

Dysgu: A Mobile-Based Adaptive System to Redesign Out-of-class Activities

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Abstract— This research to practice work in progress paper will present a mobile learning environment, called Dysgu (‘learning’ in Welsh), which will provide enhanced learning experience outside the classroom. The Dysgu environment provides students with interactive and motivating out-of-class activities and accommodates personalization and adaptation to satisfy students’ specific needs. This system employs a novel approach by incorporating engaging factors, such as interactive activities, adaptive mobile technology, social networking, and gamification to overcome the shortcoming of traditional out-of-class activities. Dysgu allows personalization to support student’s study needs and adapts to student behaviors, class dynamics, and difficulty of the out-of-class activity. By having a mobile interactive learning environment, faculty will be able to facilitate learning even after the students leave the classroom and intervene early when students fall behind their peers.

Keywords— *Active learning, mobile learning, adaptive learning.*

I. INTRODUCTION

Learning during undergraduate years occurs not only as student engagement in class, but also during out-of-class activities. Out-of-class activities are defined as “activities in which students engage during the undergraduate study that are either directly or indirectly related to their learning and performance and occur behind the formal classroom, studio or laboratory setting” [1]. Out-of-class activities expose students to real world problems, such as time management, independent learning and self-efficacy. Student’s out-of-class engagement has many positive influences, such as improved learning and personal development [2], persistence to graduation [3], social competence [4], etc. Learning well in the classroom does not always translate into doing well outside the classroom [5]. Therefore, only providing in-class activities may be insufficient in preparing students for real world situations. Unfortunately, the type of out-of-class activities faculty generally use, like, assignments, homework and projects, have not always proven to be effective [6]. Additionally, these types of activities generally are not appealing to the current generation of students who feel the pull of instant gratification much more intensely.

Traditional out-of-class activities are static in nature, big in size, students need longer amount of time to finish, and faculty needs even longer amount of time to grade them and provide feedback. As a result, faculty generally only assign a handful of these activities during the span of the semester, minimizing the assignment’s effectiveness. Furthermore, this approach often does not engage students consistently with the course content.

Moreover, the time limit enforced to complete such activities typically ranges over a few weeks. Undergraduate students are known to procrastinate and often only start working on solving these activities hours before the deadline, which may result in sub-standard and incorrect submissions. Traditional out-of-class activities often use a “one size fits all” approach, which might not be motivating and engaging enough for a wide range of students. Rather, we need personalization and choice of adaptation to satisfy students’ specific needs so that optimal learning experience can be achieved [6].

In order to address the abovementioned issues, this paper is presenting an innovative redesign of out-of-class activities and the administration of those activities by utilizing a mobile software system, named Dysgu. The redesigned activities will be smaller in scope than traditional out-of-class activities, which will allow instructional scaffolding [7]-[8]. These activities will be more frequent and interactive in nature. In the proposed model, the problem of procrastination will be addressed in several ways. Since these activities are interactive in nature and use instructional scaffolding, they may inspire students to be engaged sooner [9]-[10], and since the activities are appearing frequently, students may try to complete them faster so that they can be ready for the next one. By setting higher expectations for these types of activities (in terms of competition, problems with higher degree of difficulty, chance of gaining benefits other than scores only, etc.) than traditional activities, we hope to promote a self-fulfilling prophecy as shown in [11]. As these activities are electronically accessed and administered, students will be allowed to set up their own schedule in dysgu to make it more adaptive to their needs, i.e. activities will be available online for individual students according to their advertised schedule. This form of personalization will allow students to manage their time more effectively and to engage more in these activities. Next, we propose to use mobile technology-based learning environment to deliver and administer such activities to students as it is the most prominent platform of computing in recent years and students are active users of this technology. This will also allow faculty to administer more activities during the semester as it automates delivery, time keeping and grading. Additionally, this opens up the opportunity to incorporate different adaptive features into the out-of-class activities to make them more appealing to students. Faculty will be able to monitor student progress which will allow for early intervention, and it is proven [12] that early intervention and prompt feedback has positive effect on students’ success. Finally, Dysgu will use social networking and gamification components to encourage student

collaboration and participation. Having such a social interactive learning environment in their mobile devices should allow students to seamlessly learn anytime, anywhere and at their own pace.

II. BACKGROUND

In computer science’s cognitive and constructivist learning domain, knowledge acquisition and the development of intellectual skills are essential components [13]-[14]. This includes the recall or recognition of facts, building knowledge by doing, distinguishing patterns, hands on learning, guiding learning concepts for the development of intellectual abilities etc. In such domain, active learning is an educational approach where learners become engaged in interactive learning activities. Studies [15]-[16] reveal strong empirical evidence that active involvement in the learning process is crucially important for the mastery of skills, such as critical thinking and problem-solving, and for contributing to the learner’s likelihood of persistence to program completion. However, active learning is often not utilized for out-of-class activities and traditional unsupervised activities are used mostly to keep students engaged in the content after the class. There are a few studies [17]-[18] that presented active learning approaches for out of class activities. Although, these studies do not utilize technology, they showed that non-traditional activities for out of class work do improve student learning and engagement. Additionally, many CS courses are skill generating; meaning students are expected to gather skills on specific process with different degree of difficulties. Therefore, we need ways to make students continue to work on activities after they leave the classroom to hone their skills.

Although there is a plethora of research designed to improve student learning and engagement in the classroom, there is a dearth of research on out-of-class learning and student engagement, let alone which incorporates mobile technology and/or social networking primitives. There has been a lot of research done on pedagogical agents and learning companions [19]. However, Dysgu is different than those systems in the sense that it does not have a simulated human interface and associated AI needed for such systems. We envision Dysgu as a system which supports blended learning and where participation is part compulsory-part interest driven, is learner-centric and where learning is being evaluated continuously. By having a guided learning environment and by using mobile technology, we believe that students can be steered more effectively once they leave the classroom and expect students to maintain more focus on the course content and ultimately to learn and retain information better. There are a couple of works [20]-[23] which are similar to the idea of Dysgu. However, the major differences between Dysgu and the other systems are the type of interaction, question and assessment types, platform used, adaptability and personalization provided, delivery techniques, mode of interaction, type of activity and nature of engagement. Additionally, There are a few other pieces of work [24]-[25] and some commercial systems such as piazza [26], prulu [27], quizlet [28] and socrative [1] that are similar in nature to the proposed work, however, they are different in

scope, pedagogical intentions, technique used or intended audience.

III. DESIGN AND DEVELOPMENT OF DYSGU

Dysgu is being developed as a cloud-based software system with faculty computer running an offline server component, the student mobile devices running an online client component and the cloud services are used as active repositories for both the server and the client component. As shown in Fig. 1, the cloud holds a repository with information about all classes. For each individual class, a collection of repositories is also maintained in the cloud, which are necessary for the day-to-day operation of the software. Each of these repositories can be updated by both server or clients and changes can propagate through asynchronous access. The cloud services are completely hidden from both faculty and students and managed transparently by the system. There are no costs associated with the cloud services, as Dysgu utilizes free services offered by the cloud providers.

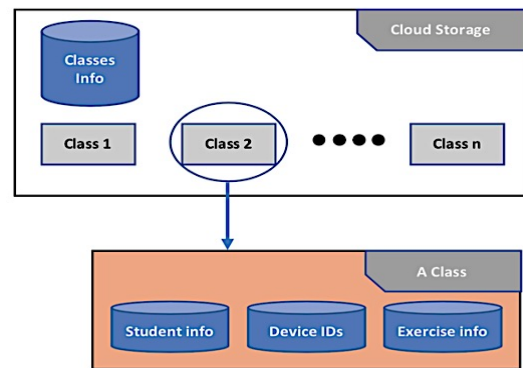


Fig. 1. Cloud services structure for dysgu.

The faculty run the server component to create a class, add students to that class, create interactive activities, initiate problem-solving sessions, grade student submissions, monitor student progress and class status etc. However, to achieve all of these, the faculty does not have to run the server-side component 24/7. Any changes made by the faculty (and also by clients) are updated in the cloud repositories and the server-side component updates itself from those data, each time the faculty runs the software. On each student device, a client application (app) allows students to login to the class, work on a problem-solving session, monitor their progress etc. Similar to the server, the client is also developed to run asynchronously with the server. Therefore, the cloud repositories are used in the background to provide transparent and seamless operation.

A. Adaptability and Personalization

Dysgu is being developed in a way to support several adaptations for different class situations and personalization to address student needs. The client app allows students to set their own schedule to participate in a set of activities. This enables students to change and update their study time to match their class, work and other schedules, and instruct the app when to remind them of pending tasks and how many times to remind them and what activities to trigger/disable (for instance twitter, snapchat etc.) during the study time. Depending on the students

schedule, the app will remind students about pending activities and their deadlines. Based on the privacy settings and student's information, the app will recognize geo-physical location and will alert the students accordingly. For instance, if the app recognizes that the student is in a bar while in a scheduled study time, it will remind the student frequently about incomplete work; however, it might be silent when the student is at home or work. Depending on student's performance, Dysgu can adapt on showing the type of notifications. For instance, if the student is not doing well, notifications can be more encouraging and directs students to useful links and shows them how to ask for help on-campus. Each student in the system acts as an anonymous entity-students will not be able to identify each other in the system. To provide anonymity, each student will create an avatar during the first login to the system. Using these avatars, Dysgu can share the progress of the class and other statistical information about activities while still following federal and state privacy regulations. However, individual grade sharing is completely optional for students. Independent of individual student scores, overall aggregate class performance indicators will be provided for every activity for students to get a better idea of how the class is doing. Depending on factors, such as, specific grades assigned to an activity, how many levels of the activity completed, how fast and successfully completing activities etc., students will gain reward points (Section IV.A). Avatars can use their accumulated reward points as currency to extend the time to complete a specific activity, or buy hints to solve harder problems. Since students now-a-days heavily utilize messaging, notification and other trendy aspects of their mobile devices in their day-to-day life, the adoption of dysgu will seem natural to them and will hopefully keep them synchronized with their busy life and the out-of-class activities.

B. Interactive Exercise

Interactive activities are visual representation of a multi-step problem, where students have to devise the answer following a set of steps guided by a particular algorithm or process [30]. In each step, students can make key choices that will impact their next step of interaction. Students can go back and forth through these steps and see the impact of their choices. This will allow them to see in real-time the effect of different selection on the result. Dysgu extends this idea even further. To accommodate student's asynchronous life style and schedule, interactive activities in Dysgu can be paused and resumed at any time before the due date. This will allow students to work on a problem on their own terms and pace. Additionally, activities in a learning path (Section IV.B) can adapt to student interaction and performance to encourage or motivate or challenge a student. Most of these types of activities will be auto-graded by the system and will give instant feedback to student. We can also start such problem bottom up or at the middle to give students different perspective on the problem and assess their problem-solving skills. These types of activities fall under knowledge acquisition, comprehension and application levels of Bloom's taxonomy [31] and can provide faculty feedback on students' mastery of specific course skills. For analytical questions, we will use analysis and synthesis levels of Bloom's taxonomy to understand how well students are engaged into the course content and how well they can compile information together and can make inferences from the knowledge learned in the course.

Analytical activities can be a reading comprehension with a content, whose underlying basis is covered in the class and students will be asked to synthesize and evaluate the reading material. These types of activities will not be auto-graded and will allow faculty to read the answer of the students before giving a grade and associated points. This will allow for a deep level of learning for students and for the faculty to oversee such activities.

C. Gamifications and Social Networking

There have been a lot of motivation-related educational approaches researched, along with various tools, and ways have been proposed [32] to increase student engagement. In the past couple of years, the use of game in non-game context has been used for different purposes including educational [33]. Games are demonstrated to make learning more effective for students [34] by engaging the cognitive and behavioral domains. The underlying architecture of games (active learning, feedback, individualization, motivation, scaffolding etc.) imitates the key components of learning. Experience based learning tools, like gaming, provide ways to develop skill-sets, attitude and improve motivation and engagement [35]. High cost and difficulty of developing full-fledged games [36] and domain-centric aspects of educational games lead to infrequent and less popular adoption in the education. However, instead of developing full-fledged educational games, Dysgu combines interactive activities with more productive and efficient gamification components [33]-[34], such as points, leaderboard, badges, which will lead to greater student engagement and a domain-independent way of incorporating gaming in education. It is recognized that gamification alone may not motivate both genders equally; therefore, as uncovered in different studies [37]-[38], by having self-directedness in engaging with the interactive activities through Dysgu, female students may get higher motivation from the utility of such activities. Additionally, by the progressive assessment nature of Dysgu with its instant and frequent feedback delivering, female students may become more motivated towards such activities.

In recent years, the traditional model of the transfer of knowledge from teacher to learner has shifted towards an approach where learners play a more active role in their own learning. In such environment, learning has become more of a reciprocal experience for both student and teacher according to the social learning theory [1]. By creating a social aspect and by providing constant delivery through pervasive mobile devices, Dysgu will allow us to incorporate such success factors to provide a richer and more effective learning experience. Having a social networking component will promote students' self-fulfilling prophecy [11] as they compare them with their peers in the class. In Dysgu, each student can use the social interface to monitor progress, collaborate with others and participate in discussions. Different social networking primitives are included in the social interface. For instance, one avatar can "like" or "thumb-up" another avatar's performance, postings or discussion items. Each avatar will gain influence points based on postings, discussions, number of "likes" etc.

IV. COURSE MODULE

A. Scores and Points

To provide previously mentioned features, Dysgu uses two separate numbering schemes, scores and points. Scores are a specific number (can only be positive) assigned to an activity. If a student solves an activity, a corresponding score will be assigned to that student depending on the rubric. On the other hand, points (can be negative) are assigned as rewards or side-effects of activities in the system. For instance, finishing an activity first in class or finishing an activity in one try will give students positive points; whereas unfinished activities will produce negative points. Scores are utilized to calculate student's grade, whereas, points are used as currency in the system. Students can use accumulated points as currency to extend the time to complete a specific activity or buy hints to solve harder problems. Students can also acquire badges depending on the amount and type of points. Badges can be as simple as "the first one to finish an activity" to as complex as "number of successful completion of activities vs. number of tries". Depending on badges, avatar will get specific privilege, such as preview of next activity or chance of earning more points for specific activity, etc.

In order to enhance student motivation and competency, the app will also provide information related to the peers in their class such as the number of peers already completed an activity, the number of peers progressing toward stage t of an activity etc. Moreover, the app will present a glimpse of progress for a student in comparison to the rest of the class. It shows the student score, where the student stands compared to the class, how many points the student has and what are the badges the student earned. For each of the activities, the students can see how much the student has completed, how much the class has completed, how many points this activity has and how long the student has to complete this activity. Students will also be able to review completed activities and compare their performance with the rest of the class.

B. Module design

Each course module within Dysgu contains several problem-sets from the core areas of the course that will assess different learning outcomes. Each set has multiple activities linked together with different degree of difficulty (Levels such as A_i , B_j , C_k in Fig. 2) to address variability in learning. As shown in Fig. 2, faculty will match a particular skill level (B_i) as the learning outcome assigned for that specific activity. In that skill level, the learning path will comprise multiple activities with different intensity.

For a specific learning outcome, the faculty will assign the associated problem level (Level B in Fig. 2) and a maximum score possible to attain at that level. Problems solved at that level and scores earned at the level will be used to assess students academically in the course. Activities in lower levels (A_i) than the assessed level will be used for practice and will not be graded, however students will gain reward points for completing those activities. Similarly, activities in higher level

(C_k) will incur higher degree of difficulty and while students can gain points from them, they will not be used toward their course grade calculation. This will allow students the freedom to try-and-fail without penalizing their course grades. Research [40] has found that, in such instances, students actually do better in solving harder problems and utilize higher order thinking.

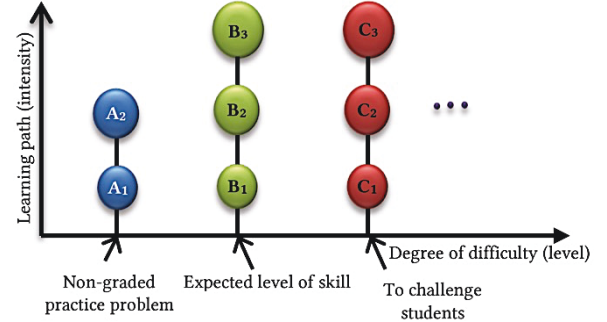


Fig. 2. Learning path for activities in a course module.

In order to motivate students to pursue challenging activities, Dysgu will allow redoing of the higher-level activity with some restrictions. Restrictions could be imposed by reducing allowed time and reward points for that activity or by enforcing more practice with a non-graded activity before students are allowed to re-take that activity. As mentioned earlier, students can use their earned points to buy extra time or hints in such situations. Utilizing instructional scaffolding built into the modules promote deeper learning in students and will also allow faculty to introduce activities with high order thinking. Activities will require rubrics that will not only grade correct answers but also partial answers (for activities in level C_k) to gauge student's problem-solving skills and thinking models. The following set of formulas will guide the proposed score and point calculations.

$$\text{Levels} = L_C > L_B > L_A$$

$$\text{Total Score} = \sum_{j=1}^n \text{score}(B_j)$$

$$\text{Total Points} = \sum_{i=1}^n L_i * \text{points}(\sum_{j=1}^m \text{Intensity}_j)$$

V. CONCLUSION AND FEATURE WORK

This work-in-progress paper presents Dysgu, a mobile and adaptive system to address the shortfall of traditional out-of-class activities and to satisfy the needs of the future generation of students with the help of instructional scaffolding, adaptation to student's needs and responsiveness through the use of pervasive platform. The paper presents the need for such a radically new type of learning environment, overall system design and software architecture of the *Dysgu*, description of interactive problems and design of course modules for this system.

Dysgu is currently under development and planned to be deployed in classes in Spring of 2019. Once tested and deployed in class, data will be collected not only to satisfy the evaluation plan, but also to assess the usability and effectiveness of the Dysgu system itself.

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