of doing well (Pintrich et al., 2002; Schunk 2004). Self-efficacy involves students estimating what they can do and the likelihood of successful performance. Students achieve more when they set specific goals for themselves (Zimmerman et al., 1989; McMillan et al., 2008). Also, performances can be improved simply by having students self-report their learning.

Students who believe that they can successfully complete a task are more motivated and engaged. What are more important, self-assessment skills can be trained and such training also improves learning and academic performance. Motivation leads to enhanced performance, persistence, and creativity. Therefore, it is important to provide strategies that affect cognitive engagement and motivation (Park, 2018).

High-achieving students could be characterized as highly self-regulated learners. Self-regulated learners could be distinguished by their systematic use of metacognitive, motivational, and behavioral strategies; by their responsiveness to feedback regarding the effectiveness of their learning; and by their self-perceptions of academic accomplishments (Zimmerman, 1990; Panadero, 2017).Metacognition, which has been widely investigated and reported in both educational and psychological literature, involves the capacity to monitor, evaluate, and know what to do to improve performance. This includes conscious control of specific cognitive skills such as checking understanding, predicting outcomes, planning activities, managing time, and switching to different learning activities. It is a set of skills that relate positively to increased achievement, and such skills can be taught to students (Schunk 2004; Panadero, 2017).

Learner autonomy, the development of study skills, the concept of life-long learning, and increased motivation were found by Oskarsson (1989) to be some of the benefits of self-assessment. Self-assessment fosters the development of the meta-competencies—like self-efficacy, self-confidence, and motivation. Self-assessment encourages the students not just to maximize the teacher-assigned grade but to learn the subject on a level of deep understanding (Beumann et al.,2018).

Currently, in most undergraduate curricula students' active participation in their learning process means much more than just attending lectures. Despite lectures still being widely used, other more interactive learning activities that provide opportunities for peer learning, as students working in small groups searching for the solution of contextualized problems are increasingly being used (Ramirez 2015,Voronina et al. 2018).

Descriptive Geometry is an educational course that provides a training of the students' intellectual capability of space perception, important for the variety of engineering professions, and it opens an insight into the structure, and metrical properties of spatial objects, geometric procedures and principles for their design. In the new context of technological environment, beside classical projections of a spatial object, DG improves students' skills in 3D modeling of various curves, surfaces and solids, by employing logical reasoning between 3D structure and 2D projection, and activating students' spatial abilities(Stachel 2007).

At the Faculty of Civil Engineering in Belgrade, in the Descriptive geometry (DG) course, non-obligatory workshops named "facultative task" are held for the three generations of freshman students with the aim to give students the opportunity to get higher final grade on the exam. The final outcome of the students' task was devisedas a creation and representation of a geometric structure applicable in architecture or other type of design.

This study is set out to investigate the linkages between their final achievement and spatial ability, as well as students' expectations of their performance on an exam, and how the students' capacity to correctly estimate their grades were associated with expected and final grades. The goal was to provide an evidence that a creative work, performed by small group of students and self-assessment of their performances are good way of helping students to maintain motivation and to accomplish their achievement.

2. MATERIAL AND METHODS

At the Faculty of Civil Engineering in Belgrade, in the Descriptive geometry (DG) course, non-obligatory workshops named "facultative task" are held for the three generations (total of 50 students) of freshman students with the aim to give students the opportunity to get higher final grade on the exam. The content of this workshop was a creative task, performed by a group of three students, offering free choice of a topic, i.e. the geometric structure associated with some real or imagery architectural object. The task consisted of: creation of 3D model of coordinate system (cardboard model)with 2D drawings-orthogonal projections of a chosen structure – 1(Fig.1a), its geometric modelling in AutoCAD software (Fig 1b) or the optional card-board model -2 and a poster presentation of the overall creative process -3 (Fig. 2). The final result was enriched by architectural/art-work examples of similar objects (buildings/art piece) and images obtained by AR application "Augment" for smart-phones aimed for the visualization of 3D objects (Fig. 1c).The workshop was performed during two days (approx. 12 hours of work in the classroom) at the end of the two near exam terms (January and February).

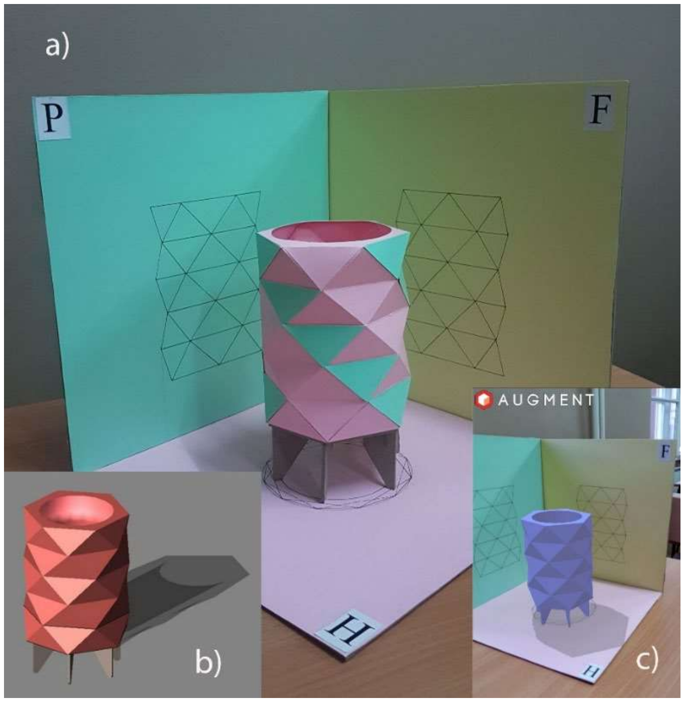


Figure 1: Students creative tasks: (a) Physical model of the art-work piece; (b) 3D model in Auto CAD software; (c) AR application (Source: authors' photo images of the students' work)

At Descriptive Geometry course at the Faculty of Civil Engineering, the students gained theoretical knowledge and were taught the methods and principles of graphical representations of various types of geometric solids and surfaces. The knowledge related to the basic ones, such as prism, pyramid, cone, cylinder, sphere, polyhedrons (cube, tetrahedron and icosahedron), and more complex ruled surfaces, as well as geometric operations that enable variety of their spatial settings, were the students' base for the investigation of a chosen inspiration – the structure that appears in the literature, or in real, or imagery world of architecture/design. Prior to the workshop students did not have the opportunity to test their actual knowledge in the practical – engineering/design manner.

In reality, most of the architectural or design/artistic structures are rather combinations or multiplications of the elements (the whole element, or its parts), either of the same type or different, and additionally, often specifically set in a spatial surroundings. One of the "problematic" issues of this experimental work with freshman students was their actual ability to recognize the exact geometric characteristics of a chosen (realistic) structure (or its elements), and to adopt an adequate approach for its' graphical representation, specifically because of the lack of their practical experience. The workshop was an ideal opportunity for the testing of students' skills and even more, their creativity.

In order to inspire students, challenge and encourage them to participate in the workshop, prior to its realization date, several examples - images of the structures (roofing structures or design creations) were made available as teaching materials at the Faculty's website (http://grf.bg.ac.rs). Some of the most creative examples were chosen from the book "Geometric surfaces in architecture" by Sonja Krasić (2012) (geometric roofing structures which combine: Plato's solids, cylinders, hyperbolic paraboloids, conoids, etc., set over regular polygonal bases or in some other spatial arrangements). Other practical instructions for the creation of a 3D physical (card-board) model of coordinate planes and several illustrations for the other parts of the task, were given along with an example of the final poster presentation (containing all the elements of the task).

The realization of the workshop assumed several practical conditions: the two available classrooms, one for the realization of the manual drawings and the other one aimed for computer drawing/modeling additionally supported by internet access (1); the two professors conducted the work of the workshop simultaneously, during all working hours, by instructing, guiding and helping students in solving the main issues of the tasks, while several (3-5) associates-older and experienced students supported the practical performance (2).

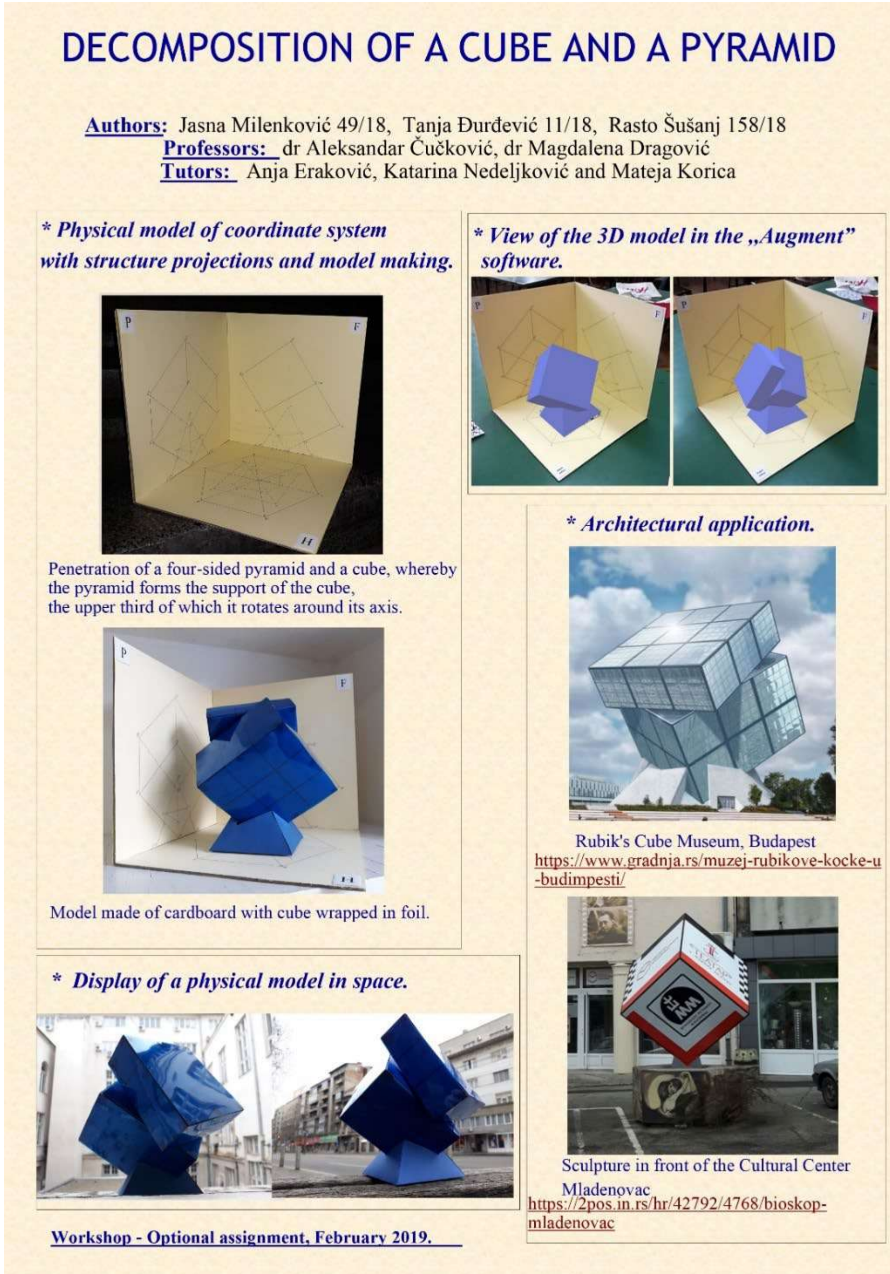


Figure 2: Final poster-presentation of one of the representative students' workshop tasks

After each of the workshops a questionnaire (composed by the professors at the course) is given to the students, in order to gather their response upon teaching/learning materials for the DG course and the workshop. During the workshop students performed one of the common tests for testing spatial abilities, named "paper folding" (PF), as one of the most important ability in working with Descriptive geometry is spatial ability which has a substantial position in human thought and for engineering students is very desirable. Variables covered by the questionnaire were students self-assessment of their own performances on the workshop, previous experience with spatial ability tests, with 3D software, mobile and AR application, as well as with teamwork, visibility and problems with projections, subjective assessment whether DG course is interesting and difficult, time necessary for exercise preparation, creativity self-assessment and overall satisfaction with workshop results. The questionnaire comprised several open-ended questions, so that the respondents had the opportunity to describe what they liked about the participation in the workshop, to give their comments and suggestions for improving the workshop quality.

3. RESULTS AND DISCUSSION

Package for the Social Sciences (SPSS) was used to code and tabulate scores collected from the survey. First, descriptive statistics were employed to take a general view of students' responses. Further, grades can be considered ordinal level data, thus demanding Spearman correlations. However, grades can be analyzed using Pearson correlations and so both Pearson and Spearman coefficients were computed. Two-tailed *P* values of 0.05 were considered statistically significant.

This paper presents some of the most important results from the very extensive research undertaken. Of the total number of students who participated in the workshops, 52.5% achieved the highest overall final grade, while 30% of students received a grade of 9. The highest grade for the project was given to 42.5% of participants, and 35% received a grade of 9.Near half of the of students (55%) rate themselves with a grade of 9, and 30% of them think that they deserve the highest grade.

On the PF test, 25% of students have the maximum achievement, while 30% of workshop participants solved the test with 90% success, although 70% of them have never had experience with aptitude tests before.

Further, the results show that 40% of the students provided perfect ratings of their final grades, among them, half of the students awarded themselves a grade of 10, 37% a grade of 9, and finally, 13% a grade of 8. 38% underestimated, while 22% of the students overestimated their final grade. Within the group who misjudge the final grade, 63 % underestimated their final grade(Figs.2a-d).Thus, the most common form of misjudgment (63 per cent of the students) involved underestimating the final grade; that is, they expected a lower grade but received a higher grade. In comparison, only 37% of the students overestimated their final grade, thus they expected a higher grade than the one they received.

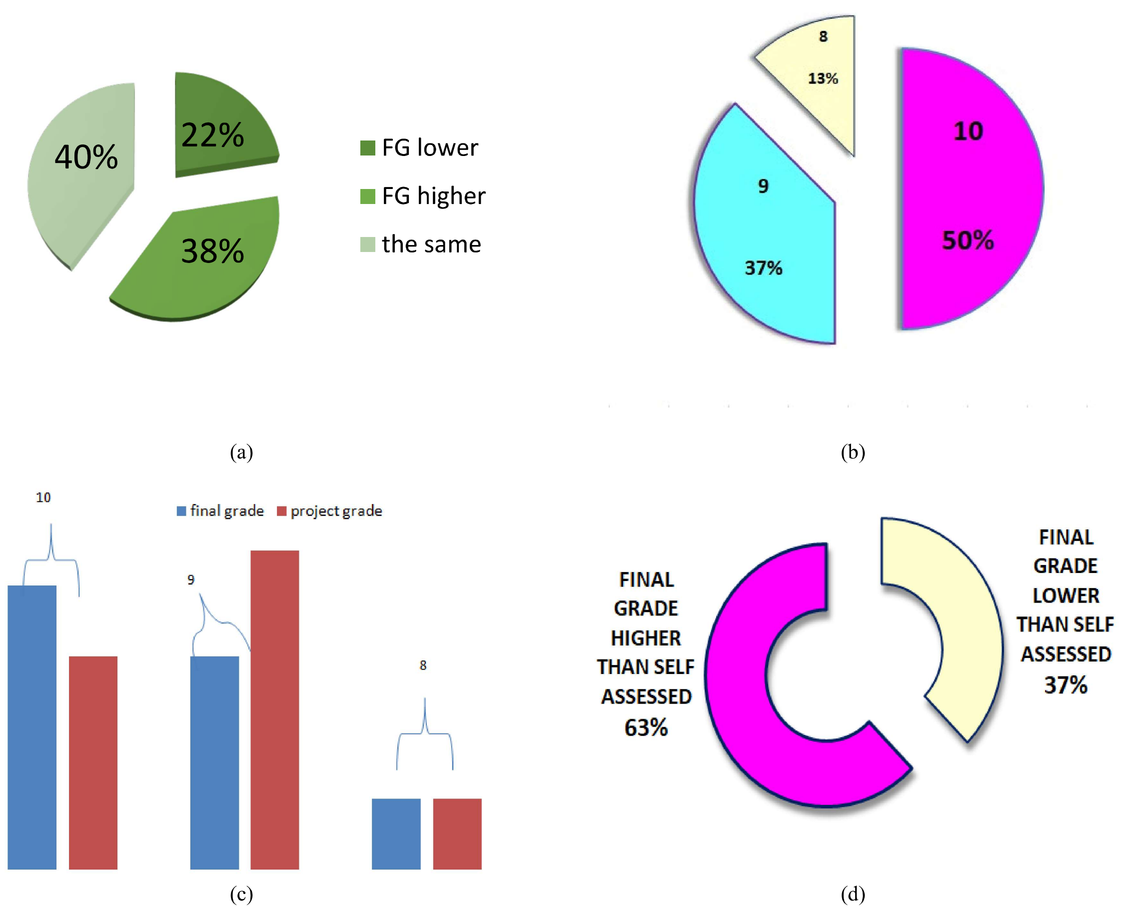
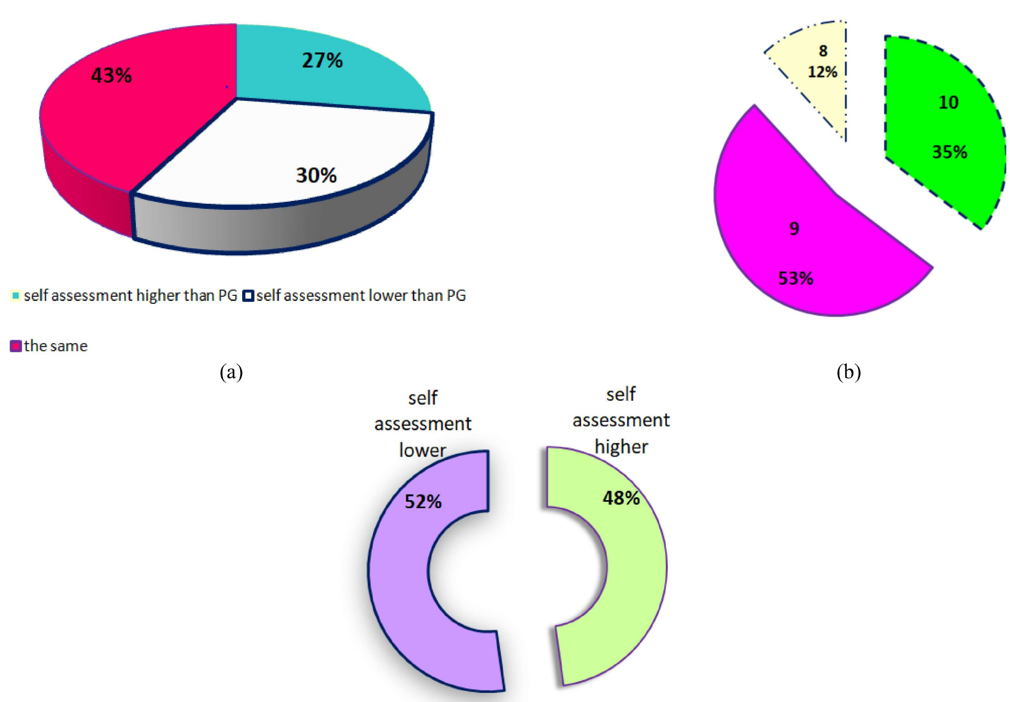


Figure 2:(a) Relationship between self-assessed and final grade, (b) Percent of cases where self-assessed and final grade are equal, (c) Relationship between project and final grade, and (d) Percent of students that misjudge the final grade

When it comes to the comparison of the project grade (all the phases of a creative task) in relation to the self-assessed, 43% of the students made perfect estimations of their project grades, among them, 35% of the students awarded themselves a grade of 10, 53% a grade of 9, and finally, 12% a grade of 8. Within the group who misjudge the final grade, there are almost the same percentage of students who under or overestimated their project grades(Figs.3 a-c).

The overall percentage of the students who provided perfect ratings of their final and project grades is almost the same, but there are differences in the ratio of the grades they awarded themselves. Namely, higher number of students assigned the grade of 10 as a final grade, while, for the project grade the majority of the assigned grades belong to category 9.

During the completion of the questionnaire, respondents had the opportunity to describe what they liked about their engagement in the workshop, to give their comments and suggestions for improving the work in the workshop. Out of the total number of students who took the opportunity to answer these open-ended questions, 47% highlighted teamwork, as well as, teamwork combined with the opportunity to express their creativity. A quarter of students emphasize the creation of 3D models as a great advantage of participating in the workshop, the final result, i.e., the realization of the idea to the end, and mastering new skills emphasizes 6.25% of participants (respectively), while close to 10% of respondents pointed out the choice of important and interesting topics. Students' open-ended comments also suggest that using self-assessment has helped them to maintain their motivation and to become more aware of their participation and involvement in the learning, thus indicating more learner autonomy.



(a) (b) (c)

Figure 3: (a) Relationship between self-assessed and project grade, (b) Percent of cases where self-assessed and project grade are equal, and (c) Percent of students that misjudge the projectgrade

Correlation coefficients show the highest positive values for the relationship between grades for practice exercises in DG and the final course grades, and also high correlations exist between achievement on the test of spatial abilities and final grades, as well as with grades for practice exercises (Figs.4 a - b).

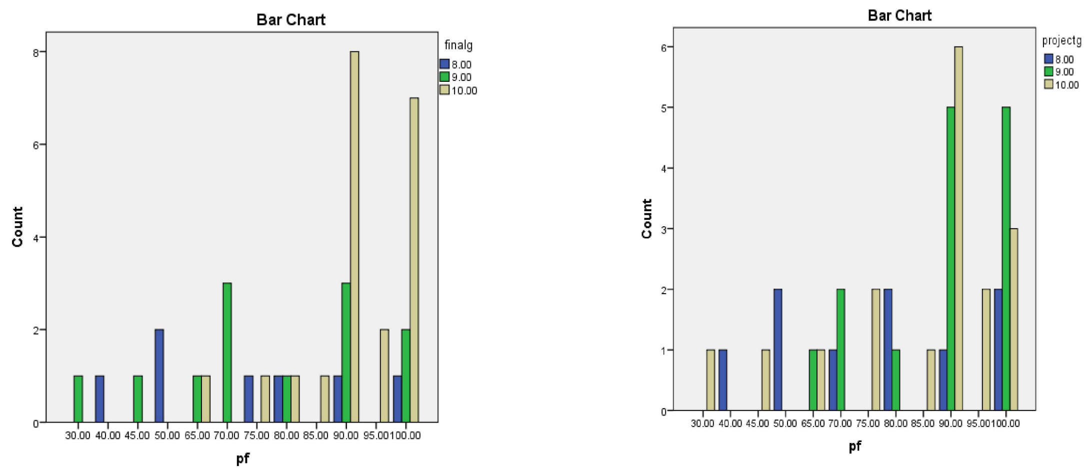


Figure 4:(a) Relationship between the paper folding test scores and the final grade, (b) Relationship between the paper folding test scores and the project grade

Negative association appear between grades for exercises and experience in teamwork, suggesting that students who participated in teamwork earlier show higher average grades for practice exercises (M=9.51) compared to those who do not have teamwork experience (M=8.6) (Table 1).

Table 1: Significant associations among variables

Site	*Final grade*	*Exercises grade*	*Project grade*
PF	*.495***	*.356**	
Final grade		*.600***	*.430***
Teamwork		*-.585***	
**. Correlation is significant at the 0.05 level (2-tailed).*			
***. Correlation is significant at the 0.01 level (2-tailed).*			

Öhrstedt et al. (2016) reported a negative association between the surface approach and expected grades, but also found positive associations between both the deep and strategic approaches to learning, respectively, and expected grades. Meta-analyses of students' capacity to predict examination grades have shown a mean correlation of r ≈ .40 (Mabe et al., 1982; Boudet al., 1989; Falchikov et al., 1989). Comparing the present findings with previous research, the correlation coefficients show somewhat higher values.

All this leads to the conclusion that, in addition to acquiring specific skills necessary to master the material on the DG course, abilities, communication skills, careful selection and cooperation among team members play a significant role, in the success and satisfaction of students. Self-assessment can increase the interest and motivation level of students for the subject leading to better academic performance and enhanced learning. It can also help in development of critical skills among students to assess and analyze their own work, an essential component of self-directed lifelong learning. Self-assessment encourages the students not just to maximize the teacher-assigned grade but to learn DG on a level of deep understanding.

CONCLUSIONS

Beside their practical role, to achieve the connection of the "world" of an engineering practice with Descriptive Geometry knowledge from students point of view, the workshops employed in the teaching/learning process at the Faculty of Civil Engineering gave significant insight into achievements of several educational goals. This paper described positive students' attitude toward DG after their participation in the motivational workshop. Namely, when students were actively engaged in the task which employed their creativity and other personal capacities, they eagerly participated, which consequently led to the positive attitudes. Results indicated that teaching DG through a motivational workshop model was more acceptable to students than traditional teaching/learning methods (Dragović et al., 2019). Evaluating what they have learned, what they still need to work on, and how they can get there can all support deeper understanding rather than superficial knowledge.

Students' open-ended comments also suggest that using self-assessment has helped them to maintain their motivation and to become more aware of their participation and involvement in the learning, thus indicating more learner autonomy. Students benefit from explaining their work and their own evaluation of quality through reflective activities and they are more satisfied with their performance when they can evaluate their work. Correctly implemented, student self-assessment can promote intrinsic motivation, internally controlled effort, a mastery goal orientation, and more meaningful learning (Mc Millan et al., 2008).Overall, students displayed good ability to self-assess accurately, variations probably relate to the discipline (DG) being specific, as well as, to circumstances characterizing the local educational setting. From a practitioner's point of view, students' ideas of assessment and their assessment literacy are of interest for the improvement of learning conditions.

It is important to train students self-assessment practices which should no longer be treated as an assessment, but instead as an essential competence for self-regulation which are to be focused throughout the learning cycle rather than at the final result. Workshops in which participants present their accomplishment are an opportunity for students to formally reflect on the learning that has taken place. This reflection occurs when students prepare themselves for the project, as well as during the presentation itself when they show and explain what they have done. Thus, a curriculum for self-assessment competence would be of great benefit to educational practice and will trigger significant developments, especially in online learning environments where teachers and learners interact in real time, and which requires new teaching and communication skills. Teacher's assistance is even more important if we want learners to develop high levels of competence and confidence. Effective online teacher finds ways to give every sort of feedback about their work to individual, as well as to groups of learners, facilitate mutual understanding, communication and learning experience which will contribute to improved classroom practice in Descriptive Geometry courses, as well as in general educational practice.

Acknowledgements

This work is partially supported by the Ministry of the Science and Technological Development of the Republic of Serbia under No. 036022, No. 036006 and No. 36008.

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