eLmL 2021

The Thirteenth International Conference on Mobile, Hybrid, and On-line Learning

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eLmL 2021

Forward

The Thirteenth International Conference on Mobile, Hybrid, and On-line Learning (eLmL 2021), held in Nice, France, July 18 - 22, 2021, focused on the latest trends in e-learning and also on the latest IT technology alternatives that are poised to become mainstream strategies in the near future and will influence the e-learning environment.

eLearning refers to on-line learning delivered over the World Wide Web via the public Internet or the private, corporate intranet. The goal of the eLmL 2021 conference was to provide an overview of technologies, approaches, and trends that are happening right now. The constraints of e-learning are diminishing and options are increasing as the Web becomes increasingly easy to use and the technology becomes better and less expensive.

eLmL 2021 provided a forum where researchers were able to present recent research results and new research problems and directions related to them. The topics covered aspects related to tools and platforms, on-line learning, mobile learning, and hybrid learning.

We take this opportunity to thank all the members of the eLmL 2021 Technical Program Committee as well as the numerous reviewers. The creation of such a broad and high-quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to the eLmL 2021. We truly believe that, thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the eLmL 2021 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that eLmL 2021 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in eLearning research.

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The Doer Effect: Replicating Findings that Doing Causes Learning

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***Abstract*—There is a dire need for replication research in the learning sciences, as methods put forth for increasing student learning should be unequivocally grounded in reproducible, reliable research. Learning science research is not only a critical input in the learning engineering process during the development of educational technology tools, such as courseware, but also as an output after student data have been analyzed to determine if the learning methods used were effective for students in their natural learning context. Furthermore, research that can provide causal evidence that a method of learning is effective for students should be reproduced—and the generality for its use expanded—so that methods that cause learning gains can be widely applied. One such method is the doer effect: the principle that students who engage with more practice have higher learning gains than those who only read expository text or watch video. This effect has been shown to be causal in prior research through statistical modeling using data mined from natural learning contexts. The goal of this paper is to replicate this research using a large-scale data set from courseware used at a major online university. The learning-by-doing data recorded by the courseware platform were combined with final exam data to replicate the statistical model of the causal doer effect study. Results from this analysis similarly point to a causal relationship between doing practice and learning outcomes. The implications of these doer effect results and future learning science research using large-scale data analytics will be discussed.**

Keywords*—doer effect; learn by doing; causal discovery; replication; external validity; learning outcomes; course effectiveness; courseware.

I. Introduction

Advances in educational technology are increasingly beneficial to learning, yet increasingly complex in nature. Courseware is one such digital tool, which is designed to provide a comprehensive learning environment for students and real-time data insights to instructors [19]. The creation of tools such as courseware, however, is a daunting task to undertake. It is no small feat to imagine and define what courseware should be, but even more complex is the development process. The courseware has an authoring platform, a data architecture, a student interface, and instructor tools and dashboards, which require software engineers, product managers, and data scientists to develop. Similarly, creating the content that goes into courseware requires subject matter experts, instructional designers, media specialists, projects managers, etc. Learning engineering—an emerging discipline itself—provides a process for development and contextualization of the goals that helps synchronize often disparate teams and processes. Proposed by Herbert Simon [15] and fostered at Carnegie Mellon University [5], learning engineering developed as a role to further the application of learning science for students and instructors. Learning engineering was applied at Acrobatiq after its emergence from Carnegie Mellon's Open Learning Initiative (OLI) to apply learning science and a student-centered approach to developing courseware [17].

Learning engineering as a practice supports learners and their development through the application of the learning sciences to human-centered engineering design methods and data-driven decision making [6]. The Learning Engineering Process (LEP) outlines an iterative cycle that includes the identification of the context and problem, design and instrumentation, implementation, and data analysis and results [7]—a development process appropriate for many contexts. While the application of learning science research was a critical component of the LEP for the development of the courseware, equally vital is the analysis of data and sharing results. To fully engage the LEP is to iteratively improve through the insights data can reveal, and to share these findings with the broader research community. A goal of this paper is to further the LEP by collaborating with an institutional partner to replicate learning science research foundational to the courseware through the analysis of data gathered from students in a natural learning context.

A benefit of courseware as a comprehensive learning environment is the wealth of data available for analysis. As students move through the courseware, their page visits, engagement and accuracy on formative practice, summative assessment scores and more can be collected to paint a picture of what students are doing both in real time and for post hoc analysis. The large-scale data from courseware run in natural settings can be used as a basis for investigating the effectiveness of learning methods. The courseware data can provide many insights, if the right questions are asked. One such question is: Are we able to identify if courseware's formative practice questions cause increased learning?

The doer effect is the learning science principle that the amount of interactive practice a student does (such as answering practice questions) is much more predictive of learning than the amount of passive reading or video watching the student does [10]. Studies have previously shown correlational support for this principle [9]. However, in order to recommend this approach with high confidence in its effectiveness, it is necessary to know that there is a causal relationship between doing practice and better learning. This requires ruling out the possibility of a third variable being a common cause of both, since in that case the relationship between doing and learning would merely be correlational. For example, a frequently cited external variable that could account for the doer effect is student motivation. A highly motivated "go-getter" student may do more practice and also obtain better learning outcomes, but this would not necessarily mean better outcomes were *caused* by doing the practice.

Koedinger et al. [9] used data collected from students engaged with a MOOC course paired with courseware developed by OLI to investigate the doer effect. In their initial research, they found the learning effect of doing the formative practice was six times larger than that of reading. Follow-up analysis [10] [11] sought to determine whether this effect was causal. A statistical design involving within- and outside-unit doing, reading and watching (described in more detail below), was able to demonstrate causal impact of doing on learning and rule out the possibility that this effect was entirely the result of a factor such as individual student motivation. There is no better explanation of the importance of causal relationships than was stated in [10]: "It should be clear that determining causal relationships is important for scientific and practical reasons because causal relationships provide a path toward explanatory theory and a path toward reliable and replicable practical application."

Replication research is critical in the learning sciences to provide additional evidence to support—or refute—claims made about effective learning practices. A large fraction of published research in the social sciences has not been replicated, and studies that cannot be reproduced are cited more frequently than those that can [14]. Methods for increasing learning should be broadly shared to benefit as many students as possible, and those methods should be grounded in substantial evidence of their validity. By replicating and sharing the data analysis and findings as part of the LEP, the researchers and developers maintain transparency and accountability to the learner [17]. Furthermore, replicating findings that are based on large-scale data mining provides valuable verification of the results, as the volume and type of data analyzed can be difficult to obtain. Through the courseware described in this paper and institutional collaboration, we have the data required to evaluate the relationship between doing practice and learning outcomes. Replicating this causal doer effect study adds to the body of evidence that this learning by doing methodology—and the doer effect it produces—are effective in a variety of learning situations, and supports a practical recommendation that students can increase their learning outcomes by increasing the amount of formative practice they do.

For this study, the data set came from students enrolled in a Macroeconomics course, C719, at Western Governors University. There are many benefits of analyzing student data from courseware used in a real university setting. Students engaged with the course without any external influences that might alter their natural behavior. This allows us to study their engagement and learning outcomes in as authentic a way as possible; students worked through this course as they would any other in their program, which contributes to the generalizable nature of the study. Benefits of utilizing real course data include lower costs and fewer ethical concerns as compared to controlled experiments. A controlled experiment in a laboratory setting would allow researchers to, for example, deliver the treatment (doing practice interleaved with content) to one randomly selected set of students while delivering static content to a control group. Performance on a standard assessment would provide a measure of the effect of the treatment. This controlled experimental method would have a high internal validity, but would also have a high cost, ethical concerns, and low external validity. Instead, due to the availability of detailed data generated by courseware as students progress through their course, post hoc studies of natural learning contexts can be done with minimal cost and without ethical concerns that can come with randomized experiments, such as withholding potentially beneficial treatment from some learners.

The value of this replication study is that it extends the external validity of the doer effect findings. The Macroeconomics courseware used was designed on the Acrobatiq platform based on the principles established at OLI. This courseware utilizes the same key features of interleaved practice, immediate targeted feedback, etc. as the OLI courses previously analyzed (Introduction to Psychology, Introduction to Biology, Concepts in Computing, Statistical Reasoning) [10]. These similarities are important for confirmatory results, as it is important to have as many common variables as possible for the replication of the statistical model [11]. Investigating an entirely different subject domain built independently—yet using the same learning science principles—strengthens the external validity of a causal relationship.

This study uses data from a business course, which is a domain outside of the STEM subjects originally analyzed, and a final exam to measure learning outcomes instead of unit tests. The final exam could potentially impact doer effect findings due to the increased learning decay that could occur over time when compared to unit tests.

Given the intention of this study to replicate causal doer effect findings, our research question is: Can causal doer effect findings be replicated on a final exam data set, generated from a competency-based online university course? To answer this, we will outline the required parallel features for this replication study in Section 2—from the learning by doing courseware environment, to the description of regression model and its inputs, to the data used for analysis. Section 3 will provide the formulas used for the analysis, the results, and a discussion on the meaning of the replication findings. Section 4 concludes the paper with remarks on the importance of these replication findings for the learning science methods used herein, the role of learning engineering and the LEP in continuing learning science research, and the implications of these findings for future research.

II. METHODS

A. Learning by Doing in Courseware

In order for this replication research to be parallel with the original study, the learning resource needed to be similar in the learning by doing approach. Learning by doing as a term has been used to describe different kinds of learning engagement (and not all use or encourage the use of scaffolding or feedback [8]), so it is important to clarify how learning by doing is applied in this courseware. Learning by doing is a method of actively engaging the learner in the learning process by providing formative practice at frequent intervals. It has been shown that formative practice increases learning gains for students of all ages and in diverse subjects, and while this method benefits all students, it can benefit low-performing students most of all [3]. The formative practice questions integrated with the content essentially act as no-stakes practice testing, which increases learning gains and retention [4]. In Acrobatiq courseware, students can answer practice questions as many times as they like, and typically students continue to answer until they get the correct answer [18]. Feedback that explains why that choice is correct or incorrect is provided for each answer option to give additional guidance and another opportunity for learning (Figure 1). Immediate, targeted feedback was shown to reduce the time it took students to reach a desired outcome [1] [12], and feedback in practice testing outperforms no-feedback testing [4] [13]. Formative practice with targeted feedback provides scaffolding and examples that support cognitive structures for effective learning [8] [13] [16].

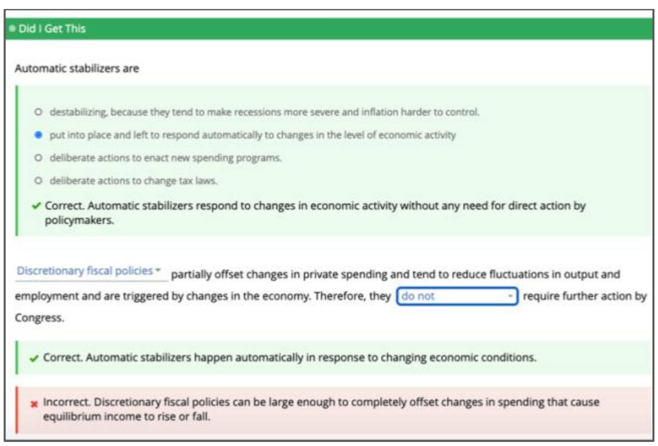

Figure 1. Formative practice questions from Macroeconomics

The courseware contains many features similar to those in used in the courses for the original study [10]. Modules are made up of lesson pages, and each lesson contains readings, images, and formative practice questions all tied to a central learning objective. Learning objectives are student-centered and measurable, and the practice questions are tagged with the learning objective to feed data to the platform's learning analytics engine, as well as to inform post hoc analysis. The formative practice questions are interleaved with small chunks of content to provide practice to students at the point of learning that content. Question types vary, but entail both recognition and recall and most frequently include multiple choice, pulldown, text or numeric input, drag and drop, and true/false. Questions were created to target the foundational Bloom's Taxonomy category, *remembering*, of which recognition and recall are both cognitive processes [2].

Western Governors University is an online, competency-based institution. Students enrolled in the course were able to review the course content (the courseware) and work with faculty at their own pace in preparation for a final exam that comprised 100% of the course grade. Students had a six-month window to complete the course by passing the final exam, which they could retake as needed during that time frame. This learning science-based courseware was developed to fit WGU's curriculum needs. In addition to a unit on general learning strategies, there are six units of Macroeconomics content. Each unit contains an introduction, up to three modules of subtopic content, and a summary. Each module contains an adaptive activity and a quiz on the content from that module, and each unit summary contains a unit test cumulative to all modules in that unit [19].

Passing the WGU course depended solely on passing a final exam. The courseware content and final exam content were written by independent development teams; however, the course learning objectives were provided to the WGU final exam development team for alignment purposes. For this study, the student's score on the first attempt at the final exam was used as the learning outcome.

B. The Model

A regression model developed by Koedinger et al. [10] analyzed the relationship of student doing, reading, and video watching in each unit of course content to scores on that unit's summative assessment. The key innovation in their model was to control for the total amounts of doing, reading and watching in *other* units of the course. Student doing outside the unit can act as a proxy for a third variable like motivation that can lead to correlation between level of effort and outcomes. In this way, if the doer effect is causal, then the amount of doing within a unit should be predictive of the student's score on that unit's assessment, even when accounting for doing outside that unit. If there is not a causal relationship between doing and outcomes, we would not expect to see a statistically significant within-unit effect beyond the outside-unit effect.

The course analyzed in Koedinger et al. [10] had eleven total content unit/assessment pairs. Within-unit doing and watching were significant, as well as outside-unit doing. Reading and outside-unit watching were not significant. Outside-unit doing significance indicates that there is a variable that influences how students who generally do a lot of practice also score higher on assessments. However, the larger and more significant predictor was within-unit doing, meaning that even when controlling for outside-unit doing, within-unit doing had a statistically significant relationship with learning outcomes, indicating a causal doer effect.

Unlike in the original study, where a summative assessment immediately followed each unit of course content, the final exam was obviously taken after all relevant student usage of the courseware. Furthermore, the units in the Acrobatiq courseware did not have a direct correspondence with the categorization of questions on the final exam. As previously discussed, all courseware resources, e.g., lesson readings and formative practice questions, were mapped to the course learning objectives. These learning objectives in turn mapped to six course competencies developed by WGU, to which final exam questions were also coded. An example competency developed for the Macroeconomics course is: 'The Economic Way of Thinking - The graduate analyzes economic behavior by applying fundamental economic principles, including scarcity, opportunity cost, and supply and demand analysis.'

In order to apply the Koedinger et al. regression model [10] in the present study, these course competencies were used as the analysis units, as this provided a way to group both the courseware content and the final exam questions into a common set of logical units. Henceforth, when referring to a *unit* of course content, we specifically mean all content corresponding to one of these six competencies, with the unit summative assessment consisting of all corresponding final exam questions that assess that competency.

C. The Data

The initial data set included historical data from 3,513 students who enrolled in the Macroeconomics course from March 2017 to April 2019 (WGU courses have rolling enrollments). As the study we intend to replicate included only students who made some use of the course materials, we likewise excluded students who did not use the courseware at all. WGU allowed students to take the course's final exam more than once (if necessary) to pass. Only the first attempt at the final exam was included in the analysis, and student engagement with the courseware was filtered to include only that which occurred before the first attempt at the final exam. This resulted in 3,120 students in the final data set.

The competencies were used to compile the unit-based reading and doing data required for the model from the clickstream usage events logged by the courseware. Following Koedinger et al. [10], the reading variables were defined as all visits to lesson pages where the student did not engage in any practice available on that page. There were 92,009 page visits for this group of students. The doing variables were defined as the number of formative practice opportunities a student attempted, including adaptively generated practice activities described earlier. The courseware's module quizzes and unit tests were not included as practice because of their presentation as scored summative assessments, even though in this case they made no contribution to the student's grade in the course; inclusion of these as practice did not materially affect the results of the analysis.

A total of 1,162 formative questions were included in the analysis, with 397,562 unique first attempts on these practice opportunities. Within-unit resource use (reading or doing) was defined as all use associated with a unit's content, and outside-unit resource use was defined as all resource use not designated as within-unit. Unlike in the original study, watching was not investigated, as video was not a critical component of the courseware.

In total, 47 finer-grained courseware learning objectives were mapped to the six course competencies. The learning objectives were not uniformly distributed across competencies, as the number varied according to the amount of content coverage. The mapping of the courseware's formative practice to the learning objectives was used to aggregate practice by competency.

III. RESULTS & DISCUSSION

For each of the 3,120 students in the data set, there is an observation (row) for each of the six competencies, bringing the total number of observations to 18,720. The multiple observations per student are not independent and therefore an ordinary linear regression model—which assumes independence—cannot be used. The lack of independence can be handled by using a mixed effects linear regression model. Following Koedinger et al. [10], we use a mixed effects model to investigate the within-unit and outside-unit reading and doing relationships with learning outcomes. Reading, doing and competency score values were converted to *Z*-scores before regression to better enable comparison of the reading and doing effects. The R formula used to fit the model is below.

```
lmer(z_WGU_COMPETENCY_SCORE ~ z_within_reading
                            + z_outside_reading
                            + z_within_doing
                            + z_outside_doing
                            + (1|student)
                            + (1|competency),
                              data=df)
```

This shows that a linear mixed effects regression model was fit using the `lmer` function. The regression formula shows (normalized) competency score modeled as a function of within- and outside-unit reading and doing, with a random intercept per student and competency to address the lack of independence of the observations noted above.

The reading and doing coefficients were tested for statistical significance using a likelihood ratio test, in which the likelihood of the full model is compared to a model with one of the variables of interest omitted. The following R code illustrates this test for the within-reading coefficient:

```
lme.model <- lmer(z_WGU_COMPETENCY_SCORE ~ z_within_reading + z_outside_reading + z_within_doing
                                         + z_outside_doing + (1|student) + (1|competency),
                                           data=df, REML=FALSE)
lme.null  <- lmer(z_WGU_COMPETENCY_SCORE ~ z_outside_reading + z_within_doing + z_outside_doing
                                         + (1|student) + (1|competency),
                                           data=df, REML=FALSE)
anova(lme.null, lme.model)
```

TABLE 1. DOER EFFECT REGRESSION ANALYSIS RESULTS.

Learning Method	*Location*	*Normalized Estimate*	*Std. Error*	*t-Value*	*Pr(>|t|)*
	(intercept)	0.0000	0.1256	0.000	1.0000
Doing	within-unit	0.1146	0.0099	11.613	< 2.2e-16 ***
	outside-unit	0.1556	0.0132	11.773	< 2.2e-16 ***
Reading	within-unit	-0.0125	0.0091	-1.367	0.1729
	outside-unit	-0.0604	0.0130	-4.645	3.432e-06 ***

The results of the regression analysis are presented in Table 1. There are significant effects for within-unit doing, outside-unit doing, and outside-unit reading, while within-unit reading is not significant. The within-unit and outside-unit doing coefficients are larger in magnitude than both the reading coefficients, and doing also had much larger *t*-values than reading. The reading coefficients are also negative, which we will discuss further below.

Both within-unit doing and outside-unit doing were strongly, positively significant. We initially discussed how significant within-unit doing would be indicative of a causal relationship between doing practice and better learning outcomes. But since outside-unit doing is also significant, does that mean that a causal doer effect is *not* supported? No. We would likely expect outside-unit doing to almost always be significant (regardless of whether the doer effect is causal), as it is well known that students who do more practice tend to get better outcomes. Significance of outside-unit doing simply reflects that; for example, students who are go-getters typically do well. What matters is that within-unit doing is *additionally* significant, which means the relationship of within-unit doing to its own unit's assessment score cannot be accounted for by the amount of outside-unit doing, indicating that relationship is causal in nature. Otherwise, we would expect outside-unit doing to be significant but not within-unit doing. But this is not the case: within-unit doing matters to learning outcomes in a way that cannot entirely be explained by a third variable—such as motivation—that leads to both greater doing and better learning.

The most important finding is therefore that within-unit doing is a highly significant predictor of learning even after controlling for outside-unit doing, and this is consistent with a causal doer effect. The size of the doer effect, taken as the ratio of the standardized doing and reading coefficients, is also of interest. Previous work by Koedinger et al. [9] [10] found the effect of doing on outcomes was about six times greater than reading. In this study, however, we cannot compute a size for the doer effect because within-unit reading was not significant. Koedinger et al. [10] reported such cases as an effect ratio of ∞.

An interesting note is that the outside-unit reading coefficient was significant but negative, showing an overall negative relationship between the amount of outside-unit reading and final exam performance. One possible explanation for this negative result is suggested from prior anecdotal observations of engagement behaviors of students with poor learning outcomes. Many of these students tended to read the same section(s) of text repeatedly, indicating they were struggling. This pattern of rereading without obtaining a good outcome may have contributed to this negative relationship. These struggling students also often did not meaningfully engage in practice, which is regrettable since the body of doer effect research would recommend that investing that study time in practice instead of rereading would have been more beneficial. Note particularly that within-unit reading was not significant, meaning no special relationship to outcomes beyond outside-unit reading was discernible. This negative relationship between reading behavior and outcomes should be a subject of additional future study.

IV. CONCLUSION AND FUTURE WORK

It is increasingly critical to utilize methods proven to benefit learners in online learning environments. Our research question—"Can causal doer effect findings be replicated on a final exam data set, generated from a competency-based online university course?"—was positively answered. The courseware and final exam data produced results consistent with those of the original study replicated. Replicating the findings of Koedinger et al. [10] using courseware designed with the same learning science principles but in a different domain and at a different higher education institution extends the generalizable nature of the doer effect findings. By engaging with a learning by doing design—formative practice questions integrated into the learning material—students activate the doer effect and increase their learning gains. This analysis confirms that even when controlling for an outside variable, doing the formative practice within the courseware caused better performance on an external final exam. Doing practice *causes* better learning.

The data available through courseware enable analysis and evaluation of learning principles, such as this one. Through large-scale data collected in a natural learning environment, learning analytics can broaden support for learning science concepts and strategies and provide generalizable results for additional learning contexts. In this particular case, the Macroeconomics courseware provided a comprehensive learning environment for students, but the final exam was what determined the course grade and final student outcome. This use-case may be similar to other higher education institutions where a high-stakes course assessment would take place as a proctored event outside of the learning environment. Identifying the doer effect using a final exam is encouraging because the potential for learning decay is greater than on a more proximal assessment, such as a unit test. What's more, separate development of the learning content and formative practice from the final exam could have made the doer effect more difficult to identify, but that was not the case. The use of a final exam for analysis may also be more typical of a college course where the content and exam are from different authors.

Learning engineering will continue to require not only collaboration of organizations and team members to engage in the LEP, but also the combination of different data sources to investigate learning principles in applied contexts. This study highlights the value of combining data from institutions and educational technology that collects large volumes of raw student data. Analysis for causality required both engagement data from the formative practice in the courseware as well as student learning outcomes from a high-stakes assessment. As more data become available, combining data from different sources can accomplish valuable analysis of learning methods and principles. The doer effect research was critical to the design of the courseware environment during the LEP, and this process is furthered by sharing this replication research.

The significance of causal doer effect findings suggests at least two main avenues for future work. The first is to bring the learning by doing method to learning environments at scale, to provide as many students as possible with the learning benefits possible through the doer effect [18]. Doing causes learning, and these findings have been replicated in a variety of subject domains, using learning resources created by different organizations, and implemented at different institutions. The second goal of future work is to use these findings for iterative improvement in the LEP by identifying ways of increasing the amount of practice students do. While variation in the amount of practice students did in the progression of the course was necessary for this statistical model, it would be ideal if every student did effectively all the formative practice available. If doing causes learning, students should engage in as much formative practice as possible to leverage the causal doer effect and maximize its contribution to their learning outcomes. Future work can focus on the role of instructor implementation practice [20] and student motivation in increasing engagement.

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A Learning Engineering Ethical Framework: Keeping the Learner Centered

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***Abstract*—Learning engineering is a learner-centered practice. Its multidisciplinary approach is part of what makes learning engineering such a versatile and valuable tool for designing learning in a wide range of contexts. This paper proposes that the learner-centered component is critical to the heart of learning engineering and is what shifts this practice from a productive method for developing learning environments to an ethical practice. The learner-centered position of learning engineering will be characterized, the ethical practices outlined, and an ethical framework described. The learning engineering ethical practice provides professional purpose to the practitioner and maintains the learner as the heart of the design and development process.**

***Keywords*—learning engineering; learning engineering process, ethical voice, professional purpose, ethics, ethical framework.**

I. INTRODUCTION

As an emerging discipline, learning engineering is "a process and practice that applies the learning sciences using human-centered engineering design methodologies and data-informed decision making to support learners and their development" [4]. Learning engineering draws from many disciplines with a goal of supporting learners [3], which makes learning engineering a useful practice in many contexts—from developing courses at higher education institutes, to creating a technology-integrated curriculum in K-12 environments, to developing online learning technology for private companies [2]. The practice of learning engineering is the same in each case and is also supported by the Learning Engineering Process (LEP) [5]. The LEP, as shown in Figure 1, is a structured development process that helps a learning engineer (or learning engineering team [1]), move through the context and problem to be solved, identification of the team to solve it, design and instrumentation cycles, implementation of the solution, data analysis and results, and iterative improvement cycles [5].

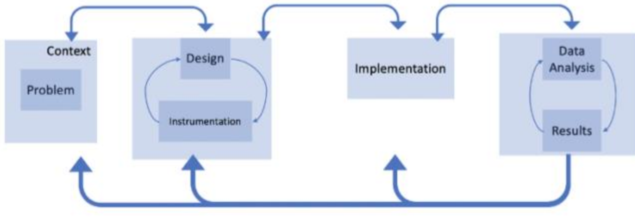

Figure 1. The Learning Engineering Process [5]

What does learner-centered mean? Learner-centered design is a common practice where the design process is centered on the learner's needs [3]. The designer considers what the goal is for the learner and determines how to best help that learner achieve said goal. Like the LEP, learner-centered design is context agnostic and is applicable in any setting. However, in the learning engineering context, there are additional requirements placed on the learning engineer in the design and development of learner-centered solutions. The consultation and application of research in the design and development of the solution is a key step at the start of the LEP, and this research-based approach ensures that the decisions being made on behalf of the learner are proven to be beneficial for them [9]. The LEP also has a series of steps that act as natural reflection points for the learning engineer (or team) to assess how the solution is operating for the learner [9]. For example, the design and instrumentation phase may have many improvement cycles as the learning engineer stops to reflect on how that design functions for the learner, and identifies potential problems or improvements. The learning engineer approaches this task by attempting to see as the learner would. The implementation of the solution is also a key moment for the learning engineer to help prepare learners to use the solution to as intended. The real-world use of the solution is as important as the intention of the design, so proper instruction for the learner during implementation is another moment for the learning engineer to keep the learner in the center of the LEP. The data analysis and iterative improvement is focused on how to improve the solution for the learner, maintaining the learner as the center of the process.

II. LEARNING ENGINEERING AND ETHICS

There are many moments in the LEP when the learning engineer is able to "center" the learner in the practice, but how does this become an ethical practice? Learning engineering as a practice is working to create something or solve a problem for the learner, and therefore, is *in service* to the learner. This service to the learner provides the learning engineer with a professional purpose, and this in turn helps the learning engineer develop and use an ethical voice during the LEP [9]. The ethical voice helps practitioners understand why they practice in addition to how they practice [6]. By maintaining a higher order professional purpose and using an ethical voice, professionals can hold themselves and their organizations to higher standards, above and beyond contractual or economic obligations [6]. The learning engineer becomes an advocate for the learner by using this ethical voice to ensure the learner's best interests are maintained during complex development processes.

This learning engineering ethical voice, used in service to the learner, helps to conceptualize the learner as real, complex human beings. This might seem strange, because what else would the learner be? But it is not hard to develop something for the learner and yet that learner has become an abstraction or generality [8]. This abstraction is especially easy to do when the learner is not an immediate stakeholder in designing and developing the learning engineering solution [8] [9]. Using this ethical voice—derived from a purpose in service to the learner—the learning engineer can imagine the learner as a complex person during the LEP. Imagining the solution through the eyes of the learner is a method of ethical practice that helps maintain the learner in a situational context: where are they, who are they, how are they learning, with what are they learning, what is their motivation, etc.

By using this ethical voice, the learning engineer engages in a dialogic ethic [9]. The communication between the learning engineer and the learner, even when not present [8], is a form of dialogic ethics as the learning engineer strives to maintain the learner as a participant in the LEP. The ethical voice is also used in dialogic ethics by communicating with team members and stakeholders in the development cycle itself [8]. The LEP itself has several points in which the team can pause to evaluate the solution, and these reflection points are natural places for this dialogic ethic to be exercised [9].

Learning engineering provides the practitioner with an ethical approach to the discipline in both professional purpose and process, as shown in the framework of Figure 2 [9]. As a learner-centered discipline, the learning engineer has a professional purpose in service to the learner, and this helps to develop an ethical voice. This ethical voice is used to engage in a dialogic ethic with and for the learner and team during the LEP. This learning engineering ethical practice brings this practitioner group into the educational community that engages in an "ethic of caring" [7].

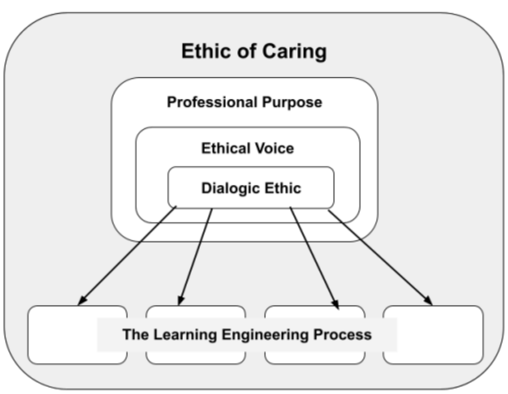

Figure 2. The Learning Engineering Ethical Framework [9]

This ethical framework is beneficial for both the learning engineer and the learner. By understanding their professional purpose, the learning engineer gains agency through use of an ethical voice. They can use this ethical voice to maintain focus on the learner during the LEP, even when confronted with challenges from other team members or stakeholders. The student benefits by receiving a learning solution genuinely created with their best interests at its center. The LEP becomes an ethical tool for the learning engineer that is used to maintain the learner as the center of the process—from initial research to design to implementation and iteration.

III. Conclusion and Future Work

Learning engineering will continue to grow as a discipline and be applied in increasingly varied contexts. By actively engaging in this ethical framework, the learning engineer can maintain an authentic learner-centered practice. As learning engineers and teams apply the Learning Engineering Process in increasingly complex and diverse ways, attention must be paid to how the learner stays centered in the practice. This learner-centered ethical framework simultaneously serves both the practitioners and learners—enabling the learning engineer to use their ethical voice and tools in service of the learner.

Future work on ethics in learning engineering should focus on gathering case studies on how practitioners use ethics in diverse contexts to continue to iterate on the framework. Future work should also discuss how to cultivate this ethical approach in practice, so as to include learning engineers and teams in the educational community of ethical caring.

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Advances in Gamification in Education

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***Abstract*—Gamification in education is not a new idea and has been investigated in the academic research field in the past years. In this paper, the latest advances of this topic have been discussed. The adaptive gamification approach has been one of the main topics in gamification in education lately and many different approaches have been proposed to achieve the best possible outcome. These approaches will be mentioned, and a comparison between them will follow, to identify which one has been the most effective yet. Also, the idea of adding narration to gamification in education, will be discussed as well. After this survey, it is clear that research in this area has not been matured yet, and there are many aspects of gamification in education that need more attention, to improve the state of it in the education criteria, and thus making it more viable.**

Keywords-Gamification; Education; Adaptive; Framework.

I. INTRODUCTION

Online education has got more attention in the year 2020 and 2021 due to the COVID-19 pandemic. In these hard times it is even harder to get students engaged to their studies. The lack of interaction between the teacher and their students, makes it harder to hold any classes as exciting as they have been in the school. There are many ways to enhance the quality of online education or e-learning. There have been multiple tools and technologies that have been introduced to overcome such challenges. One of these tools is called gamification. Gamification is using game elements in non-game environments to enhance and improve the engagement of learners to the study material by making it more interesting [1]. In this paper we will discuss recent publications around the topic of gamification that are related to E-Learning.

In Section 2, different usages of gamification are discussed, and how gamification can be helpful within the e-learning environment is mentioned. In Section 3, the design of gamification, specifically for education contexts, is explained. The similarities with video games are also discussed briefly in the same section. In Section 4, two different adaptive approaches for gamification in education are mentioned [4], and a comparison has been done among various applications, which employed these approaches based on their contexts. In Section 5, a novel software design model for adaptive gamification in education has been explained. Section 6 will discuss the effectiveness of a gamification application, in Higher Education Institutions, that was used among 24 Business class students. At the end in Section 7, the idea of using narrative for gamification in education has been discussed.

II. USAGE OF GAMIFICATION

The idea of gamification has been around us for a long time. Gamification is tied in with giving different forms of rewards to make an action more enjoyable and satisfactory than it is in a normal fashion. Even giving ranks, achievements and labels in different criteria such as military or offices are considered as some forms of gamification. Deterding et al. [1] have defined gamification as "the use of game elements and game design techniques in non-game contexts". After the advent of the Internet in the last two decades, many online businesses, websites, mobile applications, etc. have tried to employ game elements into their business models to improve user activities and motivations. These elements include leaderboards, badges, points, rankings, levels, etc. In the past few years, various startup teams and design companies have offered gamification design or software-as-a-service packages for other businesses [2]. In the year 2020, gamification market share rose up to US$ 9.1 billion and is set to grow up to US$ 30.7 billion in the year 2025 [3]. This shows a significant opportunity for the industry to adapt as quickly as possible to take the most advantage of the situation. A study from Markets and Markets back in 2016 had predicted the estimate for 2020 gamification growth to be set at US$ 11 billion [2]. This shows that at the moment gamification has not been properly used to its full potential.

Gamification can be employed by a wide variety of systems that involve with education or motivation toward improving the user engagement or final user experience. This method is not just for the digital era. Gamified elements have been around us for a long time. Any type of reward can be a form of gamification when the reward has not been the purpose of the system; for instance, when parents set rewards for their children if they do the assigned chores, or when an employee gets promoted in an organization and gets a new title. In general gamification could be defined as using gameful elements in the design approach of a system in different contexts by simulating familiar experiences from games that supports various behaviors and processes [17].

Modern gamification gained its popularity from early 2010s. It has been a topic of interest in academia and industry for many years now. The technological advancements throughout the recent years, have enabled more e-learning environments for the purpose of education that share some technical aspects in relation to video games to make learning experiences more immersive and engaging [2].

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III. Design of Gamification in Education

In the first stages of introducing gamification concept to the industry and education, the reward-based version of the system was widely being employed in the application design. In this method the application would use different rewards based on suitable game elements to improve the engagement of its users to the system. This type of gamification is effective as long as the system is willing to give more rewards. Plus, there must be users in the system who are still willing to earn them. There are two obvious problems with this methods:

1. The system should always give more and new rewards.

2. The users might get tired, and will be less motivated toward achieving more rewards.

Zichermann and Cunningham have mentioned in their book, “Gamification by Design” [26], that if you start giving a user a reward, you must keep them in the reward loop forever.

Traditional gamification which is mainly based on giving rewards to the users, could be harmful, if the goal is to create a long lasting behavior [28]. These types of rewards can replace the natural motivation which they are trying to increase. This means that if the external rewards are no longer provided to the users, then they have little to no intrinsic motivation to do the tasks. So, a better way of implementing gamification is required to increase the intrinsic stimulus and help the users with their tasks.

System designers should come up with more innovative ways of using game design elements to make motivation throughout the system rather than just giving external rewards. This matter has been done in video game design as well in the past years. Video game designers, especially online multiplayer game designers, are now facing similar difficulties. They have to encourage players to play their games for a long period of time. Some video games even last for decades and players still enjoy them. They should include internal motivation regarding the tasks which are available in the game to be done by the players. However, there are quite a noticeable number of AAA high budget video games that would lose their player-base rather quickly and prematurely due to bad game design. Most of these games suffer from bad game design elements that would not fulfill the players’ demand, or would bore them after a short period of time compared to what the designers were hoping for.

The importance of a thorough game element design also applies to the system designers who are willing to employ gamification elements for their system. Specifically in education, this is a serious problem to solve since improving students’ engagement is very complicated and it comes in many forms. So, a single element design might not work the same way for all of the students. Here we come to two different ways of gamifying a system: Static adaptation and Dynamic adaptation [4].

- In static adaptation, the system first categorizes the user into different learner profiles. Then the system adapts by changing the game elements for each distinct learner profile. This way, the system assures that each user will get suitable gamified elements for their own type, that they know they are more interested in.

  The learner profiles are commonly chosen from different versions of player types. There are various classifications available to choose from, for instance Hexad player types [5], Bartle Player types [6] and Brainhex player satisfaction model [7].

- In dynamic adaptation, not only is the system taking into account what learner profile the user belongs into, but also adapts the system to each user different behavior and activity within the system. This adaptation can be done by either customizing the gamification element pool for each user from all the available elements, or by changing the functionality of a particular game element to further match the players’ preferences. Dynamic adaptation can also be done beside the static adaptation, and use the learner profile to improve the system.

IV. Adaptive Approach in Gamification in Education

There have been many research attempts done in regards to static and dynamic adaptation in gamification in education over the past few years. In static adaptation, the player type will determine the profile for learner rather than his/her personality. These player types have been introduced to show why players are motivated to play games. For instance, in the Hexad Scale, “Socializers” are players who are willing to interact with other players and to create social connections, while “Achievers” are those who want to tackle difficult tasks to prove themselves [5].

In the literature review provided by Hallifax et al. [4] it has been stated that there are two different categories of research that have been done in the adaptive gamification design: first, papers that have put their findings and recommendations based on the literature surveys, and second, the group that have based their results on user feedback and analysis. Most of the first category of papers have linked the gamification elements to the player types that we mentioned above, prior to this section. The following papers have used this method: [8] and [9]. On the other hand, the second category have used different non adaptive gamification tools or have based their study based on a user review and survey system. These surveys measured the participants’ preference, according to their interaction with the system. The following papers have followed this method: [10]-[12].

The result of all these different approaches can be concluded in the longevity of the studies. The authors of [4] have grouped the studies in two categories of short studies and long studies.

Short studies are studies that lasted less than two weeks. Two papers include in this category [13] and [14], which both have used a dynamic adaptation approach. All of the studies of this kind have reported positive results after the studies were done. The research in [13] has shown that the number of errors the learners made during two different sessions of adaptive gamification system decreased, when the personalized system was employed. The authors of [14] have tested two different adaptive situations. For the first situation, the time, that was given to learners to answer questions, changed according to how fast they answered prior questions. For the second situation, the target score was changing based on the group performance. For both situations the authors reported an improvement in the learners' performance, and they did more tasks compared to a situation with no gamification involved.

Long studies are the studies that lasted more than three weeks. These types of studies have reported more mixed results. In the seven papers that the authors reviewed in this literature review, four papers concluded with generally positive results. The authors of [15] studied learners that used an online tool for one month. Learners were equipped with either random assigned game elements, or tailored game elements based on their motivation type. The latter resulted in considerable differences in engagement, motivation and quiz results, compared to the randomly game element assigned learners. The authors of [16] divided learners in three groups. First group was given their game elements based on their Brainhex player type; Second group was given counter-adapted game elements, and the last group got their game elements randomly assigned to them. The study took three weeks to complete. This study shows that learners with adapted game elements spent more time using the tool than learners with the counter adapter ones. The authors of [17] also concluded a positive impact in their study. Learners with adapted game elements correlating to their learning style, had a higher task completion rate than the other who had random elements assigned to them. This was further proven with the self-reported questionnaire, after the study was done. Last paper minutes. Tasks were given to middle school students, who used the tool as part of their normal lesson process. Students with counter-adaptive game elements reported to be finding the assigned game elements more fun and useful than the other students with adapted elements or random ones. Same authors studied a similar test [19], this time with adults who voluntarily used the adaptive learning tool. This study was also in a span of three weeks. They could not find any significant differences among the learners afterward.

To conclude, it has been shown that shorter studies show more positive impacts in adaptive gamification than longer studies. However, the reason is not entirely clear. One conclusion that can be assumed from these studies, is that the novelty effect of gamification elements might wear off after a particular amount of time. Hamari et al. [22] found the significance of novelty effect as well. The other problem is that adaptive systems change over time based on the user preference and activities, therefore, researchers might need to do even longer studies to come up with more substantial results. Another factor, could be different or irrelevant metrics that these studies used to measure the impact of gamification, since some papers report contradictory conclusions in the similar environments, for instance [19] and [16]. The research in [17] showed an increase in motivation in all of the learners, however, the authors of [19] reported motivation increase only for one specific group of learners known as the more invested learners. A brief summary of the conclusion of this section can be found in table I.

TABLE I. STUDIES RESULT TABLE BASED ON DURATION (SHORT OR LONG), ADAPTIVITY TYPE (STATIC OR DYNAMIC), PROFILE (PLAYER TYPE OR PERSONALITY), ACTIVITY (PERFORMANCE OR BEHAVIORS) AND EFFECTIVENESS (POSITIVE OR MITIGATED)

Paper	**Results**				
	Duration	***Type***	***Profile***	***Activity***	***Effectiveness***
[13]	Short	Dynamic	-	Performance	Positive
[14]	Short	Dynamic	-	Performance	Positive
[15]	Long	Static	Personality	-	Positive
[16]	Long	Static	Player Type	-	Positive
[17]	Long	Static	Personality	-	Positive
[18]	Long	Static	Player Type	-	Positive
[19]	Long	Static	Player Type	-	Mitigated
[20]	Long	Static	Player Type	-	Mitigated
[21]	Long	Dynamic	-	Behaviors	Mitigated

in this group [18] had positive results as well. The impact of their adaptation tool was measured via a learner's questionnaire, after using their adaptive learning tool, which reported an enhancement in emotional and behavioral engagement. For this study, some university students were divided into different groups according to their Hexad profiles. They used the learning tool for 14 weeks and each group received their own designated game elements. However, the results of the study deemed not significant, due to the small sample size by the authors.

The remaining three studies [19]-[21] had more mixed results. The authors of [20] employed three structured learning sessions over a three-week period, each would last for 45

V. ADAPTIVE GAMIFICATION MODEL IN E-LEARNING

Design of gamification systems in education has mostly followed the same practice in a significant number of developed systems. This is due to the fact that gamification systems are software, and there are clear and established development processes to how implement a software properly, for a long time in the industry now. However, gamification is very unique in a number of aspects, compared to a typical software. These aspects have to be examined and considered, while designing a new system for a learning environment. Kamunya et al. [24] have introduced an "Adaptive Gamification Model for E-Learning" that tries to solve this exact problem.

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the authors of [24] have employed the Design Science Research Methodology (DSRM) to develop their proposed model. To develop this model, they have reviewed 15 different adaptive gamification studies.

Here is a quick review of how the DSRM process works:

A) Problem identification: In the proposed model by [24], the problem can be identified as how an adaptive gamification system can be engaging and how to improve motivation.

B) Objectives of the solution: Development guidelines of the system should be presented in this stage.

C) Design and development: The first artifact of the proposed model would be created here.

D) Demonstration: This stage is to show how the artifact exactly works.

E) Evaluation: The effectiveness of the newly developed artifact will be determined.

3. Adaptive gamification elements: This part holds all the different gamification elements that the system could offer. They have been grouped in their appropriate category of elements, mechanics and dynamics.
4. Adaptive gamified course: In this module the course will be designed based on the proposed gamification approach.
5. Report: This module is to report the different aspects of the system after implementation. This can include various concerns such as motivation, engagement, effectiveness, efficiency, experience and knowledge.

The conclusion of the research that has been done in [24] is that by employing a proper gamification design framework, a better and more suitable adaptive system could be achieved. Gamification is extremely related to each individuality of any learner, and a competent adaptive system must consider all learners' motivations and different behaviors toward the system. The proposed adaptive gamification framework which is depicted in Fig. 1 has been designed to answer these concerns for future adaptive gamification system designs.

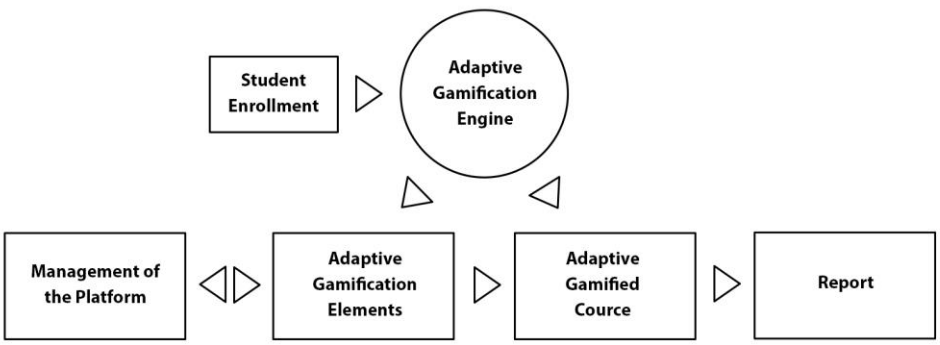

Figure 1. Adaptive Gamification model for E-learning. Adapted from [24]

F) Communication: The result of the evaluation must be published.

The authors of [24] have also shared their results after an in-depth literature review of adaptive gamification studies from 2013-2019. Nearly 50% of these studies had adaptive proposals of various adaptivity framework, in which the different game elements were to match with a specific learner profile. Only about 33% of the studies had a complete adaptive gamification system and evaluations, which about 60% of them had shown positive impact for their systems.

Finally, the authors of [24] have proposed their gamification framework based on their finding of the literature review. The key components of their model are as follows:

1. Adaptive gamification engine: The engine is responsible for assigning the game elements to learners based on their learner profile or characteristics. This can be either done in static or dynamic adaptation approach.
2. Management of the platform: This module is defined for administrative functions such as role assignment and user addition.

VI. Effectiveness of Gamification

A comprehensive study has been done by Hiroko Oe et al. [23] on how gamification works in Higher Education Institutions. In this study, the impact of gamification has been examined in a Business class, which consists of interviewing 24 different students in the field. These students were using gamification for their Business lesson in the form of a Massively Multiplayer Online (MMO) game. This game was designed to explore the challenges in the business education at higher education institutions. The game used a virtual economy that lets the participants to make decisions within the community, on one shared server in real time for the set subject [29]. Prior to this study, the positive impact of employing MMO scheme on students' learning process has been discussed, more specifically in business contexts [27]. Therefore, the study in [23] mostly aimed for gathering the students' evaluation of the system, to help improving the development of designing a blended learning system with gamification.

The study of [23] was done during the Covid-19 pandemic so the students were already engaged with Information and Communications Technology-based (ICT) learning. The MMO role-playing game was integrated in the ICT-based learning system, during classes and seminars. There are some advantages and disadvantages with ICT-based learning systems. On one hand, students could feel less pressured during a class, and participate in more discussions and activities. On the other hand, some students who are not comfortable to engage with class activities, might feel even less motivated to participate in an online environment. Plus, in an online education environment the teacher has less control, due to the nature of the class, and the fact that class presence cannot be the same as in-person classes.

The conclusion of the study that has been done in [23] can be summarized in a few key points. First and for most, the students share mostly positive feedback about using the gamification system for their business class. They all felt, that it could be a useful tool to make the process more interesting and exciting to get engaged with. However, a number of students said that, although, it seems to be helpful, they were not sure about the assessment of the whole system. They demanded a comprehensive explanation of how can this system help them better than the traditional way of learning this course, so they can focus on what makes the best out of the proposed system. Another issue to consider is that these specific students were already familiar with the MMO game elements and how the game design should work, however, that is not always the case with the target audience for such systems.

Overall, the result of the research in [23] was positive. It suggested that a good design is necessary for any specific group of students and for each individual gamified system. Therefore, the optimal impact of learning could be achieved. A Gamification conceptual framework can be found at the end of the research in [23].

VII. Narrative for Gamification in Education

It is appropriate to compare gamification systems with video games. One can argue, that a gamified system is a type of video game on its own. However, the purpose of designing and using these systems are vastly different. One is mostly used for entertainment purposes, whilst the other is trying to improve and encourage students in their studies to perform their tasks more efficiently and effectively. But the similarities are quite significant, and gamification systems might benefit from more video game components than the researchers and designers thought could be viable in the first place. One of the components that has not been extensively investigated in gamification systems is narrative.

Narrative is often used to drive the story of a video game or a movie. However, Paula T. Palomino et al. [25] have proposed a concept of Narrative for gamification in education. They argue that narrative can also be effective in a learning environment, and improve the learners' engagement. Since there are not a lot of studies around narrative for gamification, the authors have done a literature review for narrative in other medias, including video games. Then, they found the definitions and features, that is similar among the studied subjects, to finally achieve a common ground, that can be used for gamification purposes. In the process they also found out that narrative can also be part of the User Experience, since it shares some of the similar characteristics with it.

The authors of [25] have concluded that narrative can be used for gamification contexts, only if the following features are present in the system:

1. Actor as the user, learner or student.
2. The choice element, which indicates options for progression based on the answer.
3. Interactivity. This means that the system should response to the users' actions.
4. A sequence of events. Progression has to be made in logical chain of user and system actions, and should be quite clear to the user.
5. Space, time and date of the interaction.

If these features are parts of the system, then a narrative approach for the gamification system could help the students to be more involved with the system. There are two different types of narrative, embedded and emergent. These are used to differentiate the terms, narrative and story. Traditional narrative approaches cannot be used directly in the gamification contexts. Based on the user experience component of each system, only the appropriate parts of a narrative should be used to emphasize a particular part of a feature in a gamification system. Each component should be individually tested and studied before implementing any narrative into it.

At the end of the study that has been done in [25], the authors conclude that due to the limited prior research in this field, they could only focus on the theories about narrative. Further study, design and implementation is necessary for a more comprehensive conclusion in this field.

VIII. Conclusion and Future Work

In this paper, recent advances in gamification in education were discussed and a conclusion has been provided for each part. It is obvious, that the idea of gamification in education has been attracting more researchers to study and improve it in various aspects of it. These studies mostly suggest positive impacts for learner engagement and motivation for their proposed and/or tested systems.

The main problem which remains unresolved is that, there are still not enough real life evaluations of such systems to provide robust conclusions about the efficiency and effectiveness of such systems. Although, in the recent years there have been improvements in testing such systems, there are still numerous problems that need attention. These problems include: size of the test audience, the duration of the test, lack of proper assessment for the system, inability to scale the result for different cases and the rapid evolution of the ICT world. These issues make it challenging for researchers and designers to apply older conclusions on the newly designed systems. For the future work, comparing all the gathered data from different literature reviews in adaptive gamification in education, and trying to correlate them with various contexts, other than what there were tested in, are in order. Plus, there are still numerous aspects of gamification in education that have not been discussed in detail in this paper. With a thorough evaluation of the results, based on the available literature review, and a deep analysis on how each element could be enhanced, the quality and effectiveness of future gamification systems shall be improved significantly.

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Finding a Balance for Success:

Student Success Innovations vs. Faculty Workload Concerns

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***Abstract*—Researchers at a public (state funded) institution in the United States seek to increase student success rates in online courses by encouraging faculty implementation of research-based strategies in their online courses without significantly increasing faculty workloads. The researchers created a program that provided short, research-based, student-success strategy segments to faculty already enrolled in faculty development. These teaching tools were largely based on pedagogical research and methods long understood within traditional education disciplines, but not as obviously applied to online course delivery. In this sense, the professional development modules are innovations to traditional online training. After the training program, the researchers analyzed faculty response to the training to improve design principles and delivery for future development of eLearning materials. While the impact of the innovations developed in this student success endeavor are still largely to be determined, preliminary results indicate that faculty find the professional development modules helpful and will be implementing them in their courses.**

Keywords-student success rates; innovation; feedback; open educational resources; training transfer; social media

I. Introduction

This research project aims to increase student success in online courses offered in the Radow College of Humanities and Social Sciences at Kennesaw State University while at the same time being mindful of faculty workload and lack of time for faculty development and course redesign. The bulk of the paper describes phase one of the project, which was undertaken in spring 2021. Increasing student success [measured by decreases in DFWI (Drop, Fail, Withdraw, Incomplete) rates] is not only a moral imperative, it is also financially incentivized. The researchers first present the description of phase one of the project and the initial results from participating faculty. The paper concludes with descriptions of phases two and three, which will be undertaken in summer and fall of 2021.

II. Overview and Rationale

In the United States, education is supported financially by a complicated combination of federal and state funding. In fact, state by state comparisons reveal huge differences in how much a state contributes to its higher education coffers. Government funding of higher education has dropped substantially in recent decades [1]. For example, overall, higher education state funding per student dropped 27% from 2000-2014. State by state, the numbers vary widely. The state of Michigan cut funding by 53% overall during that time while North Dakota increased funding by 31%. Our own state of Georgia cut funding by 17% [2].

When cuts are substantial, the difference is made up in budget cuts at the institutional level (such as reduction in library holdings and elimination of staff and programs) and tuition increases, among other strategies. But, in the United States' political system, the same politicians who strive to cut funding to education also strive to claim that they keep taxes and other expenses low. Therefore, the state rarely allows public (that is, state funded) institutions to raise tuition to make up for these budget cuts.

With funding so tight, any opportunity to gain additional budget money to support faculty and students is highly prized, and competition is fierce if such opportunities are announced. Opportunity sometimes comes in the form of "student success dollars," which is funding that can be awarded for initiatives with the intent of bolstering student success. In this case, student success is defined as decreased DFWI and increased retention (the student stays in individual courses and in the university as a whole), progression (the student progresses through a degree program), and graduation (within a proscribed number of years). This definition is often abbreviated as RPG (Retention, Progression, and Graduation). While student success dollars are not tied directly to RPG, our Executive Director for Academic & Fiscal Operations at Kennesaw State University, Dr. Michael Rothlisberger, explained, "Student success dollars are a systemic example of tying resources to strategy" because meeting RPG targets is seen as "a moral imperative" [3].

In order to compete for these highly prized student success dollars, our college wants to stand ready with research-based support to facilitate faculty implementation of techniques that foster student success. But just as there is a balancing act that goes along with cutting state funding to higher education and also refusing to allow tuition to raise, so there is also a balancing act with innovating to improve student success and being mindful of innovations that might

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challenge academic freedom or increase already strained faculty workloads.

III. Student Success Innovations Project

RCHSS (Radow College of Humanities and Social Sciences) is one of 11 colleges at Kennesaw State University. The RCHSS ODE (Office of Digital Education) offers an award winning "Build a Web Course Workshop" to faculty to support them in creating and teaching online courses using research-based best practices. In preparing to apply for student success funding, college administrators recently looked at the DFWI rates of online courses offered pre-pandemic. Surprisingly, it was determined that there was no significant difference in DFWI rates between classes where faculty had been trained to teach online using best practices versus online courses created and taught by faculty who had not received training.

Our administration theorized the lack of discernable difference may stem from that fact that the ODE delivers training focused on best practices in online and hybrid teaching and not specifically on student success. That is, the courses created by trained faculty may have been better designed because the faculty who created and taught them had been trained in research-based best practices, but the courses may not have specifically implemented student success strategies.

IV. Problem, Considerations, Research Project

Our Build a Web Course training program is peppered with student-success research from well-known experts like Saundra McGuire, Jessamyn Neuhaus, Flower Darby, Anya Kamenetz, Richard Arum and Josipa Roksa, which we couple with advice and examples of successful strategies employed by our own faculty. However, an informal survey of former workshop participants found that none of them remembered the workshop topics that addressed student success in online courses.

A. The Problem

We realized that we needed a more focused strategy to supply faculty with information regarding implementing strategies for student success in their own online courses. But we also realized the need to emphasize student success information within the existing training while adding minimal time and work for the faculty participants.

B. Considerations

We already had a wealth of student success strategies in the workshop. However, the information was provided along with information on research-based best practices in course design and technology tutorials to create course materials. Student success strategy information was not pulled out and highlighted or emphasized for faculty participants. Especially for faculty new to online teaching, we could see how workshop participants would prioritize "how do I create the class," "how do I make it accessible to students who use screen readers or who need captioning," and "what software do I use to create course materials" over "how do I strategize for student success." The faculty participants had finite time and energy to complete the training and create the course. But could we also call attention to student success strategies in hopes of encouraging faculty participants to add a few of those to their courses, as well?

C. Research Project

As mentioned earlier, the chief impetus of this research was to position the college to be ready to apply for and receive student success funding. Beyond that, we wanted to be able to demonstrate that we had identified a way to increase and support student success. And of course, the heart of our motivation was to assist our students in achieving their academic goals.

The researchers designed a three-phase research project. Phase 1 (ongoing) involves creating our student success content, sharing it with faculty, and following up with a survey to measure their intent to adopt student success strategies into their courses. In Phase 2, we will survey faculty who have taught their new courses to determine why they did or did not implement student success strategies. For those who have adopted student success strategies, we will seek additional feedback on the impact of adoption on their time and effort and their perceptions of the impact of the strategies on student success in their courses. In Phase 3, we will survey students in courses where student success strategies have been implemented to better understand student perceptions of the strategies and their utility.

To begin Phase 1, the researchers did three things: 1) pulled the research-based, student-success content out of the faculty training modules and put it in separate pieces in the training called Student Success Minutes. 2) Added an activity to each of the Student Success Minutes to support the faculty in remembering the content. 3) Surveyed faculty at the end of the training to see if they recall and plan to use the Student Success Minutes information (intent to transfer) [4]. The researchers decided that each Student Success Minutes segment had to be less than 10 minutes, including the activity, so as not to overburden the faculty with more training content. In this initial, pilot phase of the project, our goals were to create the segments and present them to the faculty participating in the spring 2021 "Build a Web Course Workshop" and then survey faculty participants, as described above, regarding intent to transfer. We started with a small number of faculty participants (8). Because of low faculty enrollments, in this first phase of the project we were able to gather little more than a handful of initial reactions.

Phase 1 will be continued by developing additional topics and offering the Student Success Minutes in "Build a Web Course" workshops in summer and fall 2021. In addition, a second, shorter, asynchronous training using the Student Success Minutes segments is being created. This training targets faculty who have completed the "Build a Web Course" Workshop previously but did not receive the redesigned content on research-based strategies for student success. The redesigned training will take participants less than two hours to complete. It will be asynchronous and at participants' own pace. Currently, other workshops focusing on student success strategies at the institution take more time and/or lack the flexibility and interaction of our Student Success Minutes. The redesigned training and the accompanying survey of intent to transfer will be available during the second half of summer 2021.

During academic year 2021-2022, the researchers plan to move on to the additional phases in the project. In Phase 2, we would ask for volunteers from the workshop completers who would put at least one student success strategy from the workshop in their course. In Phase 3, we would survey students in the course to see if they noticed the strategy and if they found it to be helpful. While measuring DWFI rates might also be helpful, the researchers are cognizant that students drop courses for many reasons that may have nothing to do with the professor or the course content. Also, DWFI rates can be used against professors who might feel targeted by attention to such information. For this reason, we chose not to measure DWFI rates from participants in this research. At the end of the project, we will gather aggregate data on DWFI rates to see if the project had an impact on the college DWFI rates as a whole.

After the three phases of the project, the researchers plan to use the information gathered to assess whether highlighting student success strategies in faculty development training can encourage faculty to implement these strategies. And, if subsequently, that implementation leads to increases in student success and reduction in DWFI rates. If we find we have a successful strategy, we will be able to use this information to better position our college to receive student success funding when future opportunities arise.

V. Research-Based Modules on Student Success

In the first phase of this project, the research team created six, Student Success Minutes segments. This section will describe each segment, provide the research it is based on, and describe the activity provided with it and faculty participant results, if available.

A. *Student Success Minutes 1: Scaffolding*

This student success minutes segment was based on the work of Flower Darby (Figure 1). Darby explains scaffolding through her experience teaching jazz dance. She writes,

> [B]eginning dancers get frustrated and demotivated if I constantly throw new things at them. Better to practice one new step for a while, get feedback from me on their progress, and build confidence and self-efficacy before introducing a slightly more complex step or one that requires greater skill" [5 p. 27].

Darby extrapolates this idea to other academic realms. While scaffolding in college classes is not a brand-new idea, Darby provides an excellent explanation and rationale for the practice. For example, in a research paper assignment, instead of just assigning a 10-page research essay, ask students to turn in a topic early in the course. A few weeks later, ask students to turn in an annotated bibliography with a tentative thesis. And two weeks before the paper is due, ask students to turn in (or share on a discussion board) a PowerPoint with the title and thesis on slide 1 and the topic sentence and paragraph supporting points for each paragraph in the paper. Of course, the faculty member would be expected to provide timely and helpful feedback on each phase before the next phase is due.

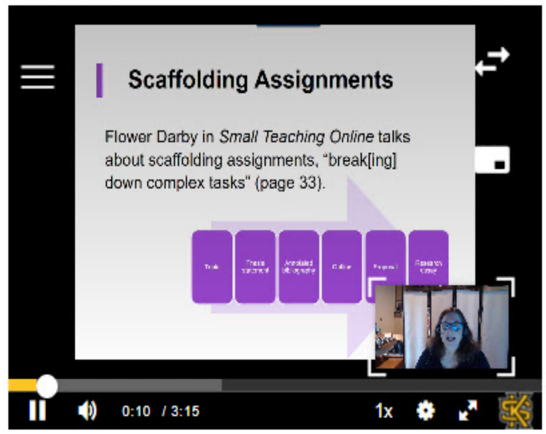

Figure 1. Student Success Minutes 1:a video explaining Flower Darby's approach to scaffolding.

To introduce (or remind) faculty of this student success strategy, in a three-minute video, Dr. Tamara Powell, Director of the RCHSS ODE, explained the concept of scaffolding and asked participants to share a reflection on when they might use the strategy to support student success in a class. In the reflection assignment, 100% of faculty participants indicated that they already used scaffolding strategies in their courses to some degree.

B. *Student Success Minutes 2: GroupMe*

The second student success minutes segment was based on a need within the institution. At Kennesaw State University, student culture results in the creation of a GroupMe (Figure 2) for each class in which students are enrolled—bypassing the professor [6]. GroupMe is a social media application that allows a group to chat via mobile app or website without exchanging personal information. On the one hand, GroupMe is excellent for creating community and support in an online course. On the other hand, some students with the best intentions have been tempted to use GroupMe to commit breaches of academic integrity.

In response to these problems, Mr. Sam Lee, a student at Kennesaw State University as well as a teaching assistant in the Spanish and French programs and an assistant instructional designer in the RCHSS ODE, created an interactive presentation using Articulate Storyline 360. The presentation walked faculty participants through an

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overview of GroupMe and provided suggestions to faculty regarding how to minimize student cheating with it and how to use it with students to support student success [5, p. 80].

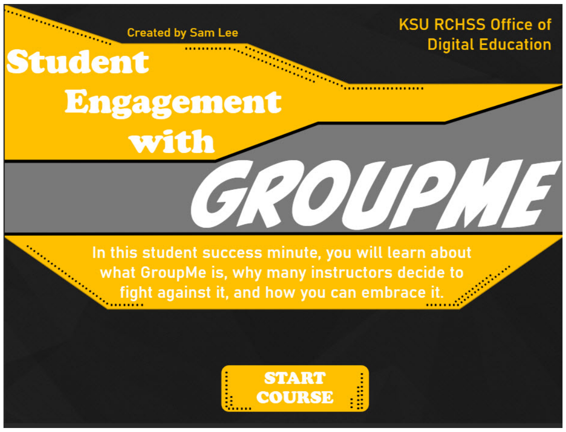

Figure 2. Student Success Minutes 2: a short, self-paced, interactive presentation on the social media tool GroupMe.

This presentation concluded with a short quiz to support comprehension of the main ideas. Faculty participants were allowed to attempt the quiz multiple times, and all faculty participants scored 100% on their final attempts.

C. Student Success Minutes 3: Open Educational Resources and Creative Commons

In the past five years, a great deal of research has been done on the impact of OERs (Open Educational Resources), or no-cost or low-cost course materials, upon student success efforts. In the United States, textbook prices have risen astronomically. In the last 10 years, the "average cost of college textbooks has risen four times faster than the rate of inflation," and "65 percent of students . . . skip buying required texts" to save money or simply because they cannot afford them [7]. As an alternative to expensive textbooks, many faculty members turn to OERs. Research into OERs has shown that OERs increase student participation, satisfaction, learning, retention, and course and program completion. They reduce student debt not only by lowering textbook costs in individual classes, but also by allowing students to take more courses in a term, thereby graduating more quickly and accruing less student loan debt [8].

Ms. Tiffani (Reardon) Tijerina (Figure 3), the Program Director for the Affordable Learning Georgia initiative, created a Student Success Minutes segment on OERs for this project. In the two minute and 37 second video, Ms. Tijerina defines open educational resources and explains their benefits as well as Creative Commons licensing. The Creative Commons licensing explanation is provided to support understanding of the types of resources that can be used as OERs in classes.

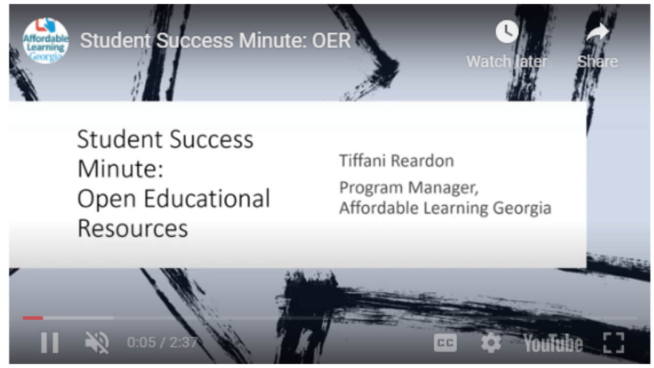

Figure 3. Student Success Minutes 3: a short video and quiz on Open Educational Resources.

Ms. Tijerina's student success minutes segment concludes with an ungraded self-assessment on the terms and concepts presented in the segment and then a graded quiz on the same terms and concepts. Faculty participants were invited to practice with the ungraded self-assessment as much as desired before taking the graded quiz on the same information. Every faculty participant scored 100% on the graded quiz. Ungraded self-assessments [9] will be the topic of a future student success minutes segment.

D. Student Success Minutes 4: The Quick Write

Dr. Saundra McGuire recommends a reflection activity as part of a class to engage students and enhance self-esteem [10, p. 10]. It is hard to imagine that something so simple to implement can be such a powerful tool for student success. Mr. Stephen Bartlett, Associate Director of the ODE, created a short video on a type of reflection assignment called "The Quick Write" (figure 4). McGuire uses the Quick Write as a confidence booster. She asks students to remember a thing they learned that was hard and recall how they learned it [10, p.84]. Mr. Bartlett also recommends using it as a reflection assignment to help cement information students have learned in a class period and to "check in" on students regarding to their progress in the class.

Figure 4. Student Success Minutes 4: a short video on the power of reflection.

Asking students to take just one to three minutes to write about an aspect of the material that was just presented is a great way to support learning and engagement, and it also allows the professor to see whether students are paying attention or "getting the material" in an online class.

The reflection assignments, serving as low-stakes or no-stakes assignments in this case, help reduce stress and support student learning [5, p. 9] [11, p. 69]. In the faculty development training, this segment ended with a Quick Write activity. Faculty participants were asked, "Think for two minutes and write for three minutes. Please write at least two sentences. What is the most important outcome that you want students to achieve in your course, and how might quick writes help students toward this goal?" While each faculty participant responded differently, the key takeaway was that each professor wanted students to be able to think critically, and the professor believed the Quick Write assignment fostered that goal.

E. Student Success Minutes 5: Weekly Modules

Universal Design for Learning Theory states that consistency is a key component for supporting increased success as it lightens cognitive load, freeing up more time and mental energy to assist the student in learning the course content [12]. It is important to be consistent in scheduling expectations for students in online courses. Students are used to organizing their college schedules by weeks in face-to-face classes, and it makes sense to use that structure in online courses as well. It also makes sense to create folders, organized by weeks, with everything a student needs in that folder to complete that week of class.

When faculty instead create modules of random lengths (module 1 is three weeks, module 2 is four days, module 3 is seven weeks, etc.), students who already struggle with time management can suffer severely. When faculty create overly long modules (one 16-week course with only four, four-week-long modules), students who wait until the last minute find out four weeks into the course that they have fallen too far behind to succeed. Student Success Minutes 5: Weekly Modules (Figure 5) provides the rationale for organizing the online course in a weekly fashion and examples of why it is the easiest way to support student success in an online course.

Figure 5. Student Success Minutes 5: a short video on weekly modules.

Weekly organization of online classes supports student success by providing consistency, reducing cognitive load, and helping students to organize their time [13]. This segment, created by Dr. Tamara Powell, ended with a quiz over the material presented in the short (two minutes and 38 seconds) video. All faculty participants scored 100% on the quiz.

F. Student Success Minutes 6: Timely and Effective Feedback

A great deal of research on student success supports not only feedback, but timely and effective feedback [5, p. 44, p. 107], [11, p. 70]. For our last student success minutes segment in this pilot, Mr. Sam Lee created a website that included an interactive presentation on the importance of timely and effective feedback. As Darby points out, "It's easy for online students to feel isolated and unsupported" [5, p. 44]. Feedback, even small notes about low or no stakes assignments, can motivate students to invest more time in the course. Such feedback can also alert students that they are not doing enough to succeed in the class—or are on the wrong track—long before they fail a high stakes assignment. In this way, timely and effective feedback promotes student success.

As the reader may remember, this project was inspired partly as a way to provide student success strategies to faculty who were already strapped for time. And as we know very well, suggesting faculty take time to provide more feedback is not a timesaver. However, in the age of technology, faculty can use the learning management system to "work smarter, not harder."

Solutions that support student success and reduce faculty workload are not always possible, but in this case, the student success strategy was able to support both positive outcomes.

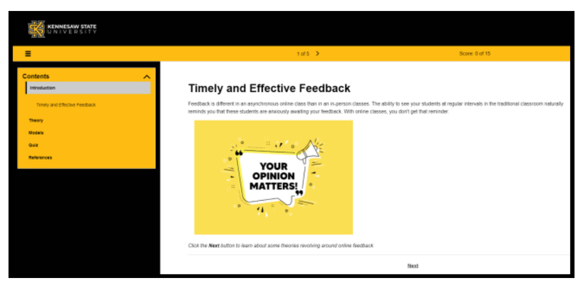

Figure 6. Student Success Minutes 6: a website with interactive exercises and a quiz that provide information about the importance of timely and effective feedback.

This module included the interactive presentation, mentioned above, along with a practice quiz that allowed participants to check their understanding of the material. After the practice quiz, participants took a graded quiz with the same questions. The quiz was worth 20 points, total, and the average grade was 75%. This information suggests that the presentation on timely and effective feedback needs adjustment to increase participant retention of the information. In the next offering of the workshop, this segment will include more engaging activities to support active learning.

VI. Conclusion

The summaries of each segment show that faculty participants did engage with the materials—although they were less successful with the material presented in module 6. At the time of this writing, four faculty members had completed the survey regarding intent to transfer. (The survey is anonymous.) The faculty members did remember all of the Student Success Minutes and liked segments 2, 5, and 6 (GroupMe, weekly modules, and feedback) the best. All faculty members indicated that they will implement at least one of the strategies in the course they are building. When asked if these segments should be included in future trainings, three of the respondents answered "yes." The fourth observed "It would depend on that person's level of familiarity with the pedagogy." Even respondents with previous training made comments such as "This was good--well put-together. Thanks! It added a few small changes that I think will have big effects to my class, so it was worth the time."

Two additional segments are planned-- the power of ungraded self-assessments and engaging discussions--for a total of eight. RCHSS ODE will offer subsequent trainings and collect more data. Additionally, the segments will be separated out and offered as an online, asynchronous faculty training on student success, and participants will be surveyed in those trainings as well. Finally, in the fall 2021, two faculty have offered to incorporate at least one strategy in classes and to survey students regarding responses to the innovation. Additionally, we hope to recruit workshop participants to do the same and share survey results.

Our goal is to have a set of strategies all faculty can easily incorporate into their courses to support student success and gather data showing positive results so that we can have strong, research-based arguments in our funding proposals that increase our chances of earning student success funding. Preliminary results indicate that faculty find the Student Success Minutes helpful and will be implementing them in their courses.

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VirtuElec : A Tool Designed by and for Students for Training in Electrical Hazards

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***Abstract*— The teaching of electrical hazards for future professionals is an important issue. This problem is complex, because to train students in risk, it is necessary to confront them with dangerous situations, but without making them take risks. The VirtuElec project was born in this context: co-producing, with a company specialized in virtual reality, an environment simulating electrical hazards and allowing to train according to different scenarios at different levels of competence. The originality of the project is to involve the students themselves in the construction of this environment. By integrating a project team, they worked in a design office to co-develop this tool and enrich it with video and virtual supports: a training support carried out by students and for students. Students who participated in this project gained knowledge in the areas of electrical hazards, virtual reality, and teamwork, but they felt they gained the most proficiency in the last two skills.**

Keywords- Co-design ; Electrical hazards Simulation ; Immersive Virtual Reality ; Interactive Devices ; Multi-disciplinary ; Problem-Based Learning ; Professional gestures

I. INTRODUCTION

It is essential for students in the field of competence of electrical engineering to have a good knowledge of electrical hazards, in order to be able to identify them and prevent accidents, which are usually very serious. This is indispensable first in the context of their training and for the actions they will have to carry out in the professional world. This is all the more true since, with the development of apprenticeship training and more generally the professionalization of training, learners are increasingly confronted in their training course with situations of potential danger in an industrial environment.

At present, training exists for the students concerned, but it takes place under conditions quite different from those they will face in their professional activity. Even if some interventions are indeed carried out in conditions close to the industrial context, on a real electrical cabinet, they require the presence of a trainer for a student, due to the presence of very real risks. Moreover, this situation is stressful for the student faced with the risk (even if all precautions are taken) and for the trainer, who assumes a heavy responsibility.

The objective of the project, co-developed with a company specialized in virtual reality, was the design of a virtual environment presenting different scenarios of electrical risks. Depending on the level of expertise of the learner, a mission is given to him or her and he or she must take the right decisions in terms of choice of intervention and protection equipment, of behavior in the face of a risk, and of control of professional gestures.

The objective is to have a unique, innovative, modern and efficient tool developed specifically for our training needs. The originality of the project is that it is a real partnership with a company, really involving students who have worked in a design office context, co-developing the tool in terms of ergonomics and functionality: An educational tool developed by students for students. After a presentation of the context of the use of virtual reality for the prevention of occupational risks and the modalities of development of the project in Section 2, the Section 3 describes the methodology followed by the project team, the functionalities of the tool developed, and the Section 4 presents first results of the evaluation of the perception of the project by the students who participated in its conception.

II. CONTEXT

The use of virtual reality for education has been the subject of many articles in recent years, addressing both the interest of this new tool, but also its limitations [1]-[4]. If we refer more specifically to the field of occupational safety and health, realistic virtual environments have many advantages [5][6]. The first and most obvious is the possibility of exploring an environment of potential danger, without taking risks, but also without putting colleagues at risk or causing damage to equipment. The learner also has the opportunity to perform actions and make mistakes without risk to him or her, and without feeling the pressure of other colleagues or the assessor, as would be the case in a real-life scenario [7]. He or she also has the possibility of being wrong, without consequence, and as many times as necessary. All these conditions lead the learner to be a real actor of his or her formation: the solution cannot come from elsewhere; the learner is obliged to act, to interact with what surrounds him or her, to progress in the mission.

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The specific case of electrical hazards, which currently remains one of the main causes of fatal accidents in industrial environments, has been the subject of numerous studies and developments in the field of virtual reality. In particular, mention may be made the application of virtual reality for the training of electricians working on substations [8][9], in the field of construction [10] or power distribution networks [11], and more generally in all fields where electrical risks are present [12]. These generally concern tools for experienced professionals, the aim of which is to enable them to train on devices on which it is usually difficult, if not impossible, to train, either because of their difficult access or because it is impossible to manoeuvre on these elements without causing a customer blackout. Other types of educational tools exist in the context of electrical risk training, the most common being based on videos illustrating risk situations and including quizzes that allow students to position themselves in terms of what to do when an electrical risk appears. Even if these tools illustrate realistic situations, the students are always in the position of an outside observer, and are never really confronted with the potential danger. These learning conditions are therefore far from reality.

The VirtuElec project's approach is complementary to these developments: it aims to enable the training of students with no professional experience related to interventions on electrical installations. In this context, the virtual environment is of course intended to reproduce as closely as possible the real environment, but not in order to remind the learners of their daily life, but on the contrary to make them discover what their real future environment will be. In these circumstances, it is important to simplify the environment by not including too many non-essential elements, so that the learner can quickly focus on his or her mission. In addition, the target audience is wide, and skill levels in electrical hazard situations are very different. It was therefore necessary to provide a virtual environment compatible with several intervention scenarios.

III. MATERIALS AND METHODS

The first step in this work was to constitute a 'project team'. The work carried out is highly multidisciplinary and has been the subject of a close partnership between (1) the "Electrical engeneering team" including two teachers in the field of electrical hazards, two technicians specialized in this field, and 9 undergraduate students; (2) the "partner company", a specialist in virtual reality and recipient of several awards in this field, (3) the "audio-visual team", composed of two technicians, for the production of audio and video media and (4) the "pedagogical engineering team", made up of two pedagogical engineers whose mission is to ensure the accompaniment of all the actors in this innovative approach (Figure 1).

From a practical point of view, the virtual environment was developed to be implemented on Oculus Quest 2 virtual reality headsets, which are autonomous headsets allowing greater freedom of movement and better portability of the device [13]. The possibility of connecting the helmet to a large screen for demonstrations was also provided. Finally, the tool made also allows recording the journey of each learner in the virtual environment in video format, to be able to debrief a posteriori.

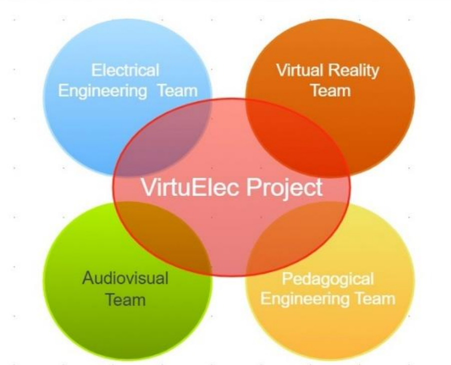

Figure 1 : Synoptic of the VirtuElec project

The actions carried out by the students in relation to the project teams can be divided into 3 main steps:
The first consisted of the design of the 3D environment, including the virtual electrical cabinet on which the learners will have to intervene, but also the operative part, consisting of a robotic arm, as well as a intervention preparation room where the necessary equipment is available. For more realism, a real device present on the training center inspired this virtual set. In this context, the students had to imagine the virtual electrical installation, draw up the electrical diagram, define and then model all the components, and finally to design the implementation in the complete virtual environment (Figure 2)

Figure 2 : Actual electrical cabinet (a) and associated VR modelling (b)

The second step was to design the intervention scenarios for electrician apprentices, simulating 3 levels of competence in a professional environment. The simplest is the beginner level, (including two options: step-by-step guidance or free learning) during which the operator must replace a defective element that was previously indicated to him. The most complex is the autonomous level (autonomy in actions, alerts are displayed in case of error and aids are available) during which the operator must look for the cause of a failure and perform troubleshooting. Finally, the expert level (anticipation of risks before the intervention) during which the operator must manage the safety of a team working on an installation. For each of these levels, the learner is expected to be able to choose the protective equipment and tools required for their mission, follow the correct procedure, and perform the correct technical actions.

In order to have a common language between the “electrical engineering team” and the “virtual reality team”, the scenarios description was developed in Grafcet (graphic programming, easily interpretable by all). For the virtual experience to be realistic, it was essential to give the learner the opportunity to make mistakes up to virtual electrification, simulated by a vibration. Three configurations are the possible (Figure 3): (a) the operations are performed correctly, (b) some errors require to stop the current action and to start it again (the troubleshooter does not intervene on the right element for example) and (c) the errors don’t have an immediate consequence, but will cause an accident in the long term (the operator has incorrectly assessed the risk, or poorly chooses its protective equipment). In case of false manipulation, a vibration of the joysticks and a flash light simulates the electric shock.

Figure 3 : Programming of intervention scenarios

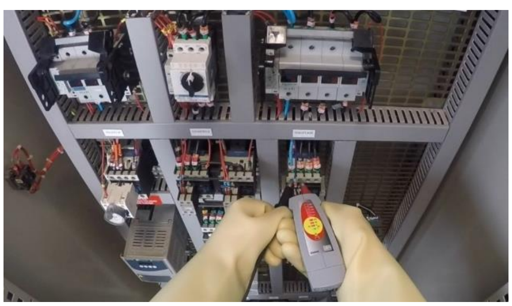

Figure 4 : Image extracted from a video explaining the voltage measurement process

Finally, to illustrate the complex technical gestures, difficult to represent in the virtual environment, because demanding in terms of calculation capabilities, videos are accessible in the form of help in the virtual environment. These videos were shot with immersive cameras to illustrate as accurately as possible the technical actions to be performed, as shown in Figure 4 in a troubleshooting procedure. The final step, which is still partially in process, is the encoding of the scenarios algorithm by the partner company and their testing in the virtual environment for validation.

During the entire development phase of the project, a double follow-up was carried out: first, a technical follow-up, with regular meetings (each week) including the different teams involved in the progress made, and a pedagogical follow-up in the form of questionnaires offered to students in order to collect their feelings on different aspects of the project. The areas questioned were the evaluation of the accompaniment in the project, the links between the project and the teaching, the material and technical environment and the contributions for them of the project, in particular its multidisciplinary aspect.

IV. Preliminary Results

The pedagogical interest of this project lies at two different levels; the creation of a custom VR tool for the training of students on the one hand, and the pedagogical approach of co-design of this tool, including future users in the design of the training tool on the other hand. Now, the tool is still under development, and it is therefore too early to assess its impact on the electrical risk training of students. This analysis will of course be carried out as soon as the tool is in place, scheduled for September 2021. Following this initial implementation and feedback from the student evaluations, we plan to continue to evolve the scenarios and to a lesser degree the virtual environment, in order to make it even more efficient. This evolution will be based on the results of surveys submitted to students in order to analyze their appropriation of the virtual reality tool. These tests will be carried out at two levels: firstly with beginners, for whom the virtual environment will be the only experience of electrical risks, but also with final year students, who will have had the opportunity to work on real electrical installations. The idea behind this double evaluation is to assess the tool's ability to address both the problem of discovering electrical risks for non-electricians and the realism of simulated situations for more experienced users.

The analysis that we have already been able to do relates to the approach of co-designing the teaching support by involving the students themselves. The results of the evaluations, relating to the items described in the description of the method, made it possible to highlight several interesting elements.

First, the students expressed an overall satisfaction level of 9.5/10 for this project. They particularly appreciated the autonomy they were given (100% satisfaction) as well as the support and follow-up (89% very satisfied, 11% satisfied)
In terms of support, the students did not have any difficulty managing the high number of interlocutors around them. On the contrary, they appreciated the cohesion and the diversity of this team and the associated skills was really experienced as an asset. Collaborative work with specialists in other technical fields was evaluated as an asset by 78% of

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students, both an asset and a constraint by 11% and neither an asset nor a constraint by 11% of students

In terms of the links between the project and teaching, the students' perception is clearly that they have developed competence in fields not directly related to their core training, electricity: 56% strongly agree and 44% agree with this perception. They are also aware that they have made progress on aspects related to electrical safety, but less noticeably: 0% strongly agree 78% somewhat agree and 22% somewhat disagree with this perception. It is clear that in this respect, students are underestimating their rise in competence in their field of specialization. To be able to write the intervention scenarios in the virtual environment, students had to reach a high level of mastery of the intervention rules in a context of electrical risk, but this essential aspect appeared secondary to the students compared to the new skills in virtual reality and video production. The reason may be that these two areas are completely absent from their initial competency panel, so the discovery was total.

In terms of the contribution of the project, the multidisciplinary and collaborative dimensions of the project were the most appreciated by the students, more than the technical contribution on the heart of the subject, that is to say the management of electrical risks. Thus, to the question of the main skill developed in the framework of this project, 56% of the students answered the ability to communicate with interlocutors from various fields of competence, 33% the ability to formalize expectations and only 11% the ability to master the technical elements.

V. Conclusion

The developed system allows the learner to be truly immersed in the virtual context. It allows students to project into their future professional world, and to progress at their own pace, and with a level of autonomy that they can manage, by requesting or not to contextual aids present in the virtual environment.

The realization of this project by the students aroused a great deal of enthusiasm and the organisation of the project team as an engineering office allowed a lot of interaction within the micro-enterprise thus formed. While the initial idea of involving students in the design of teaching tools was primarily intended to enable students to develop technical and pedagogical skills, rather, it was found that they placed greater emphasis on the opening of their field of expertise to virtual reality, video production, and team-based collaborative work experience. This awareness of the perceived gap in the interest of the project between teachers and students was only possible thanks to the support of the project by the pedagogical team and the associated desire to better understand how this type of pedagogical initiative is perceived by the main stakeholders. This better understanding of the expectations and motivations of the various people involved will make it possible to sustain and strengthen these actions and better support future initiatives.

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Developing and Assessing a Holistic eLearning 4.0 Model for Higher Education in Saudi Arabia

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***Abstract*— The rapid technological developments in various fields have changed the usual patterns of human life. Clearly, technology has contributed to the diversification of the teaching and learning methods used in the education sectors and has changed the way that information is delivered to students, particularly during the eLearning 1.0, 2.0 and 3.0 stages. The literature indicates that the Semantic Web (eLearning 3.0) has been researched extensively and few issues have yet to be investigated. However, since eLearning 4.0 is a new generation of eLearning, to the best of the researchers' knowledge, very few studies have examined the factors that facilitate its implementation. Given the recent emergence of eLearning 4.0, the aim of this research is to examine the implementation of this relatively new technology in the higher education sector, and a holistic eLearning 4.0 model for Saudi Arabia higher education will be proposed. This will contribute to the Saudi Arabian government's achievement of its goals for the education sector specified in its Vision 2030. In this research, nine factors that constitute the initial model will be thoroughly examined. These factors are: Pedagogical Quality, Academic Success, Environment, Financial Cost, User Support, Behavioural Intention, Collaboration, Satisfaction and "Smart Technology 4.0 Adoption and Design". The contribution of this research is that it examines the effectiveness of the nine factors with a focus on the new factor "Smart Technology 4.0 Adoption and Design", and then improves the initial holistic eLearning 4.0 model. A mixed-methods approach will be adopted. An explanatory sequential design will inform the data collection process. The target population for the online survey will be the academics and the students in public and private Saudi universities. For the collection of qualitative data, semi-structured interviews will be conducted with at least twenty-five e-learning experts. This paper is part of an ongoing research effort to develop and promote e-learning in Saudi Arabia.**

Keywords-*eLearning; HCI; Web4.0; Initial Model; Saudi Arabian Higher Education.*

I. INTRODUCTION

In the introduction section, we defined eLearning, its generations, eLearning in Saudi higher education, and research questions.

A. *eLearning:*

eLearning is defined as the education that the student obtains electronically through a computer network [1]. The delivery of education via information technology has several impacts on the way that teachers teach, and students learn. eLearning can be conducted through direct Internet connection at a specific time or at a time chosen by the students and via any device that suits them [2].

B. *eLearning 1.0:*

eLearning 1.0 was developed as a means of improving education by facilitating communication between teachers and learners using the technologies offered by Web 1.0. In the early transition of education to technology, several digital tools were available in the education system, but they were not connected simultaneously [3]. The use of the Internet was the first step in eLearning 1.0, making it easier for students to access educational material "anytime, anywhere, anyone" [4]. The technical capabilities of Web 1.0 allowed the learner to read only, not write. Instructions were received in the traditional way because the educational materials were unidirectional (i.e., from the teacher) without interaction with the learners [5].

C. *eLearning 2.0:*

eLearning 2.0, according to the description given by [6], is what Web 2.0 provides for educational use. Unlike Web 1.0, Web 2.0 enabled the user to write and save content [7]. It allowed people to discuss and express ideas among themselves, which helped build a social foundation that was missing in Web 1.0 [8]. More specifically, Web 2.0 comprised social networks and their technologies, such as Facebook, Twitter, blogs, podcasts, discussion board, and wikis. eLearning 2.0 enabled the building of social knowledge through multi-directional interactive communication [5]. Moreover, it allowed the teacher to communicate with the students directly and evaluate their learning process. It also gave students the opportunity to contribute their own material and share it with others [3].

D. *eLearning 3.0:*

eLearning 3.0 is based on the Semantic Web, known as Web 3.0. It provides education in a meaningful and content-related way [3]. Instead of documents, the Semantic Web is built on databases [9] that allow users to share data with

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each other without being monopolized [10]. To build an eLearning 3.0 system in a way that facilitates the learning process for students, it is possible to rely on data mining and artificial intelligence to filter the huge and complex amount of data [8]. Modern technology, such as cloud computing, high resolution screens, and large data storage capacity, have contributed to the transition from previous eLearning to eLearning 3.0 [5]. One of the most prominent examples of a system implemented for eLearning 3.0 is the Adaptive Hypermedia Knowledge Management E-Learning Platform that complies with Web 3.0 educational requirements [11].

E. eLearning 4.0:

eLearning 4.0 is the latest technology in digital transformation and innovation in the education sector along with other fields [12], and despite all the advantages that were provided by eLearning 3.0, it has shortcomings because of the nature of Web 3.0 and its technical issues including interoperability, inability of the server to check, inadequate privacy safeguards, and the security risks [13]. The successful implementation of eLearning 4.0 depends on machines as well as people, so it is vital that the two be coordinated. This coordination will find innovative solutions to various problems, which may contribute to improving modern life [14]. For the successful implementation of eLearning 4.0, teachers must be competent users of the eLearning 4.0 technologies. This could be achieved through training courses and workshops designed to improve teachers' skills and efficiency in using eLearning 4.0 in the classroom [15]. eLearning 4.0 can contribute to making learning and teaching dynamic and engaging. In particular, higher education institutions should seek innovative ways to develop educational processes that are in sync with the needs of the Industrial Revolution 4.0 [15]. The concept of Web 4.0 is connecting intelligence which has transferred to eLearning 4.0 [16].

F. eLearning in Saudi higher education

Education is the cornerstone of the Kingdom of Saudi Arabia's Vision 2030 agenda for building a vibrant society. Saudi Arabia, which seeks to develop and modernize its entire education system, aims to keep pace with modern technologies that help students develop their scientific outputs and practical skills during their educational journey to achieve the goals of 2030 Vision. This vision aims, through the educational and academic system, to obtain qualified graduates who can contribute to and help develop a prosperous economy for the country [17]. The higher education sector in Saudi Arabia comprises thirty-nine universities, both public and private, and has one hundred and thirty-nine university campuses [18][19]. In this country, computers have been used in education since the 1990s. At that time, specifically in 1996, the Computer and Information Centre was established, and was responsible for providing technical services to universities [20]. Public universities in Saudi Arabia, which constitute the majority of the higher education sector, have a policy for having a deanship for eLearning and distance education. These deanships build an infrastructure for the success of eLearning in universities by providing the technical means to convert traditional courses into those that can be offered through eLearning while providing support to users to ensure the quality of the education [21].

This paper aims to present the idea to develop a holistic eLearning 4.0 model for higher education in Saudi Arabia. Further research will be carried out in the future to examine the following research questions: 1-What are the essential factors that are required for developing a holistic eLearning 4.0 model for Saudi Arabia? 2-What are the perceptions and attitudes of stakeholders toward a holistic eLearning 4.0 model for Saudi Arabia higher education? 3-What is the Smart Technology 4.0 adoption and design factors required to develop a holistic eLearning 4.0 model for Saudi Arabia?

The rest of this paper is organized as follows. Section II summaries studies exploring eLearning factors. Section III explains the research gap. Section IV outlines the research significance. Section V explains the research methodology. Section VI about conclusion and future work.

II. LITERATURE REVIEW

Based on the studies listed in Table 1, the researchers proposed an initial holistic eLearning 4.0 model for Saudi Arabia (see Figure 1) as the first version of an eLearning 4.0 model for the Saudi Arabian higher education sector. There are nine factors in this initial model: Pedagogical Quality, Academic Success, Environment, Financial Cost, User Support, Smart Technology 4.0 Adoption and Design Factors, Behavioural Intention Factors, Collaboration Factors, and Satisfaction Factors.

TABLE 1. STUDIES EXPLORING ELEARNING FACTORS AND SUBFACTORS.

Factor Name	Definition/sub-factors	Reference
Pedagogical Quality	The pedagogical quality factor plays an important role in eLearning system, since it has seven different sub-factors related to quality: information, instructor, instructor competencies, technical support, course delivery, tutor competence and facilitating conditions.	[22]-[28]
Academic Success	Academic success has five factors: service quality, organizational factors, technology/systems factors, social factors, and instructors' factors.	[29]-[32]
Environment	The environment factor has six sub-factors: e-content development, student awareness, facilitating conditions, social presence, cognitive presence, and teaching presence.	[33]-[37]

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Financial Cost	Price value is the first sub-factor under financial cost. Bates [38] states that the use of technology in education helps to reduce the costs of education incurred by students. Financial support is the second component of financial cost. Every organization and its departments need ongoing financial support in order to survive.	[38]-[41]
User Support	User support has two sub-factors: resource support and training programs. Resource support enables students to communicate easily with both the technical support team and the teachers. The training programs play an influential role in the distance education process.	[42][43]
Behavioural Intention	Behavioural intention is a central factor in eLearning. In this research, behavioural intention consists of six sub-factors namely: social influence, trust, self-efficacy, performance expectancy, hedonic motivation and perceived enjoyment.	[34][39] [54]-[60]
Collaboration	Collaboration in education involves the activities in which a group of students jointly engage in order to accomplish the academic tasks required of them [61].	[43] [61]-[66]
Satisfaction	Student satisfaction can be determined by their continuous evaluation of the quality of teachers in teaching and the quality of the educational material provided to them [26].	[26] [67]-[70]
Smart Technology 4.0 Adoption and Design	Smart technology 4.0 adoption and design factors are essential for eLearning 4.0, and to date have been under-researched. This factor has six sub-factors: flexibility, user acceptance, computer self-efficacy, design quality, infrastructure component, and accomplishment.	[33] [44]-[53]

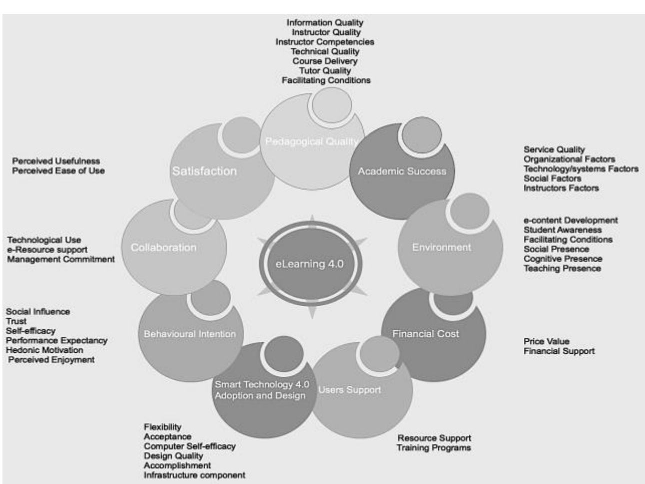

Figure 1. Initial eLearning 4.0 Model - Factors & Sub-factors for Saudi higher education.

III. Research Gap

eLearning 4.0 is a new term associated with other terms like Education 4.0, Pedagogical 4.0, Web 4.0, and Industry 4.0. Numerous factors that facilitate eLearning implementation have been investigated by [39][71]-[75]. To the best of the researchers' knowledge, most aspects of eLearning 1.0, 2.0, 3.0 have been researched and reported in the literature [5][8][13]. Lately, researchers have been studying the concept of eLearning 4.0. Studies by [12][15][16] have explained eLearning 4.0, the new technologies involved, the value added to education, and how eLearning 4.0 will meet the needs of Industrial Revolution 4.0. eLearning 4.0 has been devolved to catch up with new technologies extending to the education environment. These technologies, such as 3D Printing, Augmented Reality, Virtual Reality, Cloud Computing, Hologram, Biometrics, Paper-thin Smartphone, Multi-touch LCD screen, Internet of Things, Artificial Intelligence, Big Data, and QR-code were studied by [12][15] who give details of each technology and its benefit to education. However, many aspects of eLearning 4.0 have yet to be covered as it is a relatively new technology, together with all the technologies related to it. To the best of the researchers' knowledge, no study has been conducted that focuses on the learner or that proposes a holistic eLearning 4.0 model for Saudi Arabia higher education. The available researches conducted on Saudi Arabia [20][76]-[81] have investigated various factors, either from the teachers' or students' perspectives, that influence the implementation of eLearning.

IV. Research Significance

The overall goal of this research is to make a theoretical and practical contribution to eLearning 4.0, specifically in the higher education sector in Saudi Arabia.

A. *Theoretical Significance*

The significance of this research lies in the academic and theoretical contributions it will make to the existing literature pertaining to eLearning. Among other things, it offers a summary of the important factors required for the successful implementation of eLearning 4.0 in Saudi Arabia. Who benefits from this study? The major beneficiaries of this research are the stakeholders in the higher education sector in Saudi Arabia: Ministry of Education staff, university administrators and heads of departments, the IT departments of universities, researchers, and both undergraduate and postgraduate students. The benefit of the research will not be limited to Saudi Arabia, but could extend to neighboring Gulf countries, given the similar cultural, educational and administrative characteristics of the six countries. Overall, the study will make a theoretical contribution since there has been no investigation to date of new factors influencing the implementation of eLearning 4.0 in the higher education sector. The research limitations will open up avenues of future research for other students from Saudi Arabia who wish to pursue tertiary courses and conduct studies in this particular area.

B. Practical Significance

As mentioned previously, eLearning 4.0 is an emerging topic in academia. Given the novelty of the concept, there are several aspects of eLearning 4.0 that researchers around the world have not addressed. Specifically, Saudi Arabia, which has a large area and a diverse geography, needs to adopt eLearning more so than other countries. There is an urgent need for studies to be conducted on the important factors that constitute a successful eLearning 4.0 model for Saudi Arabia. It is anticipated that the results of this study will be of value to all stakeholders in the higher education sector in Saudi Arabia as they will inform the strategies for the practical application of eLearning 4.0. In addition, a model is needed that can avoid the shortcomings, problems, and defects that surfaced during the implementation of eLearning 3.0 in the education sector, which became more clearly evident during the Covid-19 pandemic. The Saudi Vision 2030 specifies that education is a priority and explicitly stipulates the adoption of eLearning throughout the country. This research is well-aligned with the Saudi Arabia 2030 Vision and its goal of improving education in the country. Applying eLearning 4.0 early and with quality, will be effective for Saudis in their journey to keep pace with the needs of the Fourth Industrial Revolution. Finally, the benefits derived this study can be applied to all Gulf countries that have similar systems of education and face the same challenges as Saudi Arabia in this regard.

V. RESEARCH METHODOLOGY

To examine the use of eLearning 4.0 in Saudi Arabia, and to develop an initial holistic model, the pragmatism philosophy will be adopted. Pragmatism is a method based on the abduction concept which oscillates between deduction and induction approaches [82]. For information systems researchers, pragmatism is considered as the ideal approach for their studies as it enables them to use more than one method to obtain a wide range of data, thereby facilitating the answering of research question [82]. The mixed-methods approach involves the collection and analysis of both quantitative and qualitative data [83]. In order to achieve the research objectives, a “sequential explanatory design” will be adopted for this study. The data collection process has two phases: the quantitative phase followed by the qualitative phase [83]. For this study, an online survey will be used for collecting quantitative data, and semi-structured interviews will be conducted to collect qualitative data. After these data have been collected and analysed separately, the results will be integrated so that conclusions can be drawn [84][85]. The significant benefit of adopting a sequential mixed-methods approach is that it provides a comprehensive picture of a phenomenon. Through this approach, statistical results can be obtained from the analysis of the quantitative data, and these can complement or be supported by the qualitative data obtained from, in this case, interviews [83]. The sequential explanatory design prioritises the collection of quantitative data which is considered the more significant of the two [83]. To achieve this aim, the views of stakeholders in higher education in Saudi Arabia in regard to the new eLearning 4.0 model will be collected and analysed. Quantitative data will be collected via an online survey of stakeholders (staff and students). The data will be analysed to determine whether new factors emerge that will improve the initial eLearning 4.0 model. In the second phase, the qualitative data is collected by means of semi-structured interviews conducted with IT experts who specialise in education in the Saudi higher education sector, to gather their opinions about essential eLearning factors that may improve the implementation and ensure the success of Web 4.0 technology in the education sector. In order to obtain valid and accurate data, the sample for the qualitative phase will comprise at least twenty-five experts.

VI. CONCLUSION AND FUTURE WORK

In conclusion, the drive of this research is to develop a holistic eLearning 4.0 model for higher education in Saudi Arabia. What was presented in this paper from: e-learning generations, research questions, literature review on factors and the proposed model accordingly, research gap, research significances, and research methodology will be used as the starting point and basis for future research.

We expect that the model proposed in this paper will undergo development following the next two research phases (the quantitative and the qualitative), and the results and modifications will be published in future papers including answers to the research questions. In addition, the research will suggest new factors that relate particularly to eLearning 4.0 namely “smart technology 4.0 adoption”, which will be examined in more depth. It is anticipated that this work will encourage institutions to implement eLearning 4.0 successfully, thereby supporting the Saudi government’s Vision 2030 goal for higher education.

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DesignAR: Augmented Reality Designing Prototype

Towards a Media Semantic Taxonomy for Art Educational Implementation

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***Abstract*—In the present work, DesignAR, a prototype of Augmented Reality based designing application is presented as a tool for art educational implementation. In addition, a taxonomy for Augmented Reality-related media art analysis is outlined, tracing semantical dimensions with a specific focus on the role(s) of the user when engaging with the artwork. To exemplify both DesignAR as well as the taxonomy as introduced, *Human Cell, Pixel kernel* is presented, inviting the user to reimagine the relationship of the individual within digital transformation. Both application DesignAR and taxonomy are to be employed in future art educational contexts e.g., teacher training or secondary art education.**

Keywords-AR-Designing; Art Education; Prototyping; Media Art; Taxonomy.

I. Introduction

Augmented Reality designing tools offer diverse opportunities in the field of art education with emerging concepts for classroom implementation [1]. With current artistic practice as part of the *Black Lives Matter* movement e.g., *Breonna's Garden* [2], inviting for participatory cocreation, AR art is addressing core societal challenges. When it comes to introducing Media Art with the means of Augmented Reality, didactical positions are still pioneering [3].

When considering classroom implementation, data protection and usability for teachers and students both alike are vital, with prototyping evolving ideally in iterative development cycles [4]. DesignAR was developed accordingly in iterative cycles with art teachers' feedback following the principles of Grounded Theory Methodology. In this context, DesignAR is offering a variety of drawing options and designing features to be employed in art education. Along with the taxonomy for media art analysis, results are vital as didactical material to introduce art educators and students to Augmented Reality in artistic practice.

In the following, we are looking at artistic positions and related work in the field of art education. Next, DesignAR is presented as application for augmented designing. A taxonomy is presented to introduce and analyze AR-related artwork. Finally, the artwork Human Cell, Pixel Kernel is presented exemplifying ways of creating via DesignAR in the complexity of spatial creating and meaning-formation.

II. Related Work

The term Augmented Reality Art (AR Art) is defined as "artwork exhibited in a real-world environment using AR technology" [5] subdividing artwork in pre-AR and post-AR as interactive and low-cost form of artwork [5]. In terms of art theory and semantics, there are a few positions suggesting taxonomies classifying via AR Art analysis [6] or evolving rather in proximity to media semantics [7][8]. Also, AR-related artwork is analyzed in relation to the internet cultural phenomena of interconnectedness [9]. A few positions address AR as similar to a choreographer-cocreator relationship as overlay for dance [10] drawing on media art philosophy e.g., AR-perception as reciprocal aesthetic transaction [11].

In terms of prototyping, pioneering concepts of Augmented Reality Designing were either mimicking traditional forms of painting [12] or exploring unique interfaces, even with the creator's breath as part of Augmented Designing [13]. As pioneers of AR art, the artist collective ManifestAR is to be mentioned laying foundations of public interventions of AR artwork. Here, early forms of co-creative AR-supported designing settings were evolving [14].

Artistic positions blending artistic practice with art theory are vital as predecessors, similarly combining AR-based designing tools with concepts of media art e.g., Jess Herrington [15]. Artie Vierkant is to be mentioned, exploring the borders of image and object via AR both artistically as well as via art theory (Image Object, 2018) [16][17].

Social AR forms of Augmented Reality creation and sharing are increasingly prominent, also as platform for artists e.g., with *Lens Studio (Snapchat)* [19], inviting to feed into platforms with easy-accessible ways of AR-filter-creating. Next to social media-related applications, there is a number of

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AR designing applications currently available such as graffiti-style *PaintAR* [19] or *Adobe Aereo* [20] and *AR Makr* [21].

Now, when it comes to art educational conceptualization and evaluation of AR drawing, there are a variety of positions, ranging from paper-based augmented drawing for primary and secondary school [22] to gamification and AR overlay [23]. Media Art classes in the field of AR in higher education are relevant to the prevailing work, for blending AR artwork and didactical conceptualization at university level [18][25].

III. DESIGNAR

In this section, the architecture of DesignAR is outlined along with a taxonomy for AR-related artwork.

A. Prototyping

DesignAR was developed in iterative cycles. The initial prototype was part of an art historical city guide as prototype dedicated to redesigning an existing memorial with basic features, (e.g., adding text/coloring existing shapes and adding 2D images) as participatory elements in a guided city tour on the Revolution of Bavaria (1918/1919) [26][27].

For the next developing steps, DesignAR was designed with the aim of implementing features for a wider creative choice in virtual designing as follows. In a study with art teachers (N 20) and artists (N6), media cultural framings and didactical employment were analyzed [28]. The results obtained through Visual/Grounded Theory analysis hint to cultural effects of media in the acceptance of technology. Some were riding the line of engagement and distancing while others were either affirmative or skeptically biased in their decision-making and conceptualizing towards classroom implementation. Eventually, a variety of potential projects and methods for art education were put together, from the interpretation of 2D paintings in 3D to architectural redesign or poster presentation in 3D [28].

B. Architecture

DesignAR employs Google *ARcore* [23], with simultaneous location and mapping technology, relying on the mobile devices' sensors e.g., RGB camera and accelerometer, gyroscope, and magnetometer. It is is based on Unity/C# with elements defined as Game Objects [24].

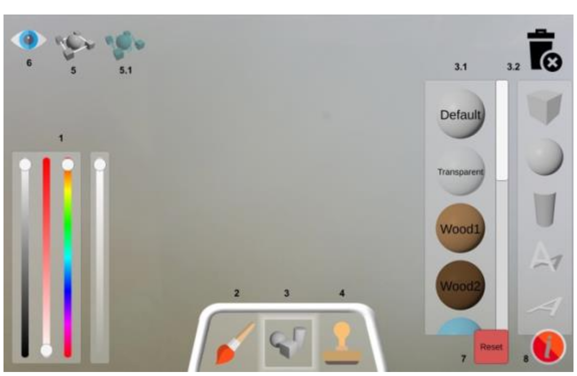

Figure 1. DesignAR UI

Features of DesignAR:
1. Color Picker/RGB/Transparency/Dark/Bright.
2. Drawing tool: related to device position and drawing on surface.
3. Brush styles: oil color/text marker/curls.
4. Inserting Objects: cube/sphere/cylinder/text editor.
4.1. Texture for objects: wood/plaster/gold/silver/transparent
5. 2D-Picture Stamp tool, access to picture gallery of device
5.1. Group objects and navigate in groups.
5.2. Ungroup objects.
6. UI mode vs. camera mode.

DesignAR is currently available for Android, planning to be released for android and ios as next step.

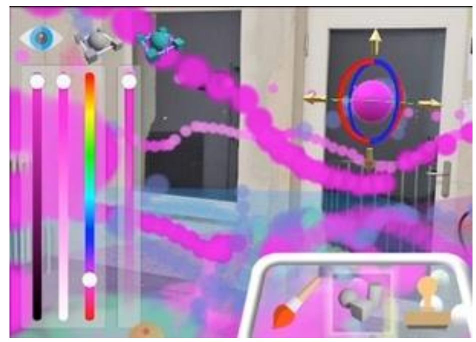

Figure 2. DesignAR exploration: Navigating 3D Objects

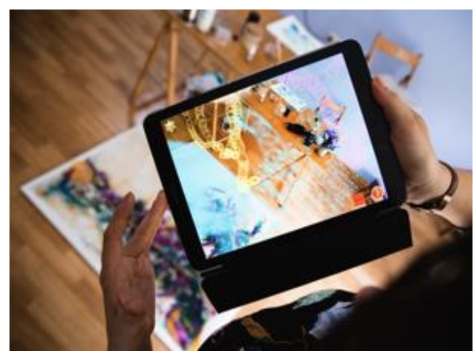

Figure 3. DesignAR, Interpreting 2D Paintings (Ledényi, Bäck 2019)

C. Taxonomy

In the following, a taxonomy to introduce AR-related artwork is presented. It is understood as a taxonomy for a first introduction to AR art, with future positions of AR-related art to be blending as variations further on. It is also understood as a media semantical classification based on the analysis of AR-related artwork and art theory (c.f. related work). The model is extending existing concepts of AR-based taxonomies [5][9], now with a closer look at the roles of the user when engaging with AR-related artwork. After all, multiple dimensions e.g., tactile or audio-augments also are to be considered, with respect to blind users as inclusive forms of AR-related artwork.

TABLE I. TAXONOMY OF AR-RELATED ARTWORK

USER	***CONTENT***	***SPACE***
Role Observer Creator Choreographer Embodiment **Combination of roles** **User Consent vs. Intervention**	**2D/3D** **Moving/ static** **Audio/Tactile** **Motif**	**Flexible vs. Site-specific vs. User-centered** **Private/Public** **Curated vs. intervention**
SOCIALAR		
Singular vs collaborative artwork **Sharing & Remix** - sharing of individual artwork - shared objects via database (Adobe Aereo)		

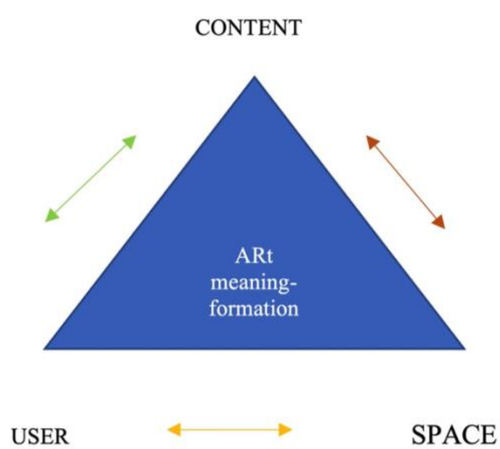

Figure 4. Taxonomy embracing User, Content, and Space, and relations as ARt meaning formation

Besides architecture of AR-related artwork, it is vital how meaning is conveyed into interrelation: **User-Content relation:** Which role is assigned to users? Are users rather observers or creators e.g., AR-drawing filter *Drawing with Jelly*, Jess Herrington (2018) [31]. Are they embodying in hybrid filter artwork (e.g., Internet Dream, Jess Herrington 2019) [32]? Are users also choreographers, i.e., with performance and dance to be augmenting via AR (*Soi moi*, n+n corsino, 2009) [33]. Is there a combination of roles e.g., creator/observer? After all, is there user consent or an intervention without awareness of participants (EIO: *Coin Chase*, Mat Rappoport 2012) [34]? **Content-Space relation:** How does content as augmented information relate to space? Is there a reconstructive to transformative take on actual spaces? It may be not relating to a specific site, but rather to the user (e.g., *Internet Dream*, Jess Herrington) [32]. **User-Space-relation:** How do users relate to the site within the Artwork? Here, navigational features or shifts of perspectives are examples as explored in artistic practice (Craig Freeman/William Tilson: *Imagining Place*, 2008) [35].

D. DesignAR: Human Cell, Pixel Kernel

In *Human Cell, Pixel Kernel* (Figure 5), virtual representations of cells are floating around the user. Via DesignAR, a selection of cells is offered to stamp in the individual's surroundings. Viewers also may add other AR objects as inspired by the theme. *Human Cell, Pixel kernel* employs the metaphor of a petri dish where the individual viewer is attributed to be floating amidst other "participants", eventually blending the roles of observer, creator, and (imaginatory) embodiment. In *Human Cell, Pixel Kernel*, questions of autonomy are addressed: "Are we passive or active amidst digital transformation?".

Figure 5. Human Cells, Pixel Kernel, Screencast DesignAR (Bäck, 2019)

IV. CONCLUSION / FUTURE WORK

We presented an AR-based designing prototype along with a taxonomy of AR-related artwork at the intersection of user, space, and content. With respect to art educational employment, the taxonomy could be introduced encouraging to look for individual examples. With respect to prevailing studies on media culture relating to technology acceptance [28], it would be interesting to look at art educators' encounters of Media Art also inviting to reflect upon media cultural self-awareness.

Also, re-evaluating DesignAR for an inclusive educational practice is considered as viable for a novel research focus. For instance, how are affordances of deaf vs. hearing students with respect to AR designing tools e.g., focus of attention when

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using in public space? It is vital to pursue further research to foster inclusive and safe criteria of AR based applications.

The next steps for app design improvement are potentially the programming for iOS besides android as it is in the current state. Additional features such as inserting individual 3D objects in motion with co-creative interfaces would be fruitful considering classroom implementation as peer-to-peer or teacher-peer interfaces. Here, gaining insight in qualities of augmented imagination in the sense of re-imagining space via DesignAR would be interesting.

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