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Speed Learning: Maximizing Student Learning and Engagement in a Limited Amount of Time

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***Abstract*—**Active learning has warranted great promise in improving student engagement and learning. It is not a new thought and has been promoted and encouraged as early as the 1980s. Due to the many benefits of active learning it is being practiced by many faculty in their classrooms. Faculty are urged to self-reflect on their teaching styles and work on improving the pedagogies to capture and maintain student interest by increasing student engagement. Although active learning has been used as an instrument to engage students and ultimately increase learning, it has seldom been implemented to directly impact learning relative to time. This paper explores the application of active learning pedagogy to help achieve maximum learning in a limited period of time. The active learning method employed in this study is grounded in classic pedagogies that have been developed based on various psychological theories of learning, motivation and engagement. After the employment of a series of this active learning technique a survey of the students revealed an increase in student learning.

***Index Terms*—**Computer science education**,** speed learning**,** maximizing learning**,** student engagement, google docs in education.

I. Introduction

We are proposing a pedagogy that maximizes learning in the shortest period of time. With the current digital generation, the time students can pay attention or devote to education is greatly reduced. We are proposing a pedagogy that will help students maximize the time they spend learning. Another important aspect of this new pedagogy is that it involves learning by repetition, where the students are learning while creating the questions, while writing down answers to the questions, while preparing for the quiz, while taking the quiz and finally while grading the quiz. We are also utilizing the concept of paired work where the students work as a pair to create and answer questions and prepare for, take and grade the quiz. The students can prompt each other and help remind each other. This process helps build their confidence. Students who are registered with the disability services choose to participate in the quiz due to the support they receive from their partner during the quiz. Active learning also positively benefits student engagement and motivation. Several studies have suggested motivation and engagement is improved when students participate in speed learning activities. Providing students an opportunity to participate in active learning helps them stay engaged during lecture components of the course. This is a crucial component of learning, and thus an important concept in regards to this methodology. This study evaluates students learning preferences, after being exposed to multiple learning methodologies. We looked primarily at students' preferred learning method, their preference to learning with a partner and their suggestions for future class structure. In doing so we hope to test the effectiveness of the speed learning and determine future actions to provide an engaging and motivating environment for all students to learn efficiently, and gain confidence in their knowledge.

As mentioned earlier, this method was designed largely due to the rising demands on student's time. A paper published by the American Association of University Professors demonstrated both the increasing time constraints students face as well as current faculty perspective of student obligations; the results of these two surveys are rather contradictory. When asked what students' work obligations were, majority of professors and collegiate administrators responded with "ten to fifteen hours on campus" however, data suggests that this is no longer the case [32]. The most current report on Educational Enrollment and Work Status from the US Census Bureau shows 72 percent of students work while attending school; and nearly 20 percent work full time [33]. In addition, the number of students working twenty to thirty hours per week has been increasing and now accounts for roughly 25 percent of all college students [32, 33]. There have been many reasons for these trends, the most notable including the inclusion of work in financial aid packages, the increased empathize on career exploration through workforce involvement and particularly for nontraditional students returning to school after a period of time in the workforce, as a their of identify [32]. The changing balance between work and education for students has been a key factor prompting

the development of time-maximizing teaching strategy.

Another factor that plays a role in students' ability to learn is the learning environment. A recent study looked at the relation between classroom environment and students' interest in the class material showed environment to have a strong effect on students' ability to grasp concepts. This study identified four areas that have a particularly negative effect on student's ability to learn and retain material: passive learning, tired in class, escaping with trouble and professional weariness. This study concluded with recommendations that include strengthening training of teachers and teaching methods, paying more attention to the health of students by acknowledging their lives, values and commitments beyond the classroom and by creating a joint system between school and family [35]. Through this study, we see a need for better align the needs of students with the teaching mechanisms being employed. This is the goal of the proposed methodology, Speed Learning, which integrates student learning preferences into course design to improve understanding in a limited period of time.

This paper will present rational for this method, strategies employed, and results from initial studies. Discussion will start with various educational strategies in which the proposed methodology is conceptually rooted; the foundation, of course, being active learning. The value of repetition as a method for retention, partner and group learning, factors effecting engagement and reinforcement methods to increase motivation and an overarching awareness of the need for classroom efficiency will be examined, followed by introduction to our methodological strategies which integrates all of the previously discussed concepts. This section will focus on four phases used to integrate speed learning into course material in which students

- Create questions and answers based class material
- Study questions and answers developed in previous phase
- Participate in short quiz
- Review quiz and evaluate comprehension of material

Following this methodology description, study results will be analyzed to evaluate effectiveness. This will include evaluation of students' preferred learning method, significant student preferences and future suggestions from student participants. Discussion will conclude with research significance and future direction.

II. Background and Theory

The Speed Learning methodology is based on multiple educational theories. Active learning strategies are incorporated into the Speed Learning methodology to encourage student engagement in a limited time period. In addition, repetition and partner learning strategies are employed to further encourage students. Finally, psychological theories and motivational tactics are utilized to better understand student engagement. To better understand the Speed Learning methodology, each of the tactics integrated into the methodology will be considered first in isolation.

A. Active learning

In a traditional classroom that does not employ active learning the faculty lectures and the students listen. There is mostly one-way communication in this type of classroom. An extremely motivated student will pay attention, listen and learn. While a student that has little interest in the subject matter is likely to be distracted and lose attention. Research suggests that the typical attention span of a student is approximately 10 to 15 minutes [28, 29, 30, 31]. Listening to a lecture for 45 to 75 minutes can be challenging and creates opportunities for the students to get distracted and even fall asleep. In addition when these students are asked a question they may not be paying attention and hence are likely to not participate. Student engagement in a traditional lecture format class becomes a challenge. As the students are less engagement there is evidence of reduced learning. Research suggests that student engagement increases learning [1, 2]. As there is no formal definition for active learning, it can be argued that even in a traditional lecture style class the students are actively learning. Chickering and Gamson [40] indicate that active learning is a process of engaging the students by doing some activity in addition to listening. Immersion in problem solving activities by means of reading, writing, engaging in a discussion, role playing or participating in a debate can be described as active learning. Although the traditional lectures increase student mastery in the subject matter active learning increases critical thinking skills and hence an enhanced mastery of the skills in the subject. [1]. To keep students engaged, activities can be designed to encourage active participation by critically thinking and analyzing a situation, a problem or a topic. One form of active learning is the incorporation of discussions during the class time either by splitting the lecture into smaller mini lectures and injecting discussions or activities where the students were given an opportunity to think about the topics being covered and apply them to solve problems.

B. Need for efficiency in the classroom

Students have many demands on their time; nearly 4 out of 5 college students work part-time while attending school; averaging 19 hours a week [14], 33 percent of 4-year degree seeking students attend part time [15] and students vary in ages, backgrounds and family obligations. This dramatically changes the classroom environment. However many research studies that have become the basis for traditional teaching methodologies were based on a "traditional" undergraduate student; who was considered to be a Caucasian, age 18-22, attending four-year institutions full-time, living on campus, not working, and who had few, if any, family responsibilities [13]. However, this is far from the norm on college campuses and thus these teaching methods may not reach all students effectively. A recent study showed that these alternate teaching methods tended to more effective. The

Speed learning methodology being suggested is better suited for college students because it acknowledges these other demands on their time. With this in mind, speed learning methodologies aim to make the most out of the time students spend in the classroom. Figure 1, used from Laws et al. [25] show test results before instruction after traditional and speed learning (called "new methods" in this graphic) instruction. This effectively illustrates that speed learning greatly increased understanding of course material in within the same amount of time.

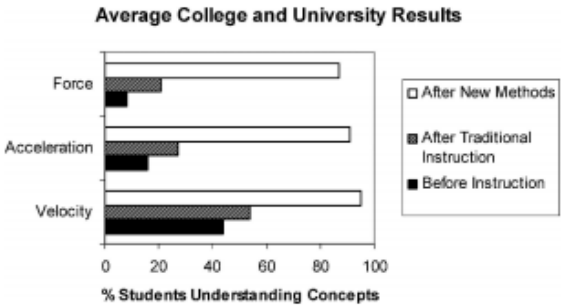

Fig.1. Test results before instruction and after traditional and speed learning Laws et al. [25].

C. Role of repetition in learning

Repetition plays a crucial role in students' learning. A study from Ohio State University looked at the use of repetition to increase understanding. This paper is particularly relevant to speed learning methodology because it focuses on comprehension rather than simply memory. As stated in this publication, "This is not to suggest that memory is unimportant, but rather that comprehension, associations, elaborations, and inferences are more important than verbatim memory… [19]. The study concluded that increased repetition increased understanding. This is a foundational idea of the speed learning methodology; by teaching material, asking students to develop questions from the material, study the questions and take and correct a quiz, the students are exposed to the material multiple times. Research suggests this is effective because with every repeat, students are able to add more information to their current understanding of a topic [20]. However, repetition alone is not enough. Content needs to be approached in different ways for students to gain the most understanding. Learning may be thought of as a two-step process of reception of information and processing the information [21]. Student's preferences in how reception and processing of information is done account for learning style differences. Speed learning acknowledges the role learning style plays in understanding material; by changing the way material is approached, speed learning effectively communicates ideas with students with varied learning styles. This strengthens the value of repetition in speed learning.

D. Value of partner learning

Speed learning techniques utilize partner learning as a way to improve understanding, improve memory of important concepts, recognize personal strengths and weaknesses, and assess the understanding of all students, including those with learning disabilities, in the same environment. Speed learning reaps the benefits of partner learning by encouraging students to work in groups throughout the process of creating, answering and grading questions. This allows students to learn from each other's understanding of a concept [22]. Teaching others has been shown to improve the teacher's understanding of the topic. By allowing students the opportunity to be in the "teacher" role, speed learning methodology helps students gain better understanding of the topic. Speed learning also helps students determine what topics they have a firm understanding of, and what topics they need to focus on more. Partners can help each other identify key topics and areas to focus understanding [23]. A final aspect that makes speed learning valuable in the classroom is that students with disabilities feel comfortable participating in in-class partner quizzes that were they individual, the student would typically take in a special testing area with extra resources. However, partner learning helps all students feel comfortable working on assessments in the same environment. By creating by a more inclusive classroom all students feel equally engaged in learning [24]. This leads to a universal theme throughout all the benefits of partner learning; increased confidence. This includes individuals being more confident in their understanding of material and more confident sharing answers in a group as opposed to offering ideas as an individual. This fruit of partner learning is a valuable one.

While many instructors hesitate to incorporate group work into their classroom; however the publication, "Group Versus Individual Performance: Are 1+N Heads Better Than One?" discusses some of the challenges of group work [22]; speed learning, while still susceptible to these challenges, provides a strategies for making group work effective and beneficial for all involved. This article identifies "problem-minded" groups (compared to "solution-minded") to be more productive. In speed learning strategies, groups are encouraged to question its current approach or to consider other aspects of the problem [22]. This leads to more constructive use of time and in turn, better learning.

E. Application of psychological theories to improve student engagement and learning

In order to perform well students must have a drive, need or intrinsic motivation [9]. Several studies have been conducted to understand the intrinsic motivation and how it is impacted to external factors such as reward, punishment, verbal reinforcement or positive feedback. Motivation can also be described as an inner power that compels an individual to reach a goal [11]. There are not only many levels of motivation there are also different intentions behind this motivation. Hence motivation is a complex construct. However, motivation plays a crucial role in student success. Researchers from the University of Chicago defined three characteristics of classroom structure that foster motivation: tasks, recognition and

authority [27]. Students' perceptions of tasks influence how they approach learning and use available time. When students perceive reason for engaging in an activity they will be motivated to develop and understanding of the content. Recognition, which will be addressed in the following section, considers standards, criteria and methods as well as frequency of evaluation and is greatly intertwined with students' perception of the evaluation methods. And finally, sharing (some) authority with students by providing options or offering choices also plays a role in motivation. As will become evident, speed learning builds off these core ideas of motivation.

Engagement is the process of acting upon a drive to achieve a goal or accomplish a task. So in essence motivation is required for engagement [11]. Several studies have identified lack of engagement to be directly linked to the students' boredom, disconnection, low academic performance and high dropout rates [12]. Similarly, engagement plays a key role in students drive to accomplish tasks. This shows the importance of engagement. However student engagement is a multifaceted construct [10] and thus defining how to motivate students poses a very challenging and complex aspect of education. Student engagement can be defined by five attributes: level of academic challenge, active and collaborative learning, student-faculty interaction, enriching educational experiences and supportive campus environment [26]. Many of these dimensions empathize the importance of having students' active participation in learning to reach encourage engagement. Speed learning methodology is designed in a way that is equal to or exceeds traditional lecture methodology in all of these aspects, and thus has been found to improve student engagement [26].

F. External reward to increase motivation and verbal reinforcement and positive feedback

There is mixed opinion on the effect of external rewards on intrinsic motivation. Some studies report a positive effect on the intrinsic motivation while others report a negative effect of external rewards [7, 8]. When this course was taught in Fall of 2014 the students were surveyed to study their attitude towards rewards and they were asked to make suggestions for possible rewards. Most students verbally or in the survey conveyed that a small reward such as a candy would suffice to motivate them while others suggested that a reward such as extra credit points would be preferred.

III. METHOD

The effectiveness of various active learning strategies were evaluated during the development of the Speed Learning methodology. A key-word search revealed that much of research in the area of active learning focuses on student engagement, participation or understanding. Speed Learning differs in that effectiveness of the methodology is evaluated on the basis of understanding in a given period of time. As was discussed previously in the introduction, time is a major constraint for college students. Thus we focused on ways to maximize the effectiveness of class time to decrease the amount of time students require outside instruction to comprehend concepts.

A. Class set up

The speed learning study was implemented in two classes. one was a upper level computer science course titled " Database Management Systems" and the other was a mid level computer information systems course titled "Database Concepts." The same textbook was used in both the classes but the depth of material covered was much more in the computer science course compared to the computer information systems course. The lecture was twice a week (Monday, Wednesday for one class and Tuesday, Thursday for the other class) for both the courses. The study was conducted for three consecutive weeks in each of the classes. The traditional lecture including some active learning activities were schedule for the first meeting time in each of the two classes and the second half of the second meeting time was used to implement the study.

To maximize learning in a short period of time a mechanism called speed learning was devised for the students to self-learn and self-evaluate their learning. This speed learning mechanism is a four-step process that can be initiated after the instructor has delivered the subject material to the students. This delivery can be in the form of a traditional lecture or any other form of active teaching. The process is outlined below.

Phase 1 - Creation - The instructor will supervise the class and instruct the students to complete phase 1 in 10 minutes: Students are asked to form pairs or groups depending on the size of the class. Each pair/group works together to create 3 questions along with answers per pair/group in a shared google doc that is created and shared by the instructor. The questions created can be either multiple choice or short answer questions depending on the subject matter covered in class. If the subject is analytical or problem based then create the short answer questions and if the subject matter is concept based then create multiple-choice questions. The purpose for creating a shared google doc is so that the students can see each other's questions and answers.

The rules for the creation of the questions are - i) No question should be repeated ii) Questions have to be related to the subject covered in class iii) The students can use the web, textbook, or any knowledge learned from the instructor's lecture iv) The instructor will go over the questions and mark any questions that are incorrect or too easy to be recreated.

During this phase the instructor will monitor the questions created by the students and highlight any incorrect, repeated or too easy questions and instruct the students to recreate the highlighted questions.

Phase 2 - Learning - This is the learning phase that is 15 minutes long: After the questions have been created, the instructor will instruct the students to study the questions and answers created during phase 1. The students are still working in pairs and are allowed to

discuss and talk about these questions while studying them.

Phase 3 - Quiz - This is the quiz phase and will take between 5 to 10 minutes: During this phase the instructor will instruct the students to close their computers or mobile devices and prepare to answer the quiz. The instructor will quiz the students using only the questions created by the students. The students will answer the quiz in pairs and will be allowed to discuss the questions amongst themselves. If the class size is smaller than 10 students then consider not pairing the students, instead the students will individually complete the quiz.

Phase 4 - Evaluation - This phase involves students grading their neighbors quiz. It's up to the instructor's discretion whether to count this grade towards the course or not. The instructor in this paper has counted the grade in the large class and not counted the grade towards the class in the smaller class.

Pairing students facilitates and enhances learning: The students working in pairs have an opportunity to discuss and talk about the questions during the creation, learning and quiz phases. This enhances learning and increases retention of knowledge. In addition it releases the students of the stress they would normally feel during an exam.

B. Subjects

The subjects were students from two different database classes. One was a 4000 level class for the computer science students while the other was a 3000 level course for the computer information systems students. The combined students were 30 but only 20 of them completed the survey.

IV. Data Analysis

In our study, multiple classes were facilitated using Speed Learning techniques and evaluated the results. As part of our analysis, we asked students to rate the effectiveness of various methodologies that had been trialed in the classroom throughout the semester. In addition, students were asked question about their learning with partners, opinion on possible changes to current course structure and open-ended suggestions on class structure.

A. Preferred learning method

To evaluate the learning methodologies, students were asked to rate each from 1-5 where 1 is "not effective", 2 is "somewhat effective", 3 is "average effective", 4 is "moderately effective" and 5 is "highly effective". The methodologies being evaluated were PowerPoint lectures, end of class exercises, quiz bowl with partner and writing questions for quiz bowl. PowerPoint lectures serve as the control in this study; in this traditional methodology, students take a passive role in their learning while the instructor presents materials. End of class exercises consists of open-ended problem solving questions pertaining to the material covered in that day's lecture. Quiz bowl is an activity in which students study material with a partner, take a quiz, also with a partner and then together correct their quiz. The final category, adds one more step to quiz bowl by allowing groups of students to create their own questions. Figure 2 shows the degree to which students reported learning with each methodology. The in class exercises and PowerPoint Presentation graphs formed a pretty standard bell curve (with slight leniency tendency). In comparison, Quiz bowl with a partner and creating/writing questions for quiz bowl have

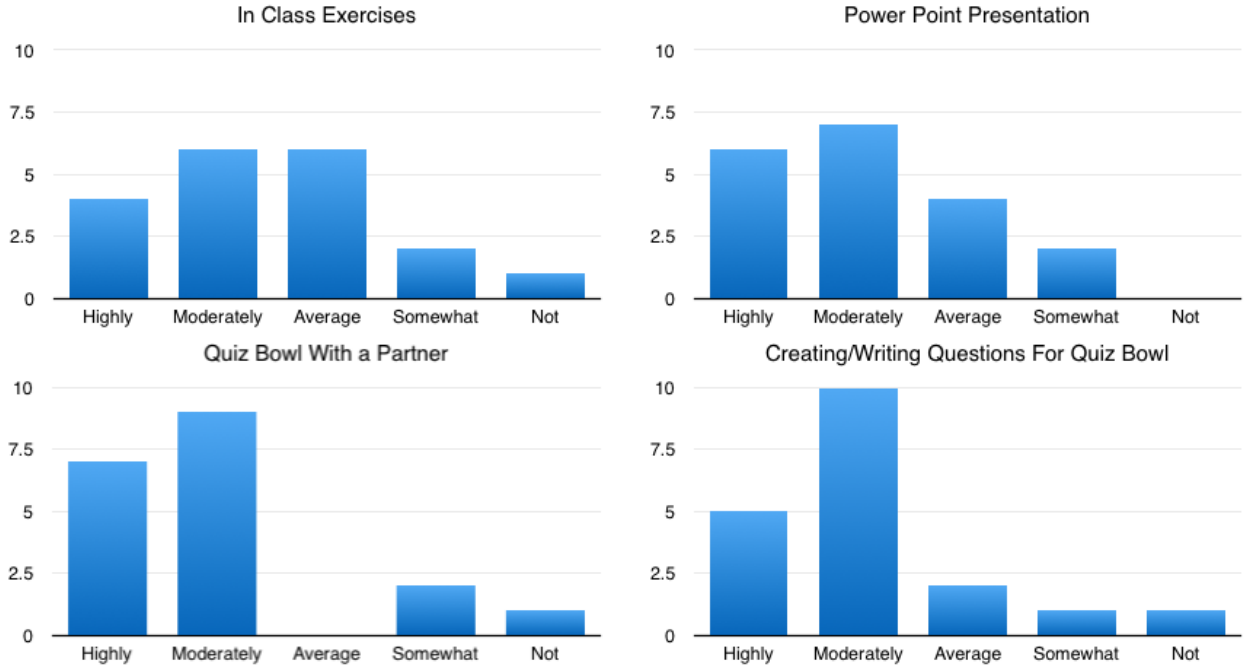

Fig.2. Student-reported preferences on learning mechanism

a strong left skew. This suggests that, compared to the in class exercises and PowerPoint Presentations, students generally have report higher amounts of learning when the class is structured around an active learning methodology. When each numeric rating is multiplied by the number of student responses and averaged with all ratings for a particular methodology, we can get a overall rating for each methodology. (For example in class exercises got 4 - 5's, 6 - 4's, 6 - 3's, 2 -2's and 1 - 1 rating. We would multiply 4*5, 6*4, 6*3, 2*2 and 1*1 and average this number). This comprehensive rating average shows us that Participating in quiz bowl was the highest rated methodology, followed by writing questions for quiz bowl, power point and finally in class exercises. The preference for group learning exhibited here was also evident from the next set of questions.

B. Partner learning

The preference for group work, which was evident in student's ratings, was re-emphasized in in the next question that asked students "To what extent did you learn from your classmates?" Results are shown in figure 3. The responses ranged from 5 (high amount) to 1 (not at all). 95% of students reported to learn from their classmates to some degree. Of those 84.2% said they learned a moderate to high amount from their peers (orange and yellow segments in figure 3). In an optional comment section, one student commented, "I learned more because we were able to talk through our questions and thought processes." This sentiment was expressed by other students and aligns with the data from the survey. From this we conclude that partner learning is a crucial aspect of the speed learning methodology.

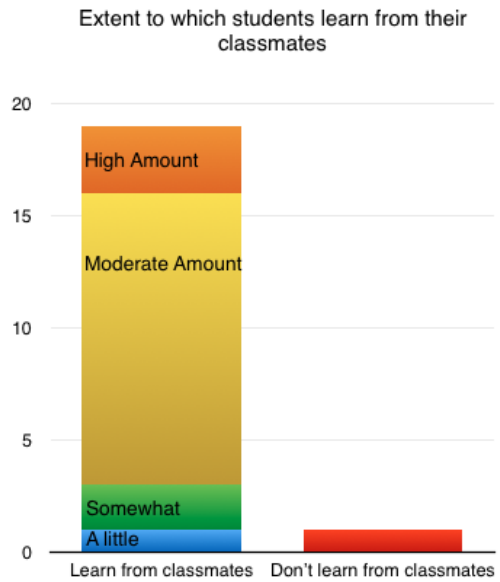

Fig.3. Extent to which student learn from classmates.

C. Evaluation as a compoment of grade

A notable difference between the two groups was seen in regards to inclusion of the quiz score in course grade. Overall, ratings and support was higher in the group in which quiz grades were not recorded as compared to the group in which quizzes were factored into the final grade. Students who were not graded on the quiz all reported the speed learning moderately or highly effective. Additionally, the majority of these students reported that they learned best when active learning was incorporated into lecture time. In comparison, students who were graded on the activity were more negative in their perception of the usefulness and rated active learning activities lower in effectively. Because of the activities' association with grade, student's short answer survey responses used verbs like "cram" or "memorize". This suggests that students were focusing on the effect the assessment would have on their grade rather than considering the activity as an opportunity for learning which opposes the goal of the activity. Based on this, it is suggested that associating this activity with a grade be done tentatively and after careful consideration.

D. Future suggestions

When students were asked to select if they would prefer more active learning with less lecture, the same amount of active learning incorporated with lectures, more lectures with less active learning, video lectures where you watch the video before you come to class and perform activities in class, or lecture only, 90 percent responded that they preferred some form of active learning. Of all the active learning activities, students preferred writing their own questions rather than responding to questions prepared by the instructor. Figure 4 breaks down student's suggestions for future classes. The options were [1] video lectures in which lecture would take place entirely online and class time would be devoted to speed learning activities [2] More SL (Speed Learning) retains the lecture component of the class, but integrate more opportunity for active learning, [3] Same Structure, as it implies, suggests no changes to current methodology, [4] Less SL suggest more focus on lecture while still retaining some speed learning strategies, and [5] Only Lecture suggests using only traditional teaching methodologies. While there is a spectrum of opinions, an important trend to notice in this graphic is it's somewhat symmetrical appearance. This indicates that either extreme; completely lecture based or completely active

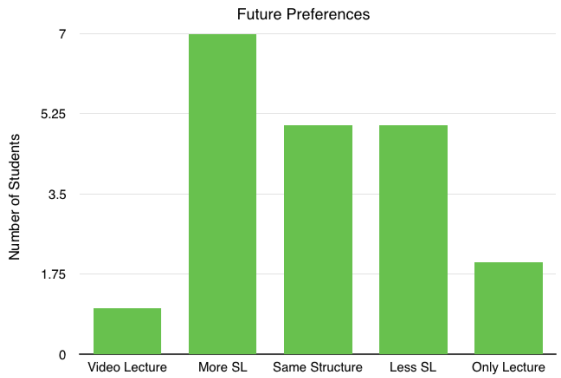

Fig.4. Student's recommendations for future courses.

learning based structure is ineffective for most students. 85% of students surveyed fall into the middle three sections, which suggests a mix of active learning and lecture is the most effective methodology based on student responses. Focusing in only on these middle three columns, we can also see a slight skew to the left, suggesting that students prefer more speed learning activities.

V. Discussion

After designing material, conducting classes using the Speed Learning methodology and reviewing data of the methodology, a few things stood out. Faculty found this method easy to incorporate into course work, as very little additional preparation was needed. In addition, having students preparing questions and answers provided a way to gage of student understanding. In addition, we saw majority of students' responding positively in regards to their level of learning from fellow students. Most students also recommended the use of active learning strategies, and in particular Speed Learning methodologies, for future classes.

One result that was unexpected was the impact grading activities had on student satisfaction. To better understand this finding, we turned to research focused on the role of assessment in developing a learning culture. This research reinforced the use of frequent assessments to evaluate student learning however, the de-motivational effects associated with assessments was also cautioned of as a strong concern [36]. In addition, grading student understanding during a learning phase can negatively impact student learning and engagement as the focus moves from engagement with topic to focus on the assessment [37]. However, this literature also stressed the importance of assessments to capture learning goals, more closely attaching assessments to ongoing instruction and critical application of knowledge to real world contexts [36]. These three elements of assessments are addressed in the proposed Speed Learning methodology. The instructor has the discretion to select questions that address core goals of the course, assessments are correlated with instructional material and students are encouraged to create questions that have strong relevance to their interests or those of their classmates or future professions. While these findings uncovered a few unanswered questions, they also reinforce the core design choices of the Speed Learning methodology.

Moving forward, this question of the de-motivational effect of grading assessments versus the need to document and assess learning throughout the course will continue to counterpoise each other. In the end, it is hoped that a balance between motivating student learning and grading assessment will be met. Another detail that was noted was the increased engagement overall seen in the smaller class. This posed the question of the effect of class size on engagement and how the number of students enrolled affects the effectiveness of this methodology. This is a question that will require further investigation to fully understand, however, much research suggests that active learning such as Speed Learning is a key component to successfully engaging students in learning, irrespective of course enrollment [38, 39].

VI. Conclusion

It is critical that faculty self reflect on their teaching styles to continually set higher goals for improving teaching and learning. Faculty should continually evaluate their teaching style and explore other pedagogies to enhance student learning. According to Penner (1984) capturing and maintaining the student attention is a skill and should be worked on. Based on the findings in the presented data, it is evident that speed learning holds an enormous potential to improve student engagement and efficiency of mastery through the use of repetition and partner collaborations. The aspect of partner collaborations stood out as a key aspect in our research as well the research of others [22, 23, 24]. Because of this team-based structure, students with learning disabilities get additional support on assessments without feeling isolated from classmates and all students reap the benefits of an elevated confidence that comes partner-based collaborations. Additionally, students accepted this methodology and most would like to see active learning continue in the classroom. Future research (currently in progress) is focused on how class size affects the viability of speed learning methodologies as well as variations between genders specifically in science and engineering classes. These situations pose unique questions on the effectiveness of speed learning. Fostering an environment where all students can achieve is the goal of all educators. Through research such as this, it's our hope that we can continue to learn how to best engage students and guide them in actively pursuing learning.

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Arshia A. Khan is an Associate Professor at the University of Minnesota Duluth. She earned a Bachelor of Engineering in Computer-Engineering, M.S. in Computer Science and Ph.D in Information Technology. Dr. Khan is extremely passionate about improving the quality of health care by using new and innovative technology.

Her research research interests are interdisciplinary and span the bioinformatics, biomedical informatics, clinical/health informatics, and consumer health informatics. Her focus is mostly on biomedical health informatics (public, personal, and consumer). It is her desire to create innovative solutions to enhance the quality of care by augmenting the health of the populace and individuals. Over the past years her research has evolved into sensor based personalized medicine, wireless mobile population health management, mobile clinical decision support, and mobile data analytic support and analysis. Currently she is working on several projects that involve wireless solutions utilizing sensors for heart rate, blood pressure, body surface temperature, oxygen saturation, accelerometer, and pressure sensors to monitor and track various conditions

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