

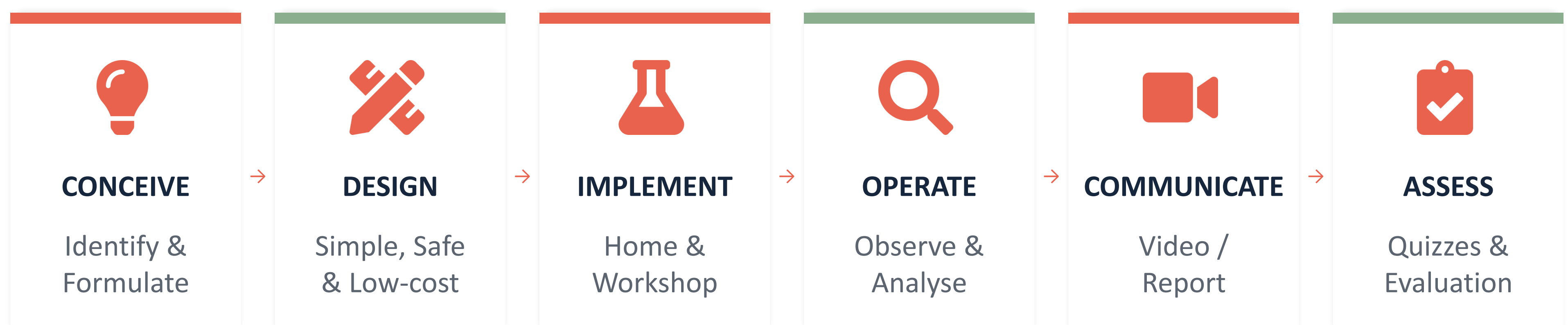
An Integrated Student-Centered Approach to Teaching Welding and Materials Science Using Flipped Classroom, CDIO, Low-Cost Experiments, and Continuous Assessment

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INTRODUCTION

Traditional engineering education often relies heavily on lectures, leaving limited opportunities for interaction and experiential learning. This work presents a student-centered approach developed and implemented in welding and materials science courses based on flipped classroom methodology, active learning, continuous assessment, and the CDIO (Conceive–Design–Implement–Operate) framework. Instructional videos are provided to students before class, allowing classroom time to be devoted to discussion, problem-solving, and practical activities. Student learning is continuously evaluated through quizzes, assignments, teamwork, and classroom participation. The additional time created by the flipped classroom approach enables laboratory activities and simple experiments to become an integral part of the learning process.

The Complete Learning Cycle



Study Workflow

The teaching approach was implemented in a BSc Welding and Joining course with 10 students, combining theoretical instruction with hands-on activities inspired by selected elements of the CDIO (Conceive–Design–Implement–Operate) framework. For each selected topic, students first identified the relevant engineering concept and then performed a simple experiment to observe and analyse its practical behaviour. Activities included ice joining, soft soldering of copper wires, and adhesive bonding using readily available materials at home, as well as SMAW and welding heat-transfer experiments in the workshop. Figure 1 shows an image of a simple experiment for wettability.

The experiments were conducted in groups. Students documented their work through short videos describing the objective, procedure, observations/results, and conclusions, with written reports also accepted. Short conceptual and analytical quizzes were conducted throughout the semester to reinforce learning and assess understanding. At the end of the course, students completed a 15-item questionnaire using a five-point Likert scale. The questionnaire examined course learning, the CDIO-based learning experience, and skill development. The mean score of each item was used to evaluate students' perceptions of the teaching approach.

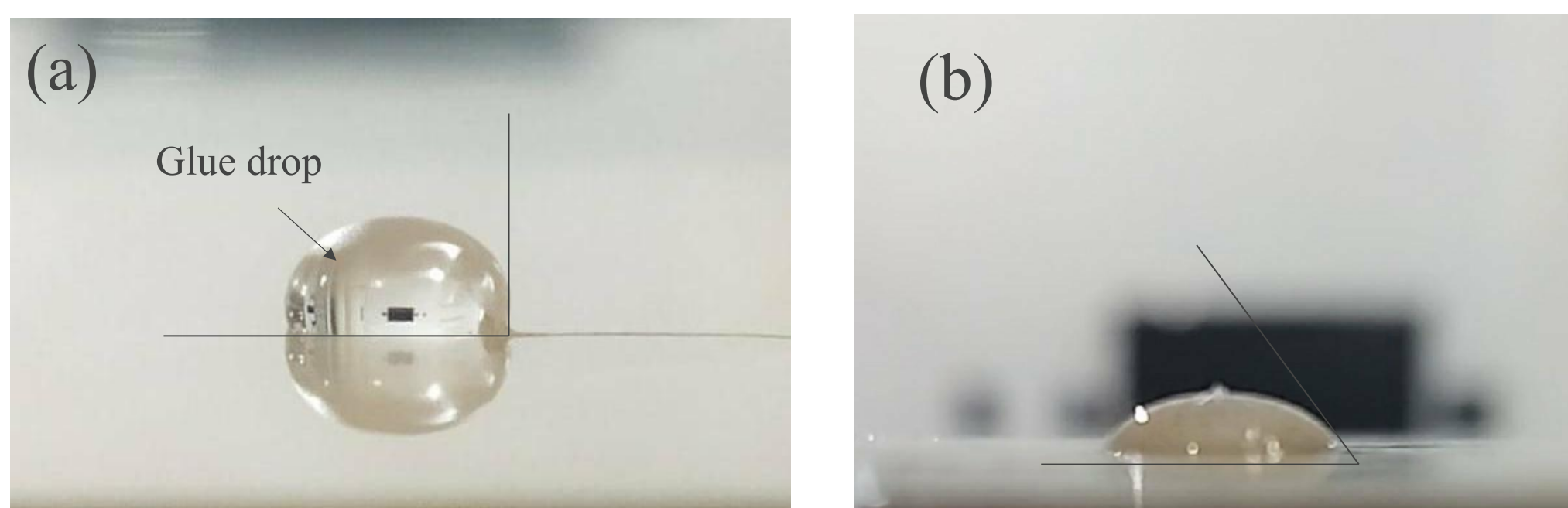


Figure 1 – Simple experiment to show wetting angle and wettability. a) Good wettability and b) poor wettability.

Results and Discussion

Overall, students reported a positive learning experience, with most questionnaire items scoring above 4.0/5. The strongest response concerned the connection between theory and practical examples (4.9/5), followed by the contribution of experiments to understanding welding and joining concepts (4.7/5). Motivation to learn welding and joining also received a high score (4.5/5).

CDIO-related activities were positively perceived, with scores of 4.0/5 for designing simple joining solutions, 4.0/5 for implementing and testing ideas, and 4.1/5 for evaluating joint performance and suggesting improvements.

Students also reported improvements in teamwork and collaboration (4.4/5), analysis of experimental results and failures (4.4/5), and confidence in applying knowledge to practical problems (4.3/5). Problem-solving received 3.9/5.

Home experiments were considered a suitable learning method (4.2/5); however, students rated them less favourably than workshop experiments (3.6/5 when comparing their effectiveness). This suggests that practical workshop activities provided additional value through greater realism and access to specialised equipment.

The overall course evaluation was 4.6/5, indicating a favourable student perception of the approach and its achievement of course objectives.

CONCLUSION

The results indicate that combining theoretical instruction with simple hands-on experiments and selected CDIO elements provided a positive learning experience in the BSc Welding and Joining course. The strong scores for theory–practice connection and experimental learning suggest that practical activities helped students understand fundamental concepts. The approach also supported perceived development of teamwork, experimental analysis, and confidence in applying knowledge to practical problems. Home experiments offered an accessible learning experience, while workshop activities were perceived as more effective. Overall, the findings support combining low-cost home experiments with realistic workshop activities as complementary approaches to engineering education.