Virtualized Active Learning for Undergraduate Engineering Disciplines (VALUED): A Pilot in a Large Enrollment STEM Classroom

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Abstract—**This student poster paper presents an innovative practice in order to increase the scalability and efficacy of student problem-based team learning in large enrollment engineering classrooms. We have devised a novel *Virtualized Active Learning (VAL)* approach to facilitate instructional delivery, assessment, and review of teams. VAL introduces a new pathway by utilizing open-source digital environments for effective and scalable team-based learning in classroom settings while empowering equitable participation from diverse learners. The proposed method provides a unique opportunity for learners to acquire knowledge and skills that are considered vital in STEM fields such as working in multidisciplinary teams proficiently and communicating with other team members in an effective manner. Meanwhile, they are engaged in finding an optimal solution to a design problem that requires certain specific constraints to be adequately met. The results of our pilot study indicate excellent potential for VAL in large enrollment STEM courses while facilitating the instructors to provide assistance and feedback to students in real-time.**

Keywords—**Technology-Mediated Instruction, Computer-Supported Collaborative Learning (CSCL), Flipped Classroom.**

I. INTRODUCTION

While offering flexibility beyond traditional classrooms, recently-developed Collaborative Learning Spaces (CLSs) can face various challenges of functionality, cost, and scalability. CLSs require dedicated rooms with meeting tables or classrooms with movable individual desks, and optionally whiteboards, easel, and pens to conduct the learning activities. Additionally, from the students' point-of-view, they become assigned to a physical group and thus are required to co-locate in order to collaborate. Moreover, from the instructor's perspective, the real-time observability of learning and feasibility of offering guidance become very challenging and thus are usually limited to assisting a single group at a time. Furthermore, there is no record of traceability for student activities to show the level of contribution of each group member. CLSs require manual grading which can become a burden in large enrollment classrooms. Moreover, CLSs are susceptible to chit-chat, small talk, social complexities, and logistic burdens of physical interactions which limits the student engagement. Additionally, the assignment of learners to groups using CLSs is not readily automated making CLSs susceptible to cliques of friends which form groups having monolithic achievement levels. Another challenge facing CLSs is their infeasibility for validating the completion of learning tasks in real-time. Scalability of CLSs is extremely limited because of challenges such as requiring numerous trained instructors and/or Graduate Teaching Assistants (GTAs) due to lack of automatable logistics. Additionally, group size in the CLSs has limited scalability due to the physical limitations of being able to co-locate productively. Also, the CLSs are not suitable for MOOCs whereas in-person attendance is precluded since enrollment is geographically-dispersed or might exceed the room's capacity. Finally, the "lone wolf" challenge can go undetected in CLSs wherein students who are assigned to a group perform the learning tasks individually and without collaborating with their teammates and assisting them. Herein, we propose a novel approach called *Virtualized Active Learning (VAL)* to address the aforementioned challenges.

II. VIRTUALIZED ACTIVE LEARNING FOR UNDERGRADUATE ENGINEERING DISCIPLINES (VALUED)

The proposed VAL approach addresses the need to conduct face-to-face component with a more scalable mechanism, which is applicable to fully live and mixed-mode deliveries. Teamwork is a science and there are many models that can be applied to VAL. While automation can enable new opportunities and increase scalability for engagement of active learning in STEM, the human interactions elucidated by collaborative cognition are also vital aspects. Numerous social, cognitive, and task-related dynamics, alongside pedagogical considerations are relevant that are addressed to varying degrees within VAL. Such issues include group structure, task relevance, and incentivization. Positive social skills in team learning could be further developed during classroom learning while fostering long-term skills for future STEM careers. VAL is replacing lecture time (with no social interaction) with digitally-mediated interactions among learners. Thus, social interaction time is greatly increased compared to traditional lecture. Compared to paper-based design teams, the impact of dominance of certain individuals can be reduced. Studies with over 500 students in required core undergraduate courses indicate that those who are shy may even participate more than paper-based team-learning and learn valuable online collaboration skills needed for future workplace.
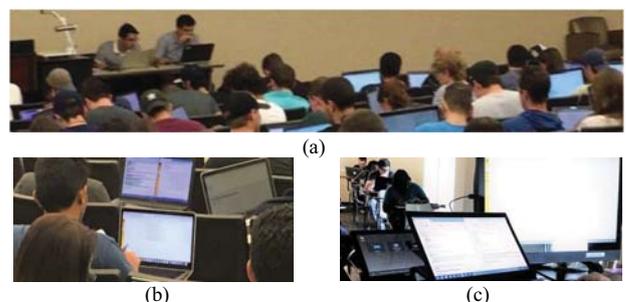

Fig.1: (a) VAL group session assignment in a large enrollment classroom, (b) Students collaborate in VAL groups, (c) Instructors moderate the team activities with auto-grading for immediate feedback.
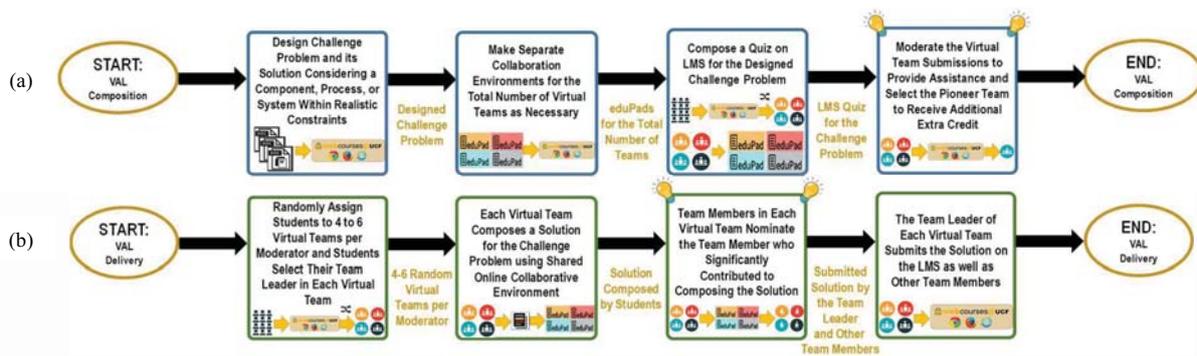
Fig. 2: (a) Illustrates the flow for composition of VAL approach, and (b) shows the flow for delivery of VAL method.

VAL increases observability and real-time remediation and it can be integrated within the Learning Management System (LMS) to provide auto-grading to reduce grading burden [1]. Additionally, VAL more broadly addresses the ABET accreditation criteria to develop team skills within any course rather than the typical case of occurring only within the Senior Design course. As shown in Fig. 1, VAL does not require a dedicated physical infrastructure. When a VAL group session is in progress, learners actively participate using their own Wi-Fi enabled laptop or tablet computer with teammates located anywhere in the room or elsewhere. Meanwhile, as depicted in Fig 1, the instructor(s) can readily view and moderate the team activities to provide instant feedback and assistance. VAL composition and delivery flows are provided in Fig. 2. Herein, in order to construct the VAL modules, we utilize the tools described in [1]. During each collaborative learning activity, students are presented with a team challenge, in which they work synchronously in virtual groups and discuss amongst each other to develop the solution to the problem. Meanwhile, the instructor of record and the GTAs have electronically-enabled opportunities to observe and monitor multiple group discussions in real-time. Rapid feedback to group members helps them remain on track to finding a solution to the challenge problem.

The proposed VAL approach provides straightforward real-time observability of learning and guidance via chat window interface with the possibility of having multiple groups viewed on a display screen. Additionally, VAL automatically keeps a record of student activity via color-coded text at keystroke resolution level which is traceable to each student [2]. Moreover, VAL's grading is done automatically via incremental solutions submitted to the LMS. Scores are automatically entered into the gradebook and traceability of participation is maintained. Student engagement in VAL is increased and focused on the task. Furthermore, the group assignment method in VAL can be fully randomized and dynamically adjusted [2]. Groups are automatically disbursed via the LMS and the pairing strategies are readily-integrated via LMS question group design.
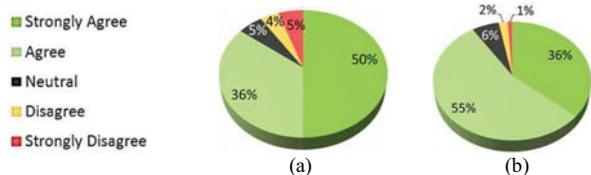
Meanwhile, as complimentary to this paper's focus on synchronous classroom-based active learning, the efficacious and widely-used CATME toolset offers extensive peer evaluation features and semester-long project management capabilities [3]. Moreover, scalability of VAL requires significantly fewer trained instructors/GTAs compared to CLSs. Additionally, VAL enables the instructor to directly observe a real-time submission stream of the grades in the LMS gradebook and identify a *Pioneer Group*, which presents their proposed solution to the class. The proposed VAL approach is suitable for MOOCs as it avoids a co-location requirement. Furthermore, VAL mitigates "lone wolf" scenario via awarding team members who contributed the most in composing the solution, who must be nominated by other teammates, with additional extra credit. A pilot study conducted in a *Computer Organization* course with 116 enrolled indicated positive results shown in Fig. 3. Results of our pilot study indicated that the majority of the participants strongly agreed or agreed that VAL provided worthwhile mechanisms to deliver incentives necessary to participate more fully to teach and assist others, as compared to conventional team activities as illustrated in Fig. 3a. Due to traceability provided in VAL, teammates indicated that they were able to accurately and fairly designate most significant contributor as shown in Fig 3b.

III. CONCLUSION

Herein, we propose an innovative practice to increase the scalability and efficacy of student problem-based team learning in large enrollment classrooms called *Virtualized Active Learning (VAL)*. The proposed VAL method provides a unique opportunity for learners to acquire knowledge and skills that are considered vital in STEM fields such as working in multidisciplinary teams proficiently and communicating with other team members in an effective manner.

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Fig. 3: Learner perceptions of VAL. (a) Incentive mechanisms to mitigate lone wolves (n=76) and (b) Traceability effectiveness (n=99).