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COOPERATIVE LEARNING IN A DISTANCE COURSE OF ENGINEERING GRAPHICS: EXPERIENCE OF IMPLEMENTING GROUP WORK VIA ZOOM

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Abstract. *This paper investigates a methodology for organising cooperative learning in a synchronous distance course of Engineering Graphics using the breakout rooms feature of the Zoom platform. The subject of the study is the pedagogical conditions for the effective implementation of small-group work in teaching the topic "Sections" in the context of the forced transition of Ukrainian higher education institutions to distance learning. The aim of the paper is to describe and analyse the tested methodology in terms of its impact on student engagement, quality of learning, and the development of collaborative skills. The methodological framework is grounded in Johnson and Johnson's theory of social interdependence, Moore's theory of transactional distance, and the principles of active and cooperative learning. The methodology follows a three-stage lesson structure: an introductory briefing by the instructor, small-group work in breakout rooms (30–40 min), and a joint presentation of results with collective error analysis. A key advantage of the format is the ability to provide feedback at the exact moment difficulties arise, which is supported by cognitive psychology research on the effectiveness of immediate feedback. An oral survey of students from three academic groups conducted after the first session in this format demonstrated unanimous support for continuing it. The proposed methodology can be applied to other topics in Engineering Graphics and related technical disciplines in distance and blended learning formats.*

Keywords: *engineering graphics; cooperative learning; distance learning; Zoom; breakout rooms; sections; active learning; feedback; Learning by Teaching.*

Problem statement. The introduction of quarantine restrictions in 2020 and the subsequent transition of Ukrainian higher education institutions to distance learning under conditions of full-scale military invasion presented teachers of technical disciplines with fundamentally new pedagogical challenges. This problem is particularly acute in the context of Engineering Graphics – a discipline that has traditionally required direct interaction between student and instructor, the development of spatial thinking, and the formation of precise graphic skills.

The online format significantly limits opportunities for timely feedback, joint discussion, and peer learning. Under the traditional distance model, the instructor receives individual assignments for review after the class and physically cannot provide each student with a comment in real time. Review takes place outside class hours – often several days after the session – and by the time students receive feedback, they have already lost the context of the task. There is a clear need for methodological solutions that preserve the benefits of live group interaction within the constraints of distance learning.

Analysis of Recent Research. The theoretical foundation of cooperative learning is Johnson and Johnson's theory of social interdependence [1]: learning in small groups with a shared goal statistically outperforms individual and competitive models in terms of academic achievement, critical thinking development, and student wellbeing. In the distance learning context, this is supplemented by Moore's theory of transactional distance [2] – the separation between instructor and student creates a psychological and communicative barrier that requires deliberate effort to overcome. In this framework, breakout rooms are not merely a technical platform feature but a pedagogical tool for reducing transactional distance: instead of one large virtual room, a network of small communicative units emerges where interaction becomes more natural and intensive.

Recent research consistently confirms the effectiveness of this approach across various educational contexts. A central theme is psychological safety: students tend to perceive a small group as a safe space for expressing ideas and practising skills, where the risk of public error is significantly lower than in a plenary session [3; 5]. At the same time, research shows that this advantage is realised only under specific conditions – when students are sufficiently prepared for the session and when the instructor remains accessible during breakout room work [3; 5]. The absence of supervision, by contrast, tends to provoke passivity and unequal distribution of workload within the group.

Group dynamics is an equally important consideration. Research experience indicates that the optimal group size is up to five participants: in larger groups, some members inevitably disengage from active interaction [3]. The effectiveness of the work is determined less by group composition than by the level of preparedness of each participant and the clarity of the assigned task [5]. Among the personal characteristics that influence the quality of group interaction, researchers identify students' technological readiness and their capacity for social identification with the group – a sense of belonging to a community working toward a shared goal [7].

The experience of applying a three-stage lesson structure – an introductory demonstration in the main room, work in breakout rooms, and a joint debriefing – in technical disciplines of a medical profile is instructive [6]. This model proved effective for mastering complex material that requires both theoretical understanding and practical application. The practice of designating a spokesperson from each group to present results increases participants' sense of responsibility for the quality of their collaborative work and provides a natural mechanism for peer review [4].

The accumulated body of evidence thus strongly supports the pedagogical potential of breakout rooms for organising cooperative learning in a synchronous online format. At the same time, the literature review reveals a notable gap: existing studies are concentrated predominantly in medical, nursing, and language education. The application of this tool in technical disciplines with a pronounced spatial-graphic component specifically in Engineering Graphics remains virtually unexplored, which defines the scientific novelty of the present work.

Statement of objectives. The aim of this paper is to describe, analyse, and provide methodological justification for an original methodology for organising cooperative learning in synchronous distance practical classes in Engineering Graphics using the breakout rooms feature of the Zoom platform, with the topic "Sections" as the case study.

The main part. The traditional format of distance practical classes in Engineering Graphics has significant limitations. Within a 90-minute session, students have time for an introductory explanation with a worked example (15 min) and only partial completion of their individual assignment – in the topic "Sections," the typical outcome by the end of class is three completed views and the beginning of the section construction. After the session, the instructor receives up to 20 variants for post-class review, which often takes place several days later – yet cognitive psychology research clearly demonstrates that delayed feedback is substantially less effective than immediate feedback in terms of learning and long-term retention [8; 9]. A student who receives a comment days later has already lost the context of the decisions they made. Additional complexity arises from the differentiation of assignment variants: to prevent identical submissions, structural element shapes are varied (cylinder, prism, cone, pyramid), which limits the possibility of collective error analysis using a single shared example. One variant of the "Complex Sections" assignment is shown in Fig. 1.

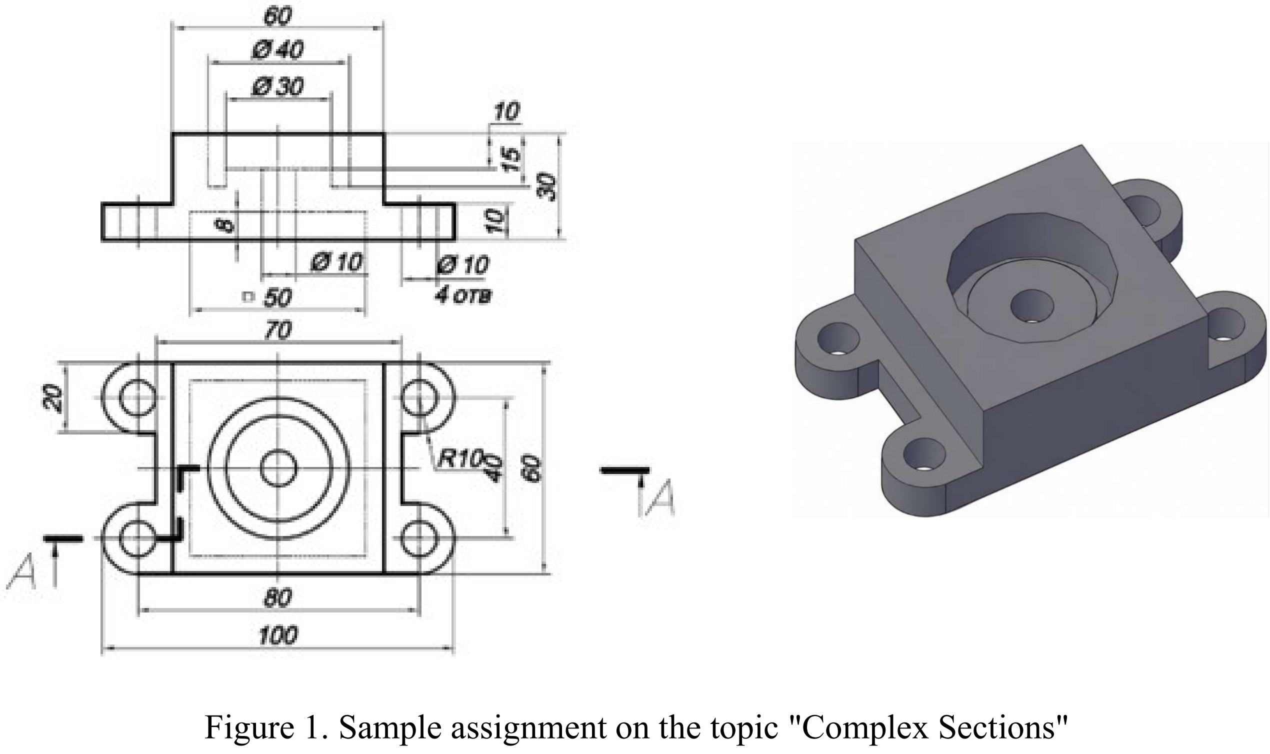

Figure 1. Sample assignment on the topic "Complex Sections"

The proposed methodology using Zoom breakout rooms addresses these challenges in an integrated way and follows a three-stage structure [6]. In the first stage (10–15 min), the instructor delivers an introductory briefing demonstrating the algorithm for constructing simple and complex sections and highlighting common errors. In the second stage (30–40 min), students are divided into groups of 3-4 – the optimal size according to Hayer's recommendations [3], ensuring higher individual participation – and receive a shared task at two levels of difficulty, with roles distributed independently within the group. The key advantage of this stage is the immediate assistance mechanism: students notify the instructor when they need help, and the instructor joins the room at once, providing feedback at the exact moment difficulties arise [8; 9]. The Zoom management panel allows real-time monitoring of each participant's status such as camera activity, microphone use, and screen sharing (Fig. 2) which paradoxically offers greater transparency of participation than a traditional classroom. The Broadcast function enables simultaneous messages to all rooms, simplifying session time management.

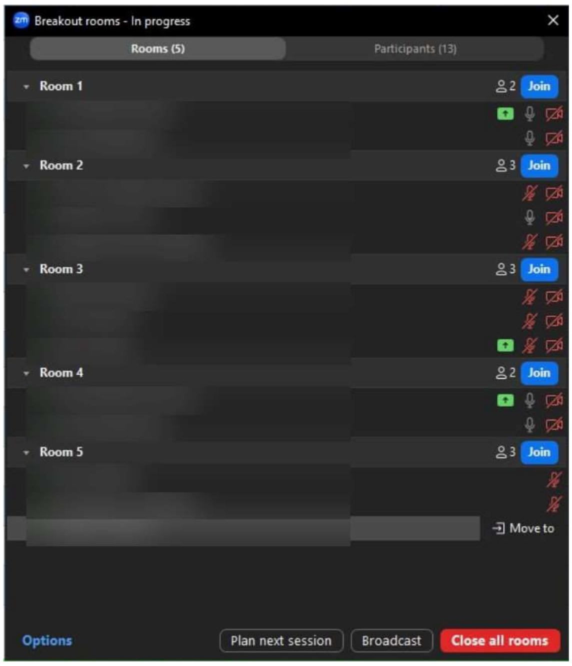

Figure 2. Breakout rooms management panel showing participant distribution across groups

An important pedagogical effect is the Learning by Teaching (LbT) phenomenon [10]: by explaining material to a classmate, a student structures their own understanding and uncovers gaps in knowledge that go unnoticed during independent work. The advantages of LbT in a group context – more effective concept acquisition, higher participation, development of teamwork skills, and higher-order thinking [11] – combined with the principle of complementary competencies [1] transform the group into an environment where all participants learn simultaneously.

Students with experience in graphic editors naturally assumed leadership in visual presentation; those unfamiliar with Zoom's annotation tools acquired that skill during the task. Visualisation techniques also proved pedagogically effective: colour-coding projections of the same surface facilitated spatial perception of the part, and through group discussion students independently arrived at the insight that correct line types and thicknesses are essential – an example of conscious rather than mechanical mastery of graphic standards. In the third stage (15–20 min), a spokesperson from each group presented the results (Fig. 3) [4], while the remaining participants asked questions and proposed alternatives. The collective error analysis replaced the time-consuming individual post-class review, and the concluding individual work – producing a clean drawing and adding dimensions – was fundamentally different from starting "from a blank page": each student approached it equipped with a collaboratively developed algorithm and a formed spatial image of the part. This two-tier model – cooperative learning as the foundation, individual work as its conscious application – is consistent with Johnson and Johnson's classical cooperative learning structure, in which group interaction precedes individual accountability rather than replacing it [1].

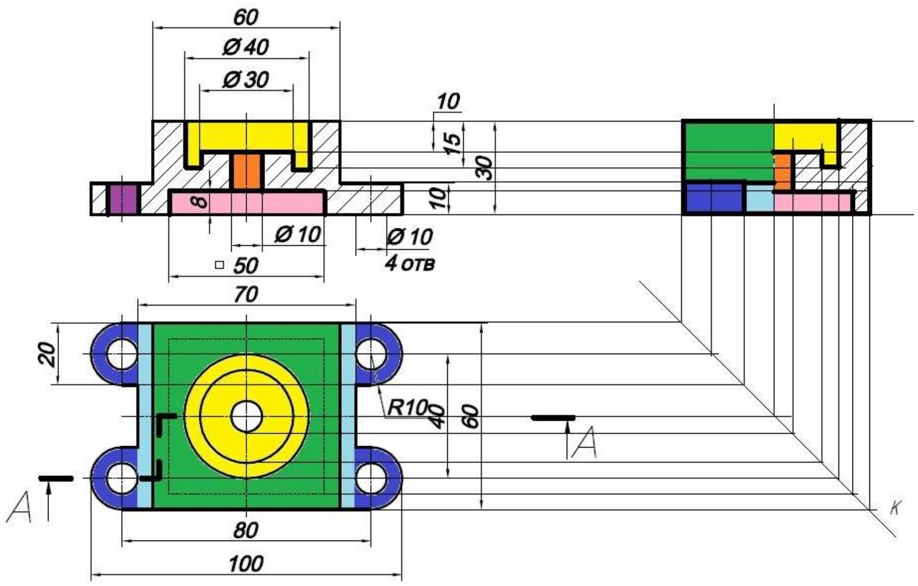

Figure 3. One of the assignment variants completed by a student group

An oral survey of students from three academic groups after the first session demonstrated unanimous support for continuing the format. The most frequently cited advantages were psychological comfort in a small group, peer learning, and immediate instructor assistance – consistent with Almendingen et al.'s finding that psychological safety is a key driver of active participation [5]. The pedagogical outcomes can be structured along four dimensions: engagement – passive presence in a group of 3–4 is conspicuous and naturally prompts contribution [5]; feedback quality – input is provided at the moment of difficulty rather than days later [8; 9]; communication – development of argumentation and constructive criticism skills; efficient use of class time – group presentation replaces time-consuming individual review. Limitations include dependence on connection quality and the risk of unequal workload distribution, mitigated by pre-assigning roles and including a brief icebreaker at the start of breakout room work [3].

Conclusions. The tested cooperative learning methodology using Zoom breakout rooms has confirmed its effectiveness in teaching "Sections" in Engineering Graphics. The three-stage structure – briefing, breakout room collaboration, and collective error analysis – compensates for the limitations of distance learning, increases engagement, and ensures quality mastery of complex graphic material through immediate feedback at the point of difficulty. Unanimous student support across three groups indicates high learning satisfaction. The study fills a gap in literature by demonstrating the methodology's effectiveness in a technical discipline with a spatial-graphic component, previously unexplored in breakout rooms research. Further directions include extending the approach to other Engineering Graphics topics, introducing gamification elements, and quantitatively evaluating learning outcomes.

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