Out-of-class Activities: What Have We Been Doing and How We Can Change it for the Future

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***Abstract*— It is believed that if students are well engaged in the learning process within the classroom, they will continue the learning process independently outside the classroom. To facilitate such out-of-class learning, there is a plethora of traditional techniques with a variety of learning theoretical backgrounds. While out-of-class activities based on these techniques have shown to improve a student's overall quality of learning, traditional activities lack the supervision, instant feedback, and personalization that the current generation of students expects. With the rising cost of college tuition, many of today's students are working more hours outside of an educational setting and therefore need more supervision and encouragement than their predecessors. These factors make traditional out-of-class activities not effective to achieve the desired level of student learning and engagement outside the classroom. The faculty needs to rethink ways to redesign traditional out-of-class activities to make these activities more effective for this generation of students. This paper presents a review of the literature on and categorization of traditional out-of-class activities. The paper also discusses the results of a survey of what the faculty is doing to engage and continue student learning outside the classroom. Finally, the paper presents a new way of designing and delivering out-of-class activities that have the potential to increase student engagement with the help of instructional scaffolding, interactive activities, and personalization and adaptation.**

Keywords—Active learning, mobile learning, homework.

I. Introduction

In a face-to-face classroom setting, learning happens not only during the class but also after students leave the classroom. Such learning 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 are traditionally viewed as an unsupervised activity with a specific learning objective that students can do in their most convenient time. Out-of-class activities prepare students for real-life challenges, such as time management, independent learning, and self-efficacy. Such out-of-class activities have many benefits as found in previous researches [2] - [5]. It is also shown that [6] learning well in the classroom does not guaranty that students will also do well outside the classroom.

Recent studies [7] found that freshman students are not as prepared for college work as their predecessors. The lack of preparation is exacerbated when students do not reinforce what they learn in class by studying outside the classroom [7]. Another study [8] shows that this trend of not studying outside the classroom starts well before the students attend college. While most college advising guidelines [9] state that students should study at home around 2-3 hours per credit hour of class per week, students rarely follow this guideline [10]. Another recent trend shows students are working increasing hours on their job outside the classroom [10]-[11] Reasons contributing to this trend include rising tuition cost, living expenses, and other socio-cultural challenges [10]-[11]. Students spending less time studying outside of class and working more hours are the two critical issues that most institutions are currently facing. Therefore, it is crucial to investigate approaches that will ensure effective usage of the time that the students have for studying outside the classroom. Instead of focusing on the relationship between hours employed and academic performance (which is a complex research study on its own), we should investigate how students can best utilize the limited time that they allocate to conduct out-of-class activities and how we can provide such activities in a more active, personalized and structured way that facilitates greater engagement and improved student learning.

This paper, therefore, looks at what faculty are currently doing to keep students engaged with the course content outside the classroom, discusses the shortcomings of such approaches, and introduce a new way to conduct such activities to better utilize time, improve learning, and engage students more.

II. Background

Homework, or out-of-class activities are an integral part of traditional teaching. However, in recent years, such activities have been scrutinized [13] because of the lack of consideration for the individual learner's learning needs, such as; learning styles, situational factors, student's aspirations, class context, and motivation. Therefore, there is a need for developing learner-centric activities using pedagogical tools to facilitate student learning and engagement. Although online and distance learning attempt to provide some personalization, the lack of interaction between faculty and students in a purely online environment makes it difficult to engage students outside the classroom. Therefore, a blended approach where face-to-face teaching is supplemented with personalized and interactive out-of-class activities is an improved way to support student learning outside the classroom.

It is important to note that the focus of this paper is not on informal learning. The proposed out-of-class activity system (Section V) is used to assess student learning and maintain an

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unsupervised continuation of the learning process so that students are more engaged with the content between classes. Most of such activities are graded and are used to assess students academically, however, some activities may not be graded and are used solely for practice or skill development. Moreover, such out-of-class activities are utilizing digital technology. As studies [14] show, there is a significant benefit of students being instructed with digital learning technology away from the confines of the classroom. The technology available today allows this transition to be seamless as most students are able to connect to a device away from class. This constant connection also enables teachers to connect with students outside of class to solidify learning.

III. Types of Out-of-Class Activities

There are many different types of documented pedagogical practices for out-of-class activities that are currently being used. The review of the out-of-class activities has two objectives. The first objective is **to provide a synthesis of the current state of research on out-of-class activities**. This objective is attempted by focusing on the following research questions: *What type of out-of-class activity is being researched, what is the discipline of that research, what type of technology is being used for out-of-class activities, what is the education level of participating students in these activities, what is the learning domain and what is the goal of the research*. The second objective is **to investigate what is the current state of innovative or nontraditional ways of conducting out-of-class activities.** We focus on this issue by looking for an answer on these questions: *what new capability the approach is offering, is it using any new technology like mobile and such, what is the attitude and perception about out-of-class activity and how it is addressing improving student engagement and learning*. With these questions in mind, we ordered each of the literature found and listed them for classification.

A. Inclusion and Exclusion Straregy

This study examined any research that focused on out-of-class activities over the last ten years. To find these activities, we looked at research (in major digital libraries and archives) that are utilizing out-of-class activities. At first, we only looked into work performed in the Science, Technology, Engineering, and Mathematics (STEM) domain. However, as we found fewer researches on diversified approaches, we included K-12 and social sciences to expand the result. We selected publications if it was published in a peer-reviewed conference or journals and archived in major digital repositories (ACM, IEEE, Springer, ERIC, ProQuest, etc.). Additionally, the work has to address out-of-class activities directly (for student learning and engagement) and not as a by-product of other research. Non-English publications were also excluded. Collaborative or distributed learning domains and Learning Management Systems (LMS)-based out-of-class learning activities are also excluded as they are not within the scope of this research. The amount of research work addressing out-of-class activities in the STEM area was surprisingly small compared to the amount of research work performed for in-class learning and engagement. Additionally, the ratio of work related to this concept on the social sciences and in the K-12 area was more than STEM disciplines. However, we only consider college level out-of-class activities in our classification. Searches in the digital archives were made with compound Boolean expressions (for instance, “out-of-class activity” or “out of class activity”, etc.) to filter irrelevant publication (which has only one of these keywords). Eventually, 87 publications were selected and used to formulate the following classification.

B. Classification

In classifying these activities, we look into teaching styles, activity goals, technology used, learning outcomes, student level etc. Each of the following types of out-of-class activities has its own benefits and drawbacks that we discuss in further detail.

- **Traditional**: The traditional out-of-class activities can be writing or reading assignments, problem-solving activities, essays, and group work; where students work on one or more problems and submit their work before the deadline. Normally, students may have several of these activities during the semester and many of these activates are graded by faculty. Even though there was a lack of research with traditional out-of-class activities in the STEM area, significant amount of research has been conducted on the K-12 and the social science area. Although these types of out-of-class activities engage students to a certain degree, a widely critiqued issue is that it allows students to procrastinate and do not provide timely feedback.
- **Blended**: These types of activities [13] are extended versions of the traditional activities where part of the activity is done either through specialized hardware (Raspberry Pi [14]), software (games [15] or visualization [17]), new technology (like AR and VR [17]), or by using online tools (for instance YouTube [18]). Although blending traditional activities with technology makes it more palatable for the current generation of students, proper design and delivery of activity is challenging yet crucial for the success of this approach.
- **Flipped classroom**: Flipped classroom attempts to keep students busy with school work at home and engage them in the classroom with discussions and activities related to what they did outside the classroom. For example, students would be assigned a section of reading and a PowerPoint presentation of slides to study before their next class period. During class time, students are quizzed on the reading. In recent years, the concept of flipped classes [19] became popular for its perceived benefits in student learning and engagement [20]. However, there are concerns [20] related to this new pedagogy, that it might not work for all types of students, especially those who come from a socially disadvantaged background.
- **Online/Distance learning:** Online/Distance learning consists of learning remotely without being in a normal face-to-face setting in the classroom. Forums, discussion

boards, or similar means are frequently used to have interaction among the class participants.

- **Pedagogical agents/learning companion**: Animated characters are used in a digital environment to help students study at home. These characters are created to interact with the student and can be used as a coach, or for help when needed. There has been a lot of research done on pedagogical agents and learning companions [21]. However, it is domain specific and developing one is difficult because of the need to develop a simulated human interface and associated AI.
- **Virtual/remote labs**: Virtual/remote labs [21]-[22] are online interactive spaces, where students can perform different experiments in a simulated lab. Some of these labs can be also cyber physical systems, where the instruments are located geographically in a different location than the student. Such labs have the potential for students to do lab works anytime and from anywhere. However, not all courses need labs and not all experiments can be done remotely, and therefore its applicability is limited to domain-specific courses.
- **Informal learning**: Informal learning activities are limited to field trips, museum visits, etc. where students are exposed to real world scenarios, and the expectation is that students will learn from the experience of that exposure. Most times, these activities are not graded and participation is voluntary.

IV. Faculty Practice

To identify what higher education faculty are currently doing to keep students occupied outside the classroom, we conducted an online survey in the ACM SIGCSE member forum. The survey was also distributed among the faculty of the author's department. The survey was conducted for little more than a month during January and February of 2018. 94 responses were recorded in the survey. 83% of responding faculty were from STEM disciplines. Of those who responded, 54% were male and 43% were female (rest did not answer). We saw a somewhat equal coverage of Full Professors (31%), Associate Professors (30%), and Assistant Professors (24%). 15% of the responding faculty were some form of temporary faculty (adjunct lecturer, teaching faculty etc.).

The majority of the respondents (74%) were from North America, while 14% were from Asia and 8% were from Europe. The survey received equal number of male and female instructor's responses from Asia and Europe. There were fewer female instructors responding from North America. There was no female instructor responding from Africa or Australia, and no male instructor responding from South America. More than 60% of the responding faculty teaches undergraduate level courses, while 32% teaches graduate level courses. Fig. 1 shows the degree program distribution of the responding faculty members against their rank.

Most of the faculty (71%) has 2 to 3 course load per semester. 70% of the responding faculty relies on traditional face-to-face lectures for teaching a course. Flipped classroom was used by 6%, while a blended approach was taken by 19% of the faculty. It was evident from the survey that traditional face-to-face lecture is still the prominent teaching style among different faculty ranks.

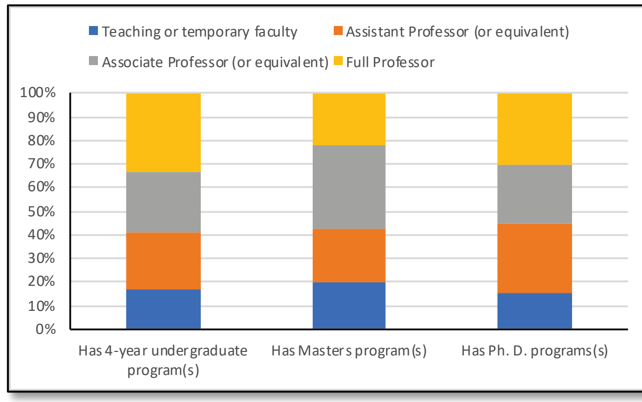

Fig. 1 Degree program by faculty rank.

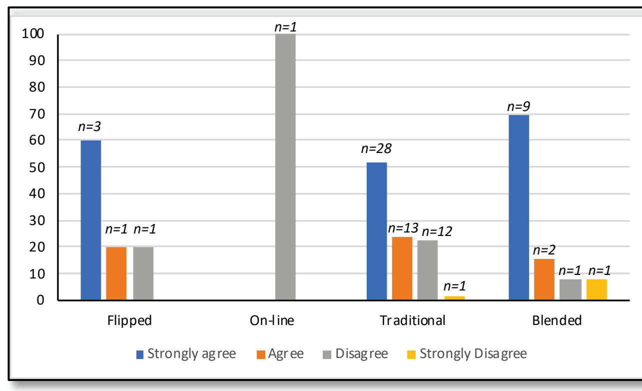

Fig. 2 Class type and student preparedness.

We asked faculty about student preparedness for classes and the time they spent studying outside of class. 76% of faculty agree that students do not spend enough time studying outside of class. 78% of faculty agree that students are under-prepared for the classes. Fig. 2. shows the intersection of faculty's impression that students are not prepared for classes and the type of classes that the faculty is teaching (where n=number of response). It is obvious that across the spectrum of class types, faculty strongly agree that students are not well prepared for classes. Related to the statement "Students do not spend enough time studying outside of class", instructors strongly agree (or agree) that students do not spend enough time out of class studying the class material (Fig. 3). This notion is prevalent all through the undergraduate years. Surprisingly, the trend is somewhat similar for the graduate students also.

The overwhelming majority (94%) of the faculty provide out-of-class activities that are graded and included in the final score. Faculty made equal use of problem-solving questions, programming assignments, group work, reading assignments, writing reports, watching or making videos, attending events, etc.) and we classified them into four distinct categories where we thought they fit. As is evident from Fig. 4, faculty mainly employ traditional types of activities to keep students engaged outside of class.

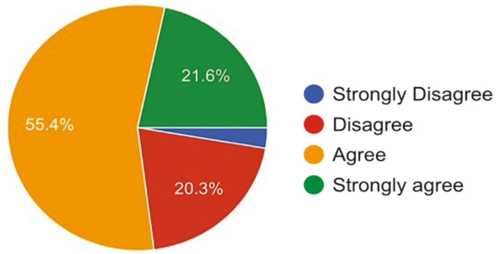

Fig. 3 Faculty impression on student not spending enough time for study outside the classroom.

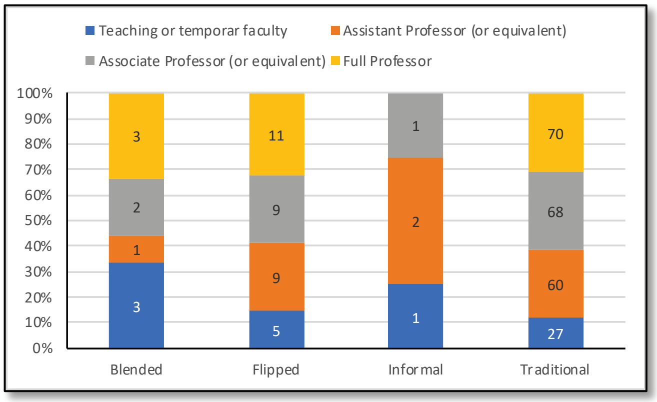

Fig. 4 Types of out-of-class activity.

Finally, we looked into the type of platform students use to perform those different types of activity. As shown in Fig. 5, the traditional personal computer (PC) is the preferred platform for the majority of the out-of-class activities. Specialized software-based activities are the second most used approach for giving out- of-class activities. Mobile phone and specialized hardware-based activities are also common, though not as prominent as the earlier two options.

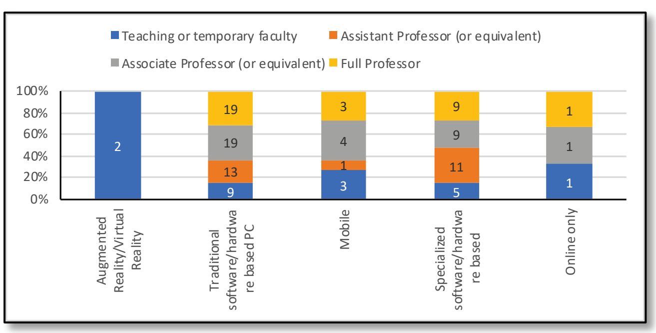

Fig. 5 Type of platform used for out-of-class activities.

The survey results tell us that most faculty teach traditional ways and use traditional out-of-class activities to keep students engaged outside the classroom. Additionally, faculty rely highly on traditional PCs and are not leveraging mobile devices, even though in the last few of years the use of mobile devices has skyrocketed. In a recent Pew Research Center study [24], 94% of the 18-29-year old has a smart phone, and mobile device users are so dependent on their phone that 1 in 5 people in the USA will access internet only through a mobile device. The same study also shows that college students prefer to use the mobile version of an application rather than to use either the desktop or the browser version of that application. Furthermore, there is a plethora of research [25]-[26] which shows that mobile learning engages students more and improves student learning. Findings from our existing research [27] also revealed a positive relationship between student learning and the use of a mobile device in class. Through the literature review and faculty survey, it is clear that there is a great potential for using mobile technologies to capture the attention of the student when they are away from the physical classroom. This is paramount not only to students and their success but also to the instructor as it aids in constant engagement, monitoring and intervention.

Therefore, a new out-of-class activity model is proposed that will exploit students' usage of technology and mobile devices for supporting interaction, engagement, and learning outside the classroom. The new model uses the mobile device in an active and innovative way, which supports blended learning and where participation is part compulsory, part interest driven, and where learning is being evaluated continuously. By having a guided learning environment and by using mobile technology, the goal is to steer students more effectively once they leave the classroom, and the expectation is to help students maintain more focus on the course content.

V. Dysgu: Out-of-class Activities for 21st Century

As described in Section III, traditional out-of-class activities are static in interaction, large in size and scope, students need a longer amount of time to finish, and faculty need an even longer amount of time to grade them and provide students with feedback. Because of that, the faculty generally assign a handful of these activities during the span of the semester, minimizing the assignment's effectiveness. Furthermore, the time limit enforced to complete such activities typically ranges over a few days to 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 engaging enough for a wide range of students. Rather, we need personalization and choice of adaptation to satisfy students' specific needs so that an optimal learning experience can be achieved [28].

In order to address the abovementioned challenges, this paper presents an innovative redesign of out-of-class activities through a guided learning environment, named Dysgu. Dysgu is a mobile and cloud-oriented client-server system. On the client side, students able to see available activities along with the status of the class. On the faculty side, educators are able to post activities, view student progress, provide feedback, send announcements, and create reports. Dysgu uses cloud services on the background to provide users a transparent view of the system. That way, the faculty doesn't have to run the server 24/7 and both the student and the faculty can act as asynchronously as they prefer. Although Dysgu is intended to be used in STEM courses, it is developed in a way to make it extensible to any discipline. Although there is a list of design and technological challenges this system has to address, we are not covering those in this paper because of the length constraint of the submission.

A. Properties of Dysgu

Dysgu is designed to support student learning and engagement out of class. Some of the key properties of Dysgu are as follows:

- *Scaffolding*: The redesigned activities in Dysgu are smaller in size and scope than traditional out-of-class activities and allows incorporation of instructional scaffolding [29]. A collection of activities form a learning path and multiple learning paths form a module. Each learning path have multiple activities linked together with a different degree of difficulty to address variability in learning and to provide instructional scaffolding support. With personalization and adaptation provided by Dysgu, this is an extension of existing approaches such as Canvas Mastery Paths [30].
- *Interaction*: Each activity in Dysgu is delivered as an interactive activity to the students. Interactive activities are a 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 [31]. Presenting a problem as an interactive entity enables the students to actively engage the problem. Students go through different steps, which aids in the construction of a better mental model. As a result, such interactive activities can potentially improve students' critical thinking and problem-solving skills. Our existing work with interactive problem solving [31] has shown that students feel excited and energized to interact with such problems and it improves their critical thinking abilities. However, in Dysgu, such activities are extended further to satisfy student's learning pace, workload, schedule, and any faculty-set policy.
- *Engagement*: Dysgu addresses the problem of procrastination several ways. The activities in Dysgu are frequent with shorter deadlines. Since these activities has light workload, are interactive in nature and use instructional scaffolding, they are more likely to inspire students to be engaged sooner [32]. Additionally, students are able to monitor their own progress compared to the rest of the class on a real-time basis. This should stimulate students' self-efficacy and encourage them to be involved in the activities.
- *Personalization and adaptation*: As these activities are electronically accessed and administered, students are allowed to set up their own schedule in Dysgu to make it more adaptive to their needs, i.e. activities are available for individual students according to their advertised schedule. This form of personalization allows students to manage their time effectively and to engage more in these activities. Additionally, with appropriate privacy settings, the students can personalize how the software acts in certain situations (for instance, when a student is not doing well compared to the class or getting close to the deadline) and in different geographic locations (home, work, or public location) depending on student progress status.
- *Platform*: Dysgu is designed as a mobile-based learning system, because mobile platforms are currently the most prominently used computing platform and most students are active users of this platform. Dysgu also allows faculty to administer more activities during the semester as it automates delivery, timekeeping, and grading. Additionally, this opens up the opportunity to incorporate adaptive features into the out-of-class activities to make these activities more appealing to students. Faculty is able to monitor student progress which enables them to intervene early, if and when necessary, and it is proven [33] that early intervention and prompt feedback has a positive effect on students' success.
- *Gamification*: Dysgu uses social networking and gamification components to encourage 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. By using *scores* (grades for correct answer) and *points* (internal system currency earned through extra credit and such; can be spent to extend the deadline, getting hints etc.), the system creates personalized goals and expectations to excite students' extrinsic motivation to actively participate in the activities.

By setting higher expectations for these types of activities (in terms of competition, problems with a higher degree of difficulty, the chance of gaining benefits other than scores only, etc.) than traditional activities, the new model aims to promote a self-fulfilling prophecy as shown to work in [34]. The proposed model aims to improve the independent learning environment that students face outside the classroom with the help of mobile platforms, scaffolding, interactive activities, frequent feedback, personalization, gamification, and social networking. Along with that, the proposed model also allows students to be supervised outside the classroom so that early intervention can be provided to students, who are struggling with the course content.

B. How Dysgu is Different

Pinter et al. [35] presented a prototype mobile learning system for out-of-class activities, with the goal to reinforce student learning in a programming course once the student left that classroom. That system allows a student to answer a specific question (multiple-choice) in a day, even if the student finishes it up right away, whereas, Dysgu has interactive problems which are adaptive to student's performance.

Carole B. et. al. [36] presented a collaborative online learning environment to link in and out of class activities and allows student to collaborate using social networking and gamification components. In their system, all questions are narrative or discussions oriented and tied to a reading material set by the faculty. Additionally, their system is browser-based, which lacks the flexibility provided by mobile apps, which the current generation of students prefers over browsers [24].

De-Marcos L. et. al. [37] combined both social networking and gamification to instruction and showed that it improves students' academic performance. This work has similar goals as Dysgu, however the delivery, mode of interaction, type of activity and nature of engagement are different in Dysgu. Additionally, there are some commercial systems such as piazza [39] prulu [40], quizlet [41], socrative [42], Kahoot [43], ClassDojo[44] etc. that are different in scope, pedagogical intentions, technique or intended audience.

VI. Conclusions

This paper explores the under-examined out-of-class activity landscape by classifying the traditional activities and discussing their shortcomings. The paper surveys faculty to see what is being done in today's classes to keep students engaged once they leave the classroom and the results of that survey showed that faculty mostly use traditional-out of the box activities and that they see that it does not improve student's continued engagement in the course content. The paper also explores and presents an out-of-class learning environment where students actively participate to solve problems using their mobile devices and partake in social-interaction and game-centric activities.

References

[1] Khu, G. D., Douglas, K. B., Lund, J. P., & Ramin-Gyurnek, J. (1994). Student learning outside the classroom: Transcending artificial boundaries. ASHE-ERIC Higher Education Report, 8, 1-160.

[2] Terenzini, P. T., Pascarella, E. T., & Blimling, G. S. (1999). Students' out-of-class experiences and their influence on learning and cognitive development: A literature review. Journal of College Student Development, 40, 610-623.

[3] Kuh, G. D., Palmer, M., & Kish, K. (2003). The value of educational purposeful out-of-class experiences. In T. Skipper, & R. Argo (Eds), Involvement in campus activities and the retention of first-year college students. (pp.1-16). Columbia, SC: South Carolina University.

[4] Langley, C. S. & Others (2000). A study of the out-of-class experiences of saint mary's college students studying in Maynooth, Ireland. Dissertation Abstracts: Humanities & Social Sciences, 61, 1291-1291.

[5] Epstein, Joyce L., and Frances L. Van Voorhis. "More than minutes: Teachers' roles in designing homework." Educational psychologist 36, 3 (2001): 181-193.

[6] Resnick, L.B. (1987). "The 1987 Presidential Address: Learning in School and Out," Educational Researcher (16:9), pp. 13-20.

[7] Philip S. Babcock and Mindy Marks (2010), The Falling Time Cost of College: Evidence from Half a Century of Time Use Data, NBER Paper No. 15954.

[8] Higher Education Research Institute. (2003). The official press release for the American freshmen 2002. UCLA Press.

[9] Academic Success Center, How Many Hours Do I Need to Study? Utah State University, 2019.

[10] Nonis, S.A. and Hudson, G.I. (2006). Academic Performance of College Students: Influence of Time Spent Studying and Working. Journal of Education for Business, 81(3), 151-159.

[11] Miller K., Danner, F., and Staten, R. (2008). Relationship of Work Hours with Selected Health Behaviors and Academic Progress Among a College Student Cohort. Journal of American College Health, 56(6), 675-679.

[12] Cooper, Harris, Jorgianne Civey Robinson, and Erika A. Patall. "Does homework improve academic achievement? A synthesis of research, 1987–2003." Review of educational research 76, no. 1 (2006): 1-62.

[13] Smithrud, David B., and Allan R. Pinhas. "Pencil–paper learning should be combined with online homework software." Journal of Chemical Education 92, no. 12 (2015): 1965-1970.

[14] Altadmri, Amjad, Neil CC Brown, and Michael Kölling. "Using BlueJ to Code Java on the Raspberry Pi." Proceedings of the 46th ACM Technical Symposium on Computer Science Education, pp. 178-178, 2015.

[15] Long, Yanjin, and Vincent Aleven. "Educational game and intelligent tutoring system: A classroom study and comparative design analysis." ACM Transactions on Computer-Human Interaction (TOCHI) 24, no. 3 (2017): 20.

[16] Li, Qingcheng, Heng Cao, and Ye Lu. "Connecting Paper to Digitization: a Homework Data Processing System with Data Labeling and Visualization." 14th ACM EAI Intl. Conf. on Mobile and Ubiquitous Systems: Computing, Networking and Services, pp. 504-510, 2017.

[17] Chatzopoulos, Dimitris, Carlos Bermejo, Zhanpeng Huang, and Pan Hui. "Mobile augmented reality survey: From where we are to where we go." IEEE Access 5 (2017): 6917-6950.

[18] Carlisle, Martin C. "Using You Tube to enhance student class preparation in an introductory Java course." In Proceedings of the 41st ACM technical symposium on Computer science education, pp. 470-474. ACM, 2010.

[19] Bishop, J.L. & Verleger, M.A. (2013) "The Flipped Classroom: A Survey of the Research," 120th American Society of Engineering Education Annual Conference & Exposition, Atlanta, Georgia, USA, June 23-26.

[20] Flipped Classroom Trends: A Survey of College Faculty, 2015, Faculty Focus, Magna Publication.

[21] Schroeder, Noah L., Olusola O. Adesope, and Rachel Barouch Gilbert. How effective are pedagogical agents for learning? A meta-analytic review. Journal of Educational Computing Research 49 (1) (2013): 1-39.

[22] Anisetti, Marco, Valerio Bellandi, Alberto Colombo, Marco Cremonini, Ernesto Damiani, Fulvio Frati, Joêl T. Hounsou, and Davide Rebeccani. "Learning computer networking on open paravirtual laboratories." IEEE Transactions on Education 50, no. 4 (2007): 302-311.

[23] Cooper, Martyn, and Jose MM Ferreira. "Remote laboratories extending access to science and engineering curricular." IEEE Transactions on learning technologies 2, no. 4 (2009): 342-353.

[24] Pew Research Center, Mobile fact sheet, http://www.pewinternet.org/fact-sheet/mobile/, February 2018.

[25] Romney C.A., "Tablet PC use in freshman mathematics classes promotes STEM retention," Frontiers in Education Conference (FIE), 2011.

[26] Avery, Z.; Castillo, M.; Huiping Guo; Jiang Guo; Warter-Perez, N.; Won, D.S.; Dong, J., "Implementing Collaborative Project-Based Learning using the Tablet PC to enhance student learning in engineering and computer science courses," Frontiers in Education Conference, 2010.

[27] Fuad, M. M., Deb, D., Etim, J., & Gloster, C. (2016, July). Using Interactive Exercise in Mobile Devices to Support Evidence-based Teaching and Learning. In Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education (pp. 17-22). ACM.

[28] Kuh, G. D., Kinzie, J., Buckley, J. A., Bridges, B. K., & Hayek, J. C. (2006). What matters to student success: A review of the literature. Washington, DC: National Postsecondary Education Cooperative.

[29] Ninio, A. and Bruner, J. (1978). The achievement and antecedents of labelling. Journal of Child Language, 5, 1-15.

[30] Mastery Paths, https://ursinus.instructure.com/courses/2850/pages/mastery-paths?module_item_id=89593.

[31] Fuad, M., Deb, D., Etim, J., & Gloster, C. (2018). Mobile response system: a novel approach to interactive and hands-on activity in the classroom. Educational Tech. Research and Dev., 66(2), 493-514.

[32] Ambrose, Susan, et al. How Learning Works: 7 Research-Based Principles for Smart Teaching. San Francisco, CA: Jossey-Bass, 2010.

[33] Wiggins, G. (2012). Seven keys to effective feedback. Educational Leadership, 70, 10–16.

[34] Blose, G. (1999). Modeled Retention and Graduation Rates: Calculating Expected Retention and Graduation Rates for Multi-campus University Systems. New Directions for Higher Education, 27(4): 69-86.

[35] Pinter, R.; Cisar, S.M., "One question per day" a mobile learning project, Intelligent Systems and Informatics (SISY), 2014 IEEE 12th International Symposium on, pp.105-109, 11-13 Sept. 2014.

[36] Beal, C. R., Strohm, J., Schwindy, L., & Cohen, P. R. (2013). Teach Ourselves: A peer-to-peer learning community linking in-and out-of-class activity. IEEE Technical Comm. on Learning Tech., 15, 13-16.

[37] L. de-Marcos, A. Domínguez, J. Saenz-de-Navarrete, C. Pagés (2014). An empirical study comparing gamification and social networking on e-learning Computers & Education, 75 (2014). pp. 82–91.

[38] Uosaki, Noriko, Takahiro Yonekawa, and Chengjiu Yin. "Supporting Out-of-class Interaction among Learners with InCircle." In Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, pp. 331-334. ACM, 2017.

[39] Piazza, https://piazza.com.

[40] Prulu, https://prulu.com.

[41] Quizlet, http://quizlet.com.

[42] Socrative, http://www.socrative.com.

[43] Kahoot, https://kahoot.com/welcomeback/.

[44] ClassDojo, https://www.classdojo.com/.