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High School Graphics Experience Influencing the Self-Efficacy of First-Year Engineering Students in an Introductory Engineering Graphics Course

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Abstract

Today's students enter engineering colleges with different technical backgrounds and prior graphics experience. This may due to their high school of provenience, which can be technical or non-technical. The prior experience affects students' ability in learning and hence their motivation and self-efficacy beliefs. This study intended to evaluate the role of prior high school graphics experience in first-year engineering students' self-efficacy beliefs in an introductory engineering graphics course. It also intended to evaluate the relationship between such freshmen's self-efficacy beliefs and their performance. Two assessment instruments were used in this study. The first is the eight-item Course Interest Survey (CIS) Confidence subscale, which was used to assess self-efficacy beliefs. The second is a multiple choice questionnaire designed on the course topics, which was used to assess performance. Ninety-nine students of the University of Brescia (Italy) participated in the experiment. Significant differences in self-efficacy were found between engineering freshmen from the technical high school versus engineering freshmen from the non-technical high school. A significant relationship between self-efficacy and performance was found only for engineering freshmen from the technical high school.

Introduction

To understand what motivates students to learn is fundamental to develop pedagogical strategies to promote student success. The effort, persistence and resilience of students through the process of learning are determined by their motivation, and particularly by their self-efficacy beliefs and expectancy for success (Pajares, 1996). Self-efficacy beliefs are also considered by many researchers as strong predictors of the level of achievement that individuals finally get (Bandura, 1997; Pajares, 1996). Therefore, many studies have tried to understand which motivational and self-beliefs provide the greater explanation and prediction of students' behavior and performance (Bong and Skaalvik, 2003; Pajares, 1996).

In engineering graphics education, previous researches conducted by Ernst and Clark have failed to find significant relationships between motivation to learn and performance or attitude in introductory engineering graphics courses. They also found no significant differences between attitudes and motivation of students at-risk and not at-risk (Ernst and Clark, 2012a; Ernst and Clark, 2012b; Clark and Ernst, 2012). In all these studies, attitude is measured in terms of spatial acuity, mental rotation abilities and 3D visualization abilities with a plurality of assessment instruments, such as the Purdue Spatial Visualization Test-Visualization of Rotations (PSVT); the Mental-Rotations Test (MRT); the VARK Questionnaire; and the North Carolina Learning Attitudes about Graphics Education Survey (NCLAGES). On the other hand, motivation is measured by using only the Motivated Strategies for Learning Questionnaire (MSLQ). Particularly, the

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motivational aspects of learning are measured by using the subscale MSLQ Self-efficacy Learning Performance (see an example in Clark, Ernst and Scales, 2009). The MSLQ is one of the most used self-report questionnaires to assess motivational beliefs and self-regulated learning. However, further robust self-assessment questionnaires have been developed to measure the motivational component of learning (see Bixler, 2006 for a review).

One example of such self-assessment questionnaires is the Course Interest Survey (CIS), which is a situational measure of students' motivation to learn. The Course Interest Survey was developed by Keller (2006) in correspondence to his ARCS Model of Motivational Design. The ARCS is a model aimed to select instructional strategies to generate interest and motivation in learners while connecting to instructional goals. According to such model, there are four steps for promoting and sustaining motivation in the learning process: Attention, Relevance, Confidence, and Satisfaction (ARCS) (Keller, 1987). Particularly, Confidence is described as the "expectancy for success", with particular reference to the attribution of responsibility. Learners can believe to be the makers of their learning success and attribute success to effort, or they can attribute success to learning environment, to luck, or to the difficulty of the tasks to do (Bixler, 2006; Pajares, 1996).

Table 1 shows a comparison between the items of the CIS Confidence items and the MSLQ Self Efficacy Learning Performance. Most of the items of the CIS Confidence scale are similar, but different in wording, to the items of the MSLQ Self-efficacy Learning Performance. However, there are two significant differences. Firstly, the CIS Confidence survey involves positively and negatively keyed items, whereas the MSLQ Self-efficacy Learning Performance involves only positively keyed items. This difference is important because a balance of positively and negatively keyed items is acknowledged to reduce the possibility of acquiescence bias in the responses.

Secondly, the CIS Confidence items pose the attention on the learner along with the learning environment and perception of tasks difficulty. On the other hand, MSLQ Self-efficacy Learning Performance items are narrowed on the learner as the only maker of their learning success. These differences induced us to consider the CIS Confidence survey more fit for the purpose of this study.

The perception of tasks difficulty and learning environment are particularly important for the development of the self-beliefs of students who are not familiar with some tasks. In fact, a sense of academic self-efficacy is most heavily affected by one's previous encounters with the same or similar tasks (Bandura, 1994; Bong and Skaalvik, 2003; Pajares, 1996). Students who are familiar with the skills required to accomplish a task can interpret their prior achievements and identify the skills on which to develop their self-efficacy beliefs. These self-efficacy beliefs are goal-referenced evaluations and can be a good predictor of their performance (Pajares, 1996). On the other hand, students

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Table 1 – MSLQ Self-Efficacy Learning Performance versus Course Interest Survey Confidence

MSLQ Self-Efficacy Learning Performance items	**CIS Confidence items***
I believe I will receive an excellent grade in this course	You have to be lucky to get good grades in this course.
I'm certain I can understand the most difficult material presented in the reading for this course	I find the challenge level in this course to be about right: neither too easy not too hard.
I'm confident I can learn the basic concepts taught in this course	As I am taking this class, I believe that I can succeed if I try hard enough.
I'm confident I can understand the most complex material presented by the instructor in this course	The subject matter of this course is just too difficult for me.
I'm confident I can do an excellent job on the assignments and tests in this course	It is difficult to predict what grade the instructor will give my assignments.
I expect to do well in this course	I feel confident that I will do well in this course.
I am certain I can master the skills being taught in this course	Whether or not I succeed in this course is up to me.
Considering the difficulty of this course, the teacher and my skills, I think I will do well in this class	I get enough feedback to know how well I am doing.

Note: * = items are here ordered to highlight the similarity with MSLQ items. See Table 3 for their real order

who are not familiar with the tasks required to successfully perform need to rely on vicarious experience on the basis of similar others' performance on the tasks and on evaluative feedback (Bong and Skaalvik, 2003). Such students' self-beliefs are usually affected by social comparison or relativistic impression. Therefore, they cannot be a predictor of their performance as good as for their 'expert' peers. Fantz, Siller and DeMiranda (2011) found that pre-collegiate technical experiences produce a significant difference in self-efficacy related to engineering studies between students who had experience versus those who did not. In particular, students with a pre-collegiate experience in technology education classes at the high school level had significantly higher self-efficacy scores.

First-year engineering students unfamiliar with engineering graphics generally come from non-technical high schools and are without prior graphics experience (Metraglia, Baronio and Villa, 2011). In a study we conducted in 2013 on the students of an introductory engineering graphics course, we found that the impact of pre-collegiate technical experiences seems to persist on self-efficacy beliefs even at the end of the course (Metraglia, Baronio, Villa and Adamini, 2013). In that experiment, we developed a self-assessment questionnaire composed of statements on well-defined tasks related to the course topics, such as "I can understand the indications of threaded parts in a drawing" or "I know how to insert the right dimensional tolerance, once the type of coupling is noted". The self-assessment questionnaire was administered to students at the end of the course and before the exam. It was found that first-year engineering students who came from technical high schools were significantly more confident than

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students who came from non-technical high schools, in almost all the tasks. The result of that study poses the possibility of a long-term impact of the high school of provenience and initial familiarity with engineering graphics on students' self-efficacy beliefs.

The present study therefore sets out to examine the role of the high school of provenience in shaping the self-efficacy and expectancy beliefs of first-year engineering students in an introductory engineering graphics course. This study also attempted to find relationships between self-efficacy and expectancy beliefs and performance. On the basis of previous research it was predicted that:

1. Introductory engineering graphics students from technical high schools have a higher level score of self-efficacy compared to students from non-technical schools;
2. For students from high technical schools, self-efficacy beliefs and performance are positively correlated;
3. For students from non-technical high schools, self-efficacy beliefs and performance are not correlated.

Methodology

Population and participants

The course "Disegno Tecnico Industriale" (namely 'Technical Drawing', but usually translated as 'Basics of Technical Drawing' or 'Basics of Engineering Drawing/Graphics') is an introductory course designed to teach the fundamentals of engineering/technical graphics. The course is listed on the University of Brescia's requirements for the Bachelor's degree in Mechanical Engineering, Automation Engineering and Management Engineering, and it is directed to first-year students. A total of 99 students voluntarily participated in the study. The population for this study was the 180 students enrolled for the first time in the course "Basics of Engineering Drawing" in the spring semester, 2012. Therefore, the response rate was about 55%. The majority of students were Italian (81.8%), male (75.8%), between the ages of 19 and 20 (86.8%), and from non-technical high schools (81.8%). The demographic characteristics of the sample are shown in Table 2.

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Table 2 – Demographics of the Study's sample

Demographic	Category	n	Percent
Sex	Male	75	75.8%
	Female	24	24.2%
Country of origin	Italy	81	81.8%
	Prefer not to respond	10	10.1%
	Morocco	3	3.0%
	Cameroon	2	2.0%
	Romania	2	2.0%
	Lebanon	1	1.0%
Age	19	1	1.0%
	20	63	63.6%
	21	23	23.2%
	22	11	11.1%
	27	1	1.0%
Engineering Major	Mechanical	47	47.5%
	Management	40	40.4%
	Industrial Automation	12	12.1%
High School of provenience	Technical	18	18.2%
	Non-Technical	81	81.8%

Instrumentation: Motivation

The Course Interest Survey (CIS) was used to measure students' self-efficacy beliefs. Two authors of this paper had already used the CIS in previous research on motivation in engineering graphics education, particularly on the use of web comics to motivate weaker students in introductory engineering graphics courses (Metraglia and Villa, 2014). The CIS is a 34-item instrument measuring four different scales – attention, relevance, confidence and satisfaction – which can be used by researchers as a whole or independently. Each item is a statement with a five-point Likert-type scale used to determine how true each statement is for each student. The rating scale is uni-polar, i.e. it reflects a single construct running from low to high, and it is composed by five labeled points with the most negative point first: 'Not True', 'Slightly True', 'Moderately True', 'Mostly True', and 'Very True'. This rating scale agrees with the recommendations of Krosnick and Fabrigar (1997) on the development of uni-polar scales to measure a single construct. For this study, the eight items of to the CIS Confidence scale were used (see Table 3). The original statements of the CIS were translated into Italian. Each statement had five points ranging from 'Not True' to 'Very True'. The statements were scored with a +1 for Not True, +2 for Slightly True, +3 for Moderately True, +4 for Mostly True, and +5 for Very True. For each respondent, the total CIS Confidence score was divided by eight (the number of items). This converts the totals into a score ranging from 1 to 5. Please note the items 2, 4 and 5 in Table 3 are negatively keyed items. The responses have to be reversed before they can be added into the response total. That is, for these items, 5 = 1, 4 = 2, 3 = 3, 2 = 4, and 1 = 5 (Keller, 2006).

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The validity of the CIS as a situation specific measure of motivation has already been demonstrated in the work of Keller (2006), in which Cronbach's alpha was used to measure the internal consistency of the responses for the instrument. For the CIS Confidence subscale, the original study of Keller (2006) had a Cronbach's alpha = 0.81. Our previous research on web comics in engineering graphics education had a Cronbach's alpha = 0.77 (Metraglia and Villa, 2014). For this study, a value of 0.70 for Cronbach's alpha was considered acceptable (Field, 2009). The instrument used in this study resulted in a Cronbach's alpha = 0.76.

Instrumentation: Performance

The second instrument was a multiple choice questionnaire designed by the researchers to assess the skills of students at the end of the course "Basics of Engineering Drawing". Such questionnaire has not officially been validated yet, but preliminary analysis showed it may be considered valid and reliable. We had a positive feedback by five students enrolled in the course who were asked to judge the clarity and the consistency of the questions. We also found a high level of test-retest reliability (r = 0.82) in a pilot study, in which we administered the questionnaire to a sample of 15 engineering freshmen enrolled in the course in two separate occasions distant two days. This multiple choice questionnaire has been used for two years in the course "Basics of Engineering Drawing" at the University of Brescia to evaluate students' comprehension of the course. The course topics are: projections methods; representation and orthographic views; cuts and sections; dimensioning; parts and assemblies; taking dimensions from physical mock-ups; tolerances; threading; fasteners; and unthreaded elements of machines. The questionnaire was administered via computer in a laboratory. The questions were randomly selected from panels of questions in correspondence with the course topics. The total amount of questions in the panels was 300. The questionnaire was made by 18 questions, each with five possible answers of which only one was correct. The order of the possible answers was random for each administered questionnaire. The scores were +1 for each right answer, 0 for no response, and -0.25 for each wrong answer. For each respondent, the total score was then converted to tenths.

Procedure

Students were taught over 13 weeks and were asked to complete the CIS Confidence survey during the last week of class, thereby allowing them to benefit from the whole course prior to completing the survey. The multiple choice test to measure Performance was administered one week after the end of the completion of the course (two weeks after the CIS Confidence survey).

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Results

Table 3 lists the CIS Confidence statements statistics for the group of students from technical high schools (T) and the group of students from non-technical high schools (NT). Descriptive statistics were used to find the skewness and kurtosis of the variables to determine normality of the data and residual plots, and scatter-plots for each variable were performed and visually inspected for any violations. The data of the total scores of Confidence scale and Performance in technical high school and non-technical high school groups were found to be within appropriate limits for the assumptions of the general linear model and adequate for this study.

Table 3 – Means and percentages for CIS Confidence statements

Statement	High School*	M	Not True	Slightly True	Moderately True	Mostly True	Very True
1. I'm confident I will do well in this course	T	3.72	0%	11%	28%	39%	22%
	NT	3.30	5%	16%	38%	26%	15%
2. You have to be lucky to get good grades in this course	T	1.67	44%	44%	11%	0%	0%
	NT	2.04	31%	43%	20%	4%	3%
3. Whether or not I succeed in this course is up to me.	T	4.28	0%	0%	11%	50%	39%
	NT	4.04	1%	6%	20%	33%	39%
4. The subject matter of this course is just too difficult for me	T	1.28	72%	28%	0%	0%	0%
	NT	1.88	32%	52%	12%	4%	0%
5. It is difficult to predict what grade the instructor will give my assignments.	T	3.06	6%	17%	44%	33%	0%
	NT	3.17	3%	20%	43%	27%	7%
6. Since the start of the course, I've been confident that I would have been able to succeed if I tried hard enough	T	4.11	0%	0%	17%	56%	28%
	NT	3.38	1%	19%	37%	27%	16%
7. I find the challenge level in this course to be about right: neither too easy nor too hard.	T	3.61	6%	6%	33%	33%	22%
	NT	3.44	1%	16%	35%	33%	15%
8. I get enough feedback to know how well I am doing.	T	3.11	6%	17%	44%	28%	6%
	NT	2.84	3%	37%	37%	21%	3%

Note: * T = Technical High School; NT = Non-Technical High School

An independent samples t-test was performed to compare the CIS Confidence scores (see Table 4) and the Performance scores (see Table 5) of the group of engineering students from technical high schools versus the group of engineering students from

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non-technical high schools. The average CIS Confidence score of engineering students from technical high schools was significantly higher than the average CIS Confidence score of engineering students from non-technical high schools (mean difference = 0.36, t = 2.54, p = .01).

The Performance scores were not significantly different between the two groups (mean difference = 0.04, t = 0.10, p = .92). There was a significant correlation between the CIS Confidence score of engineering freshmen from technical schools and their performance (r = .68, p = .02), whereas there was not a significant correlation between the CIS Confidence score of engineering freshmen from non-technical schools and their performance (r = -.09, p = .92). Table 6 shows that considering all the participants, with no regard to the high school of provenience, there was not a significant correlation between the CIS Confidence score and the Performance score (r = .10, p = .31).

Table 4 – T-test CIS Confidence Technical High School/Non-Technical High School

Group	n	M	SD	Mean Difference	*t*	*df*	*p*
Technical High School	18	3.85	0.56	0.36	2.54	97	0.013
Non-Technical High School	81	3.49	0.55				

Table 5 – T-test Performance test Technical High School/Non-Technical High School

Group	n	M	SD	Mean Difference	*t*	*df*	*p*
Technical High School	18	7.69	1.50	0.04	0.10	97	0.92
Non-Technical High School	81	7.73	1.33				

Table 6 – Correlation matrix CIS Confidence and Performance Technical High School/Non-Technical High School

Group	n		CIS	Performance
Technical High School	18	**CIS**	-	.68 (p = .02)
		Performance	.68 (p = .02)	-
Non-technical high school	81	**CIS**	-	-.09 (p = .43)
		Performance	-.09 (p = .43)	-
Total of participants	99	**CIS**	-	.10 (p = .31)
		Performance	.10 (p = .31)	-

The responses to the single items were found to be not significantly distributed in both groups. This is in good agreement with Keller (2006), who argues that, being the survey a situation specific measure, there is no expectation of a normal distribution of responses. Mann-Whitney tests were conducted to test the differences between the two groups on the eight items of the survey. Table 7 reports Mann-Whitney test values (U), level of significance (p) and effect size (r) for the differences between the two groups for

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each item. Effect sizes provide a standardized measure of the size of the effects observed and determine the strength of the relationship between variables. Criteria to indicate effect sizes are r = .01 (small effect), r = .03 (medium effect), and r = .05 (large effect). The effect size r was calculated by converting the U test statistics into a z-score and by dividing such z-score by the square root of the number of the total observations (Field, 2009), i.e. 99 (18 technical high school students + 81 non-technical high school students).

Table 7 shows that there is a significant difference between the responses of engineering students from technical high schools and engineering students from non-technical high schools to two items: "The subject matter of this course is just too difficult for me", U = 404.00, z = -3.24, p = .001,r = -.33 (a medium effect) and "Since the start of the course, I've been confident that I would have been able to succeed if I tried hard enough", U = 422.50, z = -2.90, p = .004, r = -.29 (a small to medium effect).

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Table 7 – Mann-Whitney tests CIS Confidence statements
Technical High School/Non-technical high school

Statement	High School*	Median	Avg. Rank	*U*	*Z*	p	Effect Size *r*
1. I'm confident I will do well in this course	T	Mostly True	59.11	565.00	-1.55	.121	-.16
	NT	Moderately True	47.98				
2. You have to be lucky to get good grades in this course	T	Slightly True	58.50	576.00	-1.48	.138	-.15
	NT	Slightly True	48.11				
3. Whether or not I succeed in this course is up to me.	T	Mostly True	54.08	655.50	-0.71	.478	-.07
	NT	Mostly True	49.09				
4. The subject matter of this course is just too difficult for me	T	Not True	45.99	404.00	-3.24	.001	-.33
	NT	Slightly True	68.06				
5. It is difficult to predict what grade the instructor will give my assignments.	T	Moderately True	51.67	699.00	-0.29	.773	-.03
	NT	Moderately True	49.63				
6. Since the start of the course, I've been confident that I would have been able to succeed if I tried hard enough	T	Mostly True	67.03	422.50	-2.90	.004	-.29
	NT	Moderately True	46.22				
7. I find the challenge level in this course to be about right: neither too easy nor too hard.	T	Mostly True	54.44	649.00	-0.76	.448	-.08
	NT	Moderately True	49.01				
8. I get enough feedback to know how well I am doing.	T	Moderately True	57.31	597.50	-1.26	.207	-.13
	NT	Moderately True	48.38				

Note: *T = Technical High School, NT = Non-technical High School

Discussion

This study was concerned with the association between the type of high school of provenience (technical or non-technical) and self-efficacy beliefs of first-year engineering students in an introductory engineering graphics course. It was intended to evaluate the role of prior graphics experience in engineering freshmen's motivational self-beliefs and the relationship between such self-beliefs and freshmen's performance.

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Most of the studies conducted so far in introductory engineering graphics courses have used the Motivated Strategies Learning Questionnaire (MSLQ) to assess motivational beliefs. In this study, self-efficacy beliefs were measured by using the Course Interest Survey (CIS), particularly the CIS Confidence survey. The aim of using the CIS Confidence survey was to better understand the effect of learning environment and perception of difficulties on the shaping of self-beliefs. Three hypotheses were stated in the above Introduction.

The first hypothesis was confirmed by the results: first-year engineering students from technical high schools scored significantly higher levels of self-efficacy compared to their peers from non-technical high schools. This result supports our previous study on self-assessment on well-defined tasks (Metraglia et al., 2013), in which we found that at the end of an introductory engineering graphics course, engineering freshmen from technical high schools are more confident in being able to solve basic graphics tasks, if compared to their peers coming from non-technical high schools. This result is also in line with the study of Fantz et al. (2011), who found that students with a pre-collegiate experience in technology education classes at the high school level have significantly higher self-efficacy scores related to engineering studies compared to students without such kind of experience. In our experiment, two statements played the major role in defining the difference between the self-efficacy of students from the technical high school and engineering students from the non-technical high school. The first refers to the perception of difficulty: “The subject matter of this course is just too difficult for me”. The second refers to the self-perception of initial familiarity: “Since the start of the course, I’ve been confident that I would have been able to succeed if I tried hard enough”. Note that such two statements are typical of the CIS Confidence pool of items, whereas a counterpart does not exist in the MSLQ Self-efficacy Learning scale. This supports the need to use different assessment instruments to assess motivational beliefs to get a better overview of what motivates students to learn engineering graphics, as also argued by Clark and Ernst (2012). We conclude that first-year engineering students without prior technical and graphics experience are aware of their difficulties in learning the fundamentals of engineering graphics. We also conclude that this awareness has a significant impact on developing their self-efficacy beliefs. This is in good agreement with Delahunty et al. (2013), McCadle (2002), Metraglia et al. (2011) and Pajares (1996).

The second hypothesis was confirmed by the results: for first-year engineering students from technical high schools, self-efficacy beliefs and performance were positively correlated. This is in agreement with Bandura (1994), Bong and Skaalvik (2003) and Pajares (1996). In fact, first-year engineering students from the technical high school have already some experience and familiarity with engineering graphics tasks, since they previously encountered the basics of engineering graphics at their high school. They can hence better interpret which skills are associated with the required

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performance, and evaluate their preparation. Their self-efficacy beliefs are based on previous experience, and can hence maximize the prediction of their performance.

The third hypothesis was confirmed by the results: for first-year engineering students from non-technical high schools, self-efficacy and expectancy beliefs and performance were not correlated. This is in coherence with Bong and Skaalvik (2003), who argued that the lack of experience at the very initial stage of education is expected to exhibit variability just because it is hard for students to formulate self-efficacy beliefs without prior experience on topics.

This study indicated that a better understanding of the background of first-year engineering students is important to the understanding of their self-beliefs and to the prediction of their performance. Note that if we considered the entire sample of the students of this study without distinction between the kind of high school of provenience, self-efficacy beliefs and performance would not be correlated, as also found with Ernst and Clark (2012b). The literature on self-beliefs in academic motivation (see Pajares, 1996) also indicates other factors correlated to motivation, such as gender and self-beliefs. An ongoing study on the same sample of this study is aimed to assess the relationship between the gender of students and their self-beliefs in an introductory engineering graphics course.

This study also indicated that further motivational assessment instruments need to be used to understand self-beliefs and expectancy for success of the students in engineering graphics courses. Situational measures of students' motivation to learn are especially needed to evaluate the efficacy of pedagogical methodologies used by researchers. It is hence recommended to assess the motivation of students before and after the course, to better evaluate the impact of instructional methodologies.

Three factors need to be considered in evaluating the findings of the present research. The first factor is that the engineering drawing skills of engineering freshmen at the beginning of the course were not assessed. In fact, only the high school of provenience was considered as independent variable. This is a potential source of unreliability. In fact, despite the technical high school has the major role in shaping such kind of experiences (Fantz et al, 2011), engineering freshmen from the technical high school may not all have better engineering drawing skills than the 'average' freshman. Similarly, students from the non-technical school may sometimes have some prior graphics experiences because of their personal interest, and may have hence a better background compared to their peers from non-technical schools. The second factor is that the questionnaire used to assess the performance is not validated yet. Moreover, it was designed and tailored to the topics taught at the course “Basic of Engineering Drawing” of the University of Brescia. Such topics may differ from the topics of other introductory engineering graphics courses taught in other colleges. It is hence difficult to compare the performances of the sample of students of this study with the ones of other

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studies. In a further study it would be useful to assess students' performance or attitude by using one of the validated questionnaires used, for example, in the studies conducted by Ernst and Clark. The third factor is that the populations compared in this study to others in the field do not include such majors in the USA titled automation and management engineers. Therefore, it is hard to do a direct comparison between Italian and American engineering students in relation to such majors. However, this study concerns the very beginning of the educational training. In the first year, engineering students generally learn the basics of mathematics, physics, chemistry, informatics, and, of course, engineering graphics. The curricula of the majors are hence little or none distinct at this stage. Therefore, we believe that the results of this study are not affected by the kind of major engineering students are enrolled in.

In conclusion, the high school of provenience (technical or not) affects the self-efficacy beliefs of first-year engineering students in introductory engineering graphics courses. First-year engineering students from technical high schools are more confident due to their prior technical and graphics experience. Such students are good estimators of the skills required to successfully perform. For this kind of students, self-beliefs and performance are correlated. First-year engineering students from non-technical high schools are less confident due to their lack of prior graphics experience. Such students are not able to assess the skills required to successfully perform. For this kind of students, self-beliefs and performance are not correlated and it is hence more difficult to predict their performance. Apparently, the performances of first-year engineering students from non-technical high schools do not significantly differ from the ones of first-year engineering students from technical high schools. However, students from non-technical high schools need adapted motivational instruments and methodologies to raise their self-efficacy beliefs.

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