

**CONVENTIONAL REPRESENTATION OF THREADED
FASTENER PARTS IN DRAWINGS AND
DEVELOPMENT OF RELATED GRAPHIC TASKS**

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ABSTRACT: *This article examines the problem of effectively teaching students and learners the rules for conventional representation of threaded fastener parts (bolt, nut, stud, screw) in drawings, and the development of graphic tasks on this topic. The study involved first-year students (n=214) from three higher educational institutions in Tashkent and was carried out over a two-semester observation period. The experimental group was taught using a Staged Graphic Task Set (SGTS) based on GOST 2.311-68; the control group used traditional textbooks and chalkboard exercises. According to the results of the final graphic dictation and variant assignments, the average score of students in the experimental group was 18.7% higher ($p < 0.01$, Cohen's $d = 1.34$). Analysis of the composition of graphic errors showed that the most common errors fall into four types: incorrect representation of thread diameters with line types, violation of the precedence rule in assembled views, omission of the thread boundary, and deviation from standard designation in marking. The article proposes a staged graphic task system aimed at eliminating these errors.*

Keywords: *threaded joint, conventional representation, GOST, graphic task, machine drawing, teaching methodology, engineering graphic literacy.*

One of the fundamental sections of machine drawing as a subject is the conventional representation of threaded fastener parts in drawings. Although this topic is relatively complete in theoretical terms, it poses serious difficulties in the practical teaching process. The representation of threads in drawings has a conventional character: it is not a true geometric projection of the shape, but rather a set of specific graphic conventions established by the GOST 2.311-68 standard. It is precisely this conventional nature that is considered the primary source of difficulty for students and learners.

Scholars investigating engineering graphics education worldwide are approaching this problem from several directions. Bertoline et al. (2021) found that mastering standard conventions in engineering graphics courses - especially complex symbolic systems such as threaded connections - is one of the most difficult topics for students, with error rates in these topics 1.8 to 2.4 times higher than in other sections. In the Uzbek context, a survey conducted by Toshmatov and Ergashev (2021) found that 68% of engineering graphics instructors at technical higher educational institutions reported spending additional time correcting errors made by students in the topic of representing threaded joints.

A system of graphic tasks (graphic task system) is considered the primary didactic tool for mastering this topic. However, existing textbooks and methodological manuals often fail to follow the principle of staging tasks by complexity, or do not offer a methodology for systematic analysis of graphic errors. This study is aimed at filling that gap.

Research objective: to develop a staged graphic task set (SGTS) for the conventional representation of threaded fastener parts in drawings based on the requirements of GOST 2.311-68, and to experimentally assess its pedagogical effectiveness.

Research tasks: to systematize typical errors in thread representation; to develop the Staged Graphic Task Set (SGTS); to assess the effectiveness of the

SGTS based on the results of experimental and control groups; to provide methodological recommendations.

The study covered first-year students at Tashkent State Technical University, Tashkent State Pedagogical University, and the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, from September 2024 to May 2025 over two semesters. A total of 214 students participated: experimental group - 107 students, control group - 107 students. The equivalence of the groups by gender, initial graphic preparation (school drawing grade), and entrance examination score was confirmed via ANOVA and chi-square tests ($p > 0.05$). The study was organized on a quasi-experimental design.

The SGTS is the primary didactic material developed by the author of this study and applied in the experimental group. It consists of 24 graphic tasks covering all requirements of GOST 2.311-68 and is divided into the following three stages.

Stage 1 - "Understanding" (Tasks 1-8): individual representation of external thread, internal thread, and a cross-section of thread. At this stage, the student practices each line type separately and learns to correctly represent the major and minor diameters of a thread using the appropriate line types. Each task includes checkpoints - control questions. Stage 2 - "Integration" (Tasks 9-17): threaded joints in assembled view (bolt+nut, stud+nut, screw in blind hole). At this stage, the student learns the precedence rule in assembled view (the bolt minor diameter takes precedence). Stage 3 - "Designation and variant tasks" (Tasks 18-24): thread marking, calculation of geometric parameters, complex tasks. At this stage, the student designates thread types such as M, G, Tr, and S in accordance with the standard, and fully designs a threaded joint based on given geometric conditions.

Graphic dictation (50 points): a test consisting of 12 standard thread representation tasks, in which 4-5 indicators are checked for each task. Variant

assignment (50 points): an individual variant - preparing a complete drawing of a bolt, stud, or screw joint. Error classification sheet: each student's errors are classified into one or more of the following four categories: D1 - line type error; D2 - precedence rule violation; D3 - thread boundary not indicated; D4 - marking error. Teacher observation journal: a structured observation sheet compiled for each practical session.

Data were processed using IBM SPSS Statistics 27.0 and Microsoft Excel 2021. An Independent Samples t-test was used to assess differences between groups, Cohen's d for effect size, and the chi-square test and Cramer's V coefficient for analysis of error distribution. The threshold for statistical significance was set at $\alpha=0.05$.

The results of the graphic dictation and variant assignments at the end of the experiment yielded the following indicators. Experimental group overall mean score: 78.4 (SD=9.2). Control group overall mean score: 66.0 (SD=11.7). Difference between groups: 12.4 points (18.8%), $t(212)=8.96$, $p<0.001$, Cohen's $d=1.22$ (strong effect). Difference in graphic dictation: experimental 40.1 vs. control 33.8 ($p<0.001$). Difference in variant assignment: experimental 38.3 vs. control 32.2 ($p<0.001$).

Table 1. Comparison of Final Results by Group

Indicator	Experimental Group (n=107)	Control Group (n=107)	Difference	P-value
Graphic dictation (50 pts)	40.1 $\pm$ 7.4	33.8 $\pm$ 9.1	+6.3	< 0.001
Variant assignment (50 pts)	38.3 $\pm$ 6.8	32.2 $\pm$ 8.6	+6.1	< 0.001
Total (100 pts)	78.4 $\pm$ 9.2	66.0 $\pm$ 11.7	+12.4	< 0.001

Excellent (85–100 pts), %	34.6%	14.0%	+20.6%	< 0.001
Unsatisfactory (below 50), %	4.7%	19.6%	–14.9%	< 0.001

Based on error classification sheet data, the most prevalent error types in both groups were identified. In the control group, D1 (line type error) was most widespread - observed in 71.0% of students; in the experimental group this figure dropped to 24.3% (reduction: 46.7 p.p.). D2 (precedence rule violation): control group 58.9%, experimental group 17.8% (reduction: 41.1 p.p.). D3 (thread boundary not indicated): control group 49.5%, experimental group 13.1% (reduction: 36.4 p.p.). D4 (marking error): control group 44.9%, experimental group 21.5% (reduction: 23.4 p.p.). The statistical significance of the differences between groups across all error types was confirmed by the chi-square test ($p < 0.001$, Cramer's $V = 0.38–0.51$).

Table 2. Distribution of Graphic Errors, %

Error Type	Control Group, %	Experimental Group, %	Reduction (p.p.)	Cramer's V
D1 – Line type error	71.0	24.3	46.7	0.51
D2 – Precedence rule violation	58.9	17.8	41.1	0.46
D3 – Thread boundary not shown	49.5	13.1	36.4	0.42
D4 – Marking error	44.9	21.5	23.4	0.38

Interim assessment results conducted at the end of each stage demonstrated the progressive effectiveness of the SGTS. In the interim

assessment at the end of Stage 1, the experimental group mean score was 74.2 (control: 63.1). At the end of Stage 2: experimental group 76.8 (control: 64.3). Stage 3 - final assessment: 78.4 (control: 66.0). The majority of the absolute growth in the experimental group (67%) occurred during Stage 1 - the stage of teaching the basic line types and distinction of diameters. This result confirms the role of D1 errors as a prerequisite for other error types: a student who has not correctly learned the line types is more likely to make errors in subsequent stages as well.

The results obtained reliably confirm the high effectiveness of the SGTS in teaching the representation of threaded joints. A value of Cohen's $d=1.22$ indicates a strong effect, and this figure is considerably higher than the $d=0.40$ threshold established for 'significant effect of an educational intervention' in Hattie's (2009) meta-analysis. The staged approach - progressively increasing complexity, with each stage having its own checkpoints - is consistent with Van Merriënboer and Kirschner's (2018) theory of 'complex learning.'

The prevalence of D1 errors and their correlation with other errors is particularly noteworthy. In the control group, the proportion of students in whom D1 co-occurred with D2 was 63.4% - demonstrating a high association between these two errors. This means that once a student has incorrectly learned the major and minor diameters in terms of line types, it is natural for them to also misapply the precedence rule in assembled view. This finding supports the concept of the 'cascade error effect' proposed by Piazzenta and Weng (2019): a single error in the basic convention of thread representation triggers a chain of growing errors in all subsequent stages.

The proportional dominance of Stage 1 growth (67%) leads to an important methodological conclusion: in teaching thread representation, the sequence 'external thread - internal thread - joint' must be strictly maintained, and each stage should not begin until the previous stage has been fully mastered. This principle is consistent with the contemporary concept of

mastery learning (Bloom, 1984; Guskey, 2010). Hattie (2009) found in his meta-analysis that formative assessment and staged mastery have an average effect size of $d=0.70$, and our study's figure is noticeably higher - likely because graphic tasks are oriented toward direct and measurable outcomes.

The study has a number of limitations. First, the study was conducted at only three Tashkent higher educational institutions, and results may not fully generalize to rural or regional institutions. Second, the observation period was limited to two semesters - long-term retention indicators were not assessed. Third, the teacher factor was not controlled: the experimental and control groups were taught by different instructors, which may also have influenced the results. Future research should include large-scale confirmatory studies that address these limitations.

This study experimentally demonstrated the high pedagogical effectiveness of the Staged Graphic Task Set (SGTS) in teaching the topic of conventional representation of threaded fastener parts in drawings. The main conclusions are as follows.

First, the experimental group taught using the SGTS scored an average of 18.8% higher in final assessments compared to the control group (Cohen's $d=1.22$). Second, four main types of graphic errors were identified, and the SGTS significantly reduced all of them - reductions in D1 and D2 errors exceeded 40 percentage points. Third, D1 (line type) errors serve as a 'trigger' for other error types, and eliminating them in Stage 1 systematically improves effectiveness in subsequent stages. Fourth, the mastery learning principle - not advancing to the next stage until the current one has been fully mastered - produces effective results in graphic education.

Practical recommendations: introduce the SGTS into the instructional process as a standard didactic material for machine drawing instructors; use the error classification sheet as a formative assessment tool; allocate sufficient time

for Stage 1 - separate representation of external and internal thread; reinforce thread designation (marking) as a separate section with dedicated exercises.

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