Early use of augmented cognition for online learning games in Hawai‘i

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Abstract: This paper provides a historical and regional perspective on the adoption of technologies in online learning, focusing on gamification as an aspect of technological innovation and research in Hawai‘i. The paper also addresses transitions in technology uses and instructors' opportunities for adopting new technologies for online learning, specifically gaming and its potential contribution to augmented cognition's goal of increasing task performance by directly addressing the motivation of the user to remain engaged in the learning activity. An extended example is provided from research involving language learning in an online instructional collaboration between Hawai‘i and Japan. Further, we discuss how gamifying instruction in online learning and technology has transitioned, empowering both instructors and learners to create content with learning driven strongly by them. We show how historically gaming in online learning has help foster the flow of ideas, connection, and relevance for students.

Keywords: augmented cognition, gaming, simulations, online instruction

1 Introduction

This paper examines serious online games used for educational purposes in schools and universities. Given the popularity of online games and applications (apps) among children, adolescents, and young adults, there is enthusiasm for their implementation as instructional tools, especially as much of the world's instruction has moved online in the Covid-19 era. However, is this enthusiasm warranted? What specific gamification features are effectively and easily adopted by instructors in online instruction? What are the challenges to incorporating gamification aspects in instruction? To address these questions, we first examine relevant research that empirically examines aspects of educational games that have been demonstrated to be effective. Then we present, as a case study from a historical perspective, the development of aspects of gamification in online instruction Hawai‘i. As the 50th state in the US, Hawai‘i's demographics – its cultural milieu - and geographic isolation have created a unique environment for technological innovation including online instruction and gamification in educational contexts.

1.1 Games, gamification, and serious games

For purposes of this paper, we begin by describing a serious game as one with a purpose beyond mere entertainment. As computer science and education professors, in this paper, we focus on serious games that help students learn some content.

However, what is a game? Defining "game," and "gamification" is no simple task and could be the focus of the entire paper. However, as Plass, Homer, and Kinzer [48] described, "What exactly is meant by gamification varies widely, but one of its defining qualities is that it involves the use of game elements, such as incentive systems to motivate players to engage in a task they otherwise would not find attractive" (p. 259). Further, they quote Salen and Zimmerman's [54] definition of game, as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p. 80).

In considering serious educational games, we note that although most definitions of games such as the ones above focus on incentives, Plass, Homer, and Kinzer [48] also mentioned the importance of "play" in games and the potential social and participatory aspects of games. We would emphasize these aspects in our conceptualizations of instructional games. Furthermore, although reward structures often imply competitive elements, we include simulations, role play, and social/collaborative aspects within immersive environments as elements of gamification in online settings. Such elements do not always involve clear reward structures, competitive aspects, or winner/loser outcomes beyond the intrinsic motivation inherent in participation. For example, students can work together to create or participate in an immersive environment. Additionally, we recognize that not all online learning environments employing elements of gamification are fully gamified. Realistically, a teacher or instructor incorporates aspects of gamification when those are determined to facilitate instructional goals, are within the instructor's (and students') technological expertise and are available for use. Thus, costs and benefits are assessed. One way to begin to assess potential costs and benefits is to evaluate research on serious games. In the next sections, we review research on Internet and game use generally, then we focus on empirical research on serious games for instructional purposes.

1.2 Internet and Game Research

Anderson and Rainie [1] of the PEW Research Center described the results of an online survey in which "53% agreed…[that] 'By 2020 there will have been significant advances in the adoption and use of gamification. It will be making waves on the communications scene and will have been implemented in many new ways for education, health, work, and other aspects of human connection and it will play a role in the everyday activities of many of the people who are actively using communications networks in their daily lives." (p. 3). Several respondents also objected to the term "gamification," and predicted it would soon be outmoded, and others elaborated on the potential contributions and detriments of games.

More recently, Perrin [45] of Pew Research Center described five trends in American gaming culture. A survey study by Parker et al. [43] found that a majority (72% ages

18-29 and 58% ages 30-49) of young men often or sometimes play video games. About 48-49% of women ages 18-49 often or sometimes play video games. Overall, about 43% of adults play video games. Of the types of games that were most popular, strategy (62%) and puzzle games (62%) were most played followed by adventure (49%) and shooter (42%) games. Among teenagers, 82% reported having a game console at home and 90% reported they played games on their computer, game console, or cell phone [17]. About 41% of teen boys and 11% of teen girls reported that they spent too much time playing games. Another 41% of teen boys and 42% of teen girls reported that they spent about the right amount of time playing video games [17]. The last major trend was that many adults, 82% of those 65 years or older and 42% of those 18-29 years of age, thought video games were a contributing factor to violence [43].

Over the years these authors have observed and assessed technological innovations and their inclusion in instructional contexts, we note some common trends: Hyper-enthusiasm of some convinced that a new technology will be an instructional panacea (e.g., instructional television American Samoa in the 1960's and 1970's) contrasted to fears and resistance exhibited by those convinced we are on a road to instructional and social ruin. For example, Gershenfeld [19] pointed out with respect to today's computer games, "On the one hand [some authors] are making the case that games and 'gamification'...can save the planet. On the other hand, parents struggle with the amount of time their kids spend on digital media – roughly eight hours a day.... And it is hard for parents to watch their children gleefully annihilating virtual humans with heavy artillery and not be concerned" (p. 56).

In contrast, one of the strongest claims in favor of the contribution of games in education is the example Anderson and Rainie [1] who described the University of Washington's game Foldit. In 2011, 46,000 gamers on Foldit participated in generating a solution for how a particular protein might advance a cure for HIV. Most notably, the gamers' solution was generated in 10 days in contrast to the 15 years that scientists had invested in this work. Indeed, it appeared that the potential for serious gaming contributions had only been touched upon. Even before Foldit, the Sony PlayStation was used by the Stanford Folding@Home program [26, 65], where Sony and PlayStation reported more than 15 million users donated over 100 million computation hours from their home console the PlayStation 3 from 2007 to 2012.

However, these prognosticators, both optimistic and pessimistic, certainly did not count on the rapid and ubiquitous move to online instruction as a response to the COVID-19 pandemic – a factor that has pushed serious games, and their related potentials into the forefront. However as dramatic the COVID-19 pandemic reaction seems; we predict this surge will be surpassed by an extensive use of AI and LLM software that gamify educational online games to augment a learner's cognition. Although in a Pew report on the state of the internet, Anderson, Rainie, and Vogels [2] consulted various innovators, experts, and researchers on their views of social change and technology considering the aftermath of the 2020 pandemic and with an eye toward 2025. Amidst the many themes described changes in education prompted by the mass movement to online instruction as a driver for instructional innovation is relevant to the present discussion. Clearly any teacher or instructor (or parent) knows the strongly motivational aspect of games. As Theodor Geisel [20] stated in a children's book, "Oh the places you'll go! There is fun to be done! There are points to be scored. There are games to be won!" The contention that underlies this paper is that if employed in ways that facilitate learning, "serious" or educational games, in contrast to merely entertaining ones (of the sort we presume Suess described), valuable contributions to learning can be made.

1.3 Game research

Given that games have been highly touted in educational contexts and considering given the presence of high degrees of optimism regarding these and other technological advancements, it is imperative to examine the genuine empirical effects of games as documented in the research. Mayer [32] quotes his own earlier determination, "Many strong claims are made for the educational value of computer games, but there is little strong evidence to back up those claims" [31, p. 281].

In 2013, Wouters, van Nimwegen, Oostendorp and van der Spek [69] conducted a meta-analysis of serious games. They concluded that games facilitated learning over conventional teaching strategies, particularly when accompanied by additional instruction and involving group activities. Contrary to popular expectation, serious games alone did not increase motivation. However, Ikehara et. al. [25] reported a gamified activity in which the instructor's goal of the child learning fractions and the child's goal of participating in an engaging activity were mutually satisfied. Evaluating the value of a fraction can increasingly be a challenging task for children and adults alike, as the numerator and denominator of the fraction increase in size. The goal of teaching fractions is normally accomplished by asking children to repetitively practice fraction problems of increasing difficulty. A typical fraction exercise may consist of a set of problems varying from an easy example such as "Is 1/2>1/3?" to "Is 11/18>1/3?" which can be more difficult. In a project initially designed to use the physiological sensors of augmented cognition to determine cognitive load, the fraction exercise, known as "The Moving Targets Fractions (MTF) task was gamified by Ikehara and his colleagues. MFT presented a fixed number of oval targets containing fractions on a computer screen. These fractions floated across the screen from left to right. The cognitive load was controlled by adjusting fraction values, speed of the fractions across the screen, and how many fractions were presented. The primary goal of the user is to maximize the score by selecting the fractions greater than 1/3 before they reached the right edge of the screen. This engaging activity also gave the instructors the ability to determine if individual students found the level of difficulty to be easy or hard.

Since streaming video games became popular, an activity emerged where spectators (streamers) watch players engaging in video games. Twitch is one of these popular sites viewed by millions of viewers who visit it each day to watch other players compete in popular online games. Biometric data is used to enhance the spectator experience. Software such as "All the Feels" [52], developed by Robinson et. al. in 2017, provides an overlay of biometric and webcam-derived data onto the screen to reveal the biometrics of the streamers to the spectating audience. A dashboard provides a visualization of the streamer's heart rate, skin conductance, and emotions. The researchers found that this additional layer of data enhanced the viewers' experience and improved the connectivity between the streamer and spectator.

A systematic review by Manzano-León et al. [30] of studies from 2016 through 2020 that sorted through 750 articles from Web of Science, Scopus, and Dialnet, found that 227 were duplicates. From 198 of these studies that were further analyzed., 184 were further excluded because they were not about formal education environments, not about gamification in education, or did not specify gamification. The reviewers' final fourteen experimental and quasi-experimental studies of educational games indicated that games can improve students' academic performance and motivation [30]. Additionally, the commitment of students to persevere through the learning experience provided by the games was elevated.

An additional recent review is provided by Mayer [31] who reviewed empirical research on educational games and developed a useful tri-fold typology or trifecta for this research including: "(a) value-added research, which compares the learning outcomes of groups that learn academic material from playing a base version of the game to the outcomes of those playing the same game with one feature added; (b) cognitive consequences research , which compares improvements in cognitive skills of groups that play [a]… game to the skills improvement of those who engage in a control activity; and (C) media comparison research which compares the learning outcomes of groups that learn academic material in a game…to those who learn with conventional media" (p. 531).

In the value-added category are features of games that can render them useful. He described the following as having positive effects in the value-added research: the use of "spoken text," language that is "conversational," pretraining on a game, "coaching" throughout and prompts requiring participants "to explain or reflect" (p. 538). Unexpectedly, Mayer [31] described his own finding that virtual reality was not a feature that improved learning over simple computer depictions. For cognitive consequences studies, games were found to improve perceptual attention and aspects of mental rotation. Finally, media comparisons indicated games facilitate learning in math, science, and second-language studies.

In addition to typologies and empirical research reviews, the present authors contend that case studies of the development and implementation of educational games in specific cultural and historical milieus can be valuable for understanding the processes, developments, and instructional factors that contribute to instructional success with games. Thus, we focus on the Hawai‘i context.

2 Hawai‘i background

To provide some geographic/demographic background, Hawai‘i comprises eight major islands in the central Pacific and other uninhabited islands, atolls, and seamounts across 1,500 miles. The annual estimate of the population in Hawai‘i is 1,407,006, 21% of which are age 17 or under according to U.S. 2020 census data [62]. The larger ethnic groups are white (25.5%), Asian (37.6%), two or more races (24.2%), Native Hawaiian and other Pacific Islander groups (10.1%). Hawai‘i’s state (public) university system consists of 3 universities and 7 community colleges and there is a single statewide department of education (DOE) that administers public schools and complexes at the elementary and secondary levels.

Although Hawai‘i’s cultural/ethnic mix is different from the rest of the US, many technological and educational needs are the same. Further, by virtue of geographic isolation and distribution of the population over an island chain, there is a pressing need to be at the forefront of technological innovation particularly with innovations regarding distance education. A further and central consideration is accommodating learners from a range of linguistic and cultural backgrounds in the broader Asia-Pacific region, making Hawai‘i the ideal “test bed” for 21st century technologies in educational contexts.

In the next section, we focus on several seminal developments that took place in Hawai‘i to describe its long history of gamification.

2.1 Past online instruction in Hawai‘i with simulations

Returning to the Hawai‘i situation, we illustrate with examples from the past the continuing cycle of challenges and successes in implementing games in online instruction. Then, we describe more recent examples and contrast the early enthusiasm and optimism regarding these technologies’ instructional potentials with a perspective tempered by instructional use in different contexts. We as authors draw upon our different disciplinary and teaching perspectives in computer science, educational psychology, and high school teaching.

We integrated a wide variety of platforms and social technologies with collaborative learning approaches into courses taught at the University of Hawai‘i by different instructors to address educational trends to increase engagement in college courses. The courses spanned educational psychology, computer science, and language learning. Students made use of a variety of free interactive technologies to meet synchronously online in small teams of three or four to carry out collaborative tasks and projects assigned in a particular course.

The advent of the Internet provided fertile ground for improving the design of learning. Networks made it possible to use simulations of natural social settings, even using somewhat primitive technology. The success of the improved curriculum design, however, should be attributed more to the pedagogy that provides the stimulus, than the technology. If technology is used in ways that make sense for the curriculum to the students and teachers, the projects are likely to succeed.

For example, UH researchers were able to use primitive tools such as experimental computers and teletypes to provide online education to high school students from the neighbor islands and other areas of Oahu in the early 1970’s. This was accomplished by using an innovative system of networked computers called ALOHAnet, a precursor to the Ethernet and Wi-Fi systems [24]. Almost thirty years later, in 1999, cross-cultural content was made possible also using relatively primitive Web technologies that allowed language learners to interact with other learners and native speakers of the second language in role-playing and problem-solving games.

An example of the early possibilities of a language learning game was Kanji City, begun in 1988 [4]. This game utilized hypermedia (HyperCard) to create as fully an immersive experience for language learning as was possible at the time. As the authors explained, “It employs the metaphor of navigating an urban environment (Tokyo) by reading and reacting to the signs occurring there -- a special problem in the case of Japanese and Chinese Orthography” (p. 28). Actual signs in the city, stops on the train, were used in participants’ navigation. Participants exchanged money, bought tickets for the train, interpreted maps, planned, and “went” on excursions to restaurants, used menus and placed orders, went to casinos, school, a disco, a bank, and a coffee house. In the school they could pass tests to earn currency, calculate using an abacus. In the casino, they could “play” a slot machine to earn currency. At the disco, they could listen to popular music. Even at this writing, over 30 years later, one can imagine the students’ excitement and enthusiasm in participating in such an environment.

Another early example of a learning environment that began in 1997 [67] involved the collaborative and cross-institutional development of virtual team projects by students and instructors of Japanese working together from the University of Hawai‘i in Honolulu, Hawai‘i, USA, Seiryo Commercial High School in Nagoya, Japan, and Haverford University in Philadelphia, Pennsylvania, USA (three very geographically-dispersed locations) [23]. Students conducted Internet-based synchronous and asynchronous sessions using the following tools: eWeb Chat and Forum, Microsoft Chat-2 and Net Meeting, WebCrossing, CUSeeMe, CoolTalk, and email. Teams created an “ideal town” via MUD/MOO-like team rooms. Designing the town required intensive imagination, negotiation, and design - a clearly gamified and immersive aspect that capitalized upon the tools that were available at that time. The town included a bookstore, restaurant, educational and recreational facilities, and a hot spring. Thus, in this virtual town teams visited and completed business dealings involving the use of more specialized and advanced language and conversational skills than would be used in many Japanese- language courses. The USA-based students also produced a Web-based magazine with the Japan-based students acting as reviewers. Additional socialization among groups took place during brainstorming activities, interviews, and presentations.

These socializations and conversational exchanges exceeded typical language-learning dialogues with other language learners that occur in face-to-face classes. Situations were created that simulated a range of genuine social interactions with Japanese native speakers. Students’ conversations were in Japanese language and computer-based interaction involved using Romanji (Roman characters). For instructional planning, faculty members utilized groupware technology that then existed. Other interactions and introductions between the groups of students involved the early uses of chat rooms. Technologies that were used at this time involved CUSeeMe enabling video-based interactions, and CoolTalk, an Internet telephony program.

The first author of the present paper and other researchers involved in this project noted that students’ involvement in gamified aspects of this project, particularly the “design a town” task seemed truly immersive and appeared to parallel game designer Jane McGonigal’s work [33, 34]. Specifically, she identified four “powers or abilities” inherent in computer games [35, 36] that facilitate the progress of a game for players resulting in a "flow" state. According to Csikszentmihalyi [9, 10, p.74], "Flow tends to occur when a person's skills are fully involved in overcoming a challenge that is just about manageable". Murphy [35] identified the affective current essential to flow states in the discussion of the laws of learning and game design, "flow is entirely about motivation, our first law of learning for games. Specifically, flow is about intrinsic motivation – the joy of doing." The first game power McGonigal [33] described was termed "urgent optimism" and represents an ability and desire to enthusiastically re-assess the environment to find the next challenge. The second power, "blissful productivity" enables one to continue the quest by evaluating progress through benchmarks and feedback. Third is "social fabric" that enables one to experience the pleasures of community belonging. Lastly, "sense of epic meaning" involves efforts directed toward large-scale rather than solely individual goals.

1. Urgent Optimism
2. Blissful Productivity
3. Social Fabric
4. Sense of Epic Meaning

Results from analyses of chats showed various approaches to teaching and indicated challenges inherent at that time in using an Internet-based learning environment. The sample analysis shown in Table 1 shows a sample of chat transcripts coded to indicate McGonigal's [33] four "powers or abilities" associated with aspects of gamification that were speculated to be associated with flow states.

This type of early virtual classroom allowed students to practice and develop second language and cross-cultural communication and collaboration skills in as highly realistic yet simulated environments as were possible given the technologies at the time. Developing a town involved the kinds of creativity and imagination one employs when interacting in imagined, virtual worlds that typify the contextual aspects of online games that were emerging and would follow. Early uses and recognition of aspects of gamification and how they might effectively be employed in serious learning contexts depended upon implementations such as these, mostly developed by Computer Science faculty members. However, adoption and use of such aspects of gamification for online learning was slower among instructors, lecturers, and professors not as adept with Computer Science, aspects of gamification, or online learning.

These approaches to gamification in online learning demonstrated early use of augmented cognition in these systems. When evaluating gamification implementations, measures such as time-to-respond were considered but not deeply rooted in the design and development of the learning environments.

Fifteen years later, the initial optimism regarding online learning and gamification had dampened a bit and focused on instructional and pedagogical issues rather than on the online technologies themselves. The rapid development of online technologies to improve online teaching and learning experiences has improved the veridical nature of the instruction so that in many ways early criticisms of lack of face-to-face contact among students and instructors is no longer an issue. However, the inclusion of gaming as an instructional strategy in online environments appears to have been adopted initially by the most technologically adept instructors, such as those in computer science, educational technology (with a professor using Second Life) and learning technology.

Table 1. Powers of gamification example (translated from Romanji into English)

Threaded Discussion Posts	Game Power
Well then...shall we send everything that we decide to Nagoya? Then, getting feedback from them…how about it? Without waiting for time	Urgent Optimism
Why don't we make up the list of things to decide right now…I'm a bit confuse…sorry about that	Urgent Optimism
It may be a better idea to send a compilation of things about how the town is shaping up.	Urgent Optimism
On the roof, why don't we just put some kind of bench up there like they have in the park?	Blissful Productivity
In any case I think the first floor will end up being pretty noisy because there are comics and cartoons there.	Blissful Productivity
And on the roof, you can even talk in a quiet voice because it is outside.	Blissful Productivity
Did you read the email from Nagoya people? She recommended dokudamiburo and the sakeburo. What do you think?	Social Fabric
Don't you know about dokudami tea? It's a variety of tea that is bitter and, to tell you the truth, it tastes really bad but it's good for the health apparently. They say that it's good if you put the leaves into the bath and it's apparently very effective in relieving back pain.	Social Fabric
I think that having a sake bath would attract a lot of customers but if you enter a sake bath you will smell of alcohol and people will mistake you for being drunk.	Epic Sense of Meaning
A sake bath means that you put sake into the bath. Wouldn't you get drubk from the aroma?!	Epic Sense of Meaning
Yeah, let's continue with the discussion of the hot springs.	Epic Sense of Meaning

2.2 The U.S. and Hawai‘i in the present context

The Pew Research Center [46] estimates that 90% of people in the U.S. use the Internet. The 2019 United States Census revealed that of the 121,520,200 households in the U.S., 91.8% had a computer and 85.4% had Internet access in 2018. Hawai‘i households were very similar. Of 455,300 Hawai‘i households, 91.8% had a computer and 85.9% had Internet access in 2018. In 2016, Hawai‘i already had slightly higher broadband subscriptions such as cable, fiber optic or digital subscriber lines/DSL at 73% and the U.S. at 67% [21].

As seen in Table 2, about 77.7% of the population in 2017 used the Internet from anywhere, with 25-29 years olds reporting the highest use at 85.6% followed by 20- to 24-year-olds then 15- to 19-year-olds. The largest fluctuation was seen in the 3- and 4-year-olds who jumped from 19.9% in 2003 to 86.9% in 2010 then back to 31.6% in 2012 then up again to 51.0% in 2017 (see Figure 1). But the largest growth has been among those age 70 and older, increasing by 37%. In general, the adult population increased about 22 percentage points between 2003 and 2017. Should there be alarm that so many young people are using Internet technologies so early in life? Perhaps not since access to those technologies would likely not be possible without adults giving them access. But the impression remains that these children will be growing up into a world where the Internet will have more influence than not.

Table 2. Number and percentage of persons 3 years old and over who use the Internet

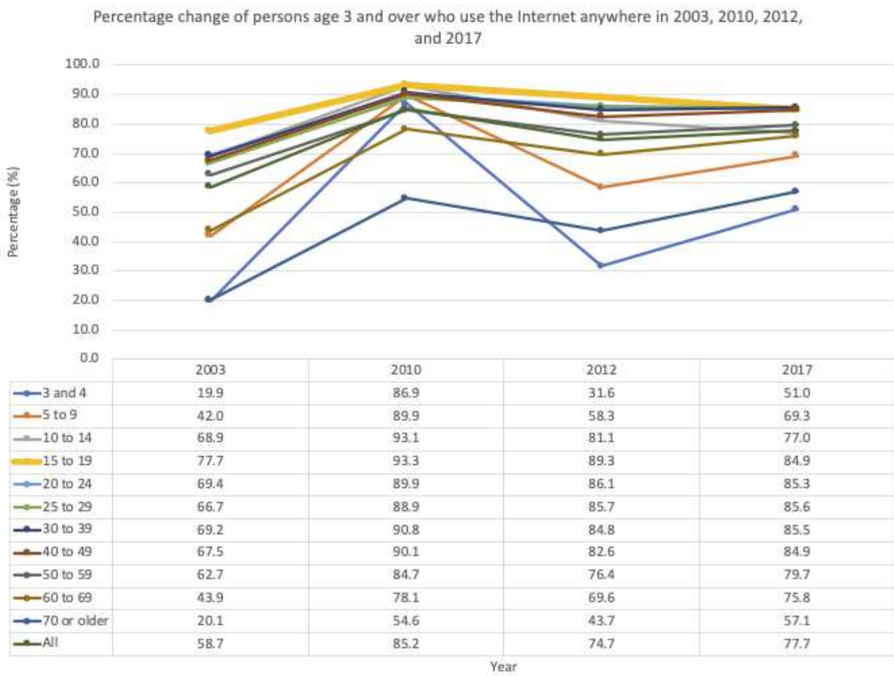
	2003 U.S. Census		2010 U.S. Census		2012 U.S. Census		2017 U.S. Census		Between 2003 and 2017
Age	# (in thousands)	% of population	# (in thousands)	% of population	# (in thousands)	% of population	# (in thousands)a	% of population	% change
3 and 4	1,662 (62.5)	19.9 (0.67)	7,693 (80.9)	86.9 (0.73)	2,534 (81.9)	31.6 (0.93)	8,003	51.0 (1.18)	+31.1
5 to 9	8,259 (137.2)	42 (0.54)	18,753 (109.3)	89.9 (0.50)	11,961 (148.95)	58.3 (0.65)	20,434a	69.3 (0.68)	+27.3
10 to 14	14,570 (179.4)	68.9 (0.49)	18,640 (90.2)	93.1 (0.39)	16,720 (152.83)	81.1 (0.64)	20,699a	77.0 (0.71)	+8.1
15 to 19	15,768 (186.1)	77.7 (0.45)	19,410 (81.3)	93.3 (0.37)	18,785 (200.46)	89.3 (0.47)	21,042a	84.9 (0.58)	+7.2
20 to 24	13,800 (174.9)	69.4 (0.50)	18,986 (93.3)	89.9 (0.44)	18,846 (258.24)	86.1 (0.50)	22.066a	85.3 (0.55)	+15.9
25 to 29	12,492 (167)	66.7 (0.53)	18,781 (95.6)	88.9 (0.45)	17,721 (185.24)	85.7 (0.51)	23,336a	85.6 (0.52)	+18.9
30 to 39	28,580 (242.3)	69.2 (0.35)	35,792 (133.5)	90.8 (0.34)	33,493 (199.96)	84.8 (0.41)	43,876a	85.5 (0.42)	+16.3
40 to 49	29,978 (247.3)	67.5 (0.34)	38,582 (123.5)	90.1 (0.29)	34,526 (162.92)	82.6 (0.35)		84.9 (0.43)	+17.4
50 to 59	21,911 (215.9)	62.7 (0.40)	35,171 (165.3)	84.7 (0.38)	32,890 (221.95)	76.4 (0.42)		79.7 (0.40)	+17.0
60 to 69	9,677 (148)	43.9 (0.51)	22,622 (158)	78.1 (0.45)	22,171 (176.46)	69.6 (0.49)		75.8 (0.43)	+31.9
70 or	4,940 (106.9)	20.1 (0.39)	14,603 (158.3)	54.6 (0.60)	12,391 (233.25)	43.7 (0.54)		57.1 (0.52)	+37.0

older									
All	161,636 (309.1)	58.7 (0.14)	249,031 (580.7)	85.2 (0.20)	222,032 (673.6)	74.7 (0.21)		77.7 (0.24)	+19.0

[a] Numbers were no longer reported with percentages in age groups. Age groupings were reported as 3 and 4, 5 and 6, 7 to 13, 14 to 17, 18 and 19, 20 and 21, 22 to 24, 25 to 29, and 30-34. Numbers are estimated. Data yet available for 35 and over.

Note: Standard errors appear in parentheses

SOURCE: U.S. Department of Commerce, Census Bureau, Current Population Survey, October 2003, unpublished data, [57, 58]; U.S. Department of Commerce, Census Bureau, Current Population Survey (CPS), October 2010, (U.S. Census Bureau, 2018); U.S. Department of Commerce, Census Bureau, Current Population Survey (CPS), October 2012 [60]; U.S. Department of Commerce, Census Bureau, Current Population Survey (CPS), July 2011 and November 2017 [61]; U.S. Department of Commerce, Census Bureau, Current Population Reports, Series P-25, Nos. 1000, 1022, 1045, 1057, 1059, 1092, and 1095; 2000 through 2009 Population Estimates, retrieved August 14, 2012, from https://www.census.gov/popest/data/national/asrh/2011/index.html; and 2010 through 2019 Population Estimates, retrieved November 29, 2019, from https://www.census.gov/data/datasets/time-series/demo/popest/2010s-national-detail.html#par_textimage_57373479 [36, 37]



	2003	2010	2012	2017
3 and 4	19.9	86.9	31.6	51.0
5 to 9	42.0	89.9	58.3	69.3
10 to 14	68.9	93.1	81.1	77.0
15 to 19	77.7	93.3	89.3	84.9
20 to 24	69.4	89.9	86.1	85.3
25 to 29	66.7	88.9	85.7	85.6
30 to 39	69.2	90.8	84.8	85.5
40 to 49	67.5	90.1	82.6	84.9
50 to 59	62.7	84.7	76.4	79.7
60 to 69	43.9	78.1	69.6	75.8
70 or older	20.1	54.6	43.7	57.1
All	58.7	85.2	74.7	77.7

Figure 2. Percent of change, persons aged 3 and above using the Internet anywhere [59].

In highlights of the 2019 American Community Survey for Hawaiʻi, the number of households with one or more computing devices was 465,299 or 93%, 28.9% of which have people under the age of 18 [14]. Interestingly, though the category of smartphone and tablet or portable device were only added during the 2016 survey, they were more present than the traditional laptop or desktop. Hawai‘i households reported that the most prevalent type of computer in their homes were a smartphone, tablet or other portable wireless computer (82.8%) followed by a desktop or laptop computer (81.5%). 9.6% reported having only a smartphone, tablet, or other portable wireless computer. Those numbers varied by county also as seen in Table 3. Of the four major counties, Kauai County (94.0%) had the highest percentage of households that had a computer, followed by Honolulu County (93.7%), Hawai‘i county (91.9%), and Maui County (90.9%).

Table 3. Computers and broadband presence in households in Hawai‘i by county, 2019.

		Total households	With a computer	With broadband Internet
State of Hawai‘i	Estimate Percentage	465,299 (5,012)	432,658 (5,351) 93 (0.5)	409,577 (5,448) 88 (0.8)
Hawai‘i County	Estimate Percentage	71,193 (2,209)	64,872 (2,505) 91.1 (1.9)	60,573 (2,594) 85.1 (2.6)
Honolulu County	Estimate Percentage	316,456 (3,394)	296,525 (4,072) 93.7 (0.7)	282,366 (4,360) 89.2 (0.9)
Kauai County	Estimate Percentage	22,898 (1,313)	21,521 (1,414) 94 (2.3)	21,012 (1,413) 91.8 (2.7)
Maui County	Estimate Percent	54,744 (2,300)	49,732 (2,612) 90.8 (2.3)	45,618 (2,600) 83.3 (2.8)

Note: 1-year dataset includes geographic areas with populations of 65,000 or more.
Source: U.S. Census Bureau, 2019 American Community Survey 1-Year Estimates, Table DP-02, released September 17, 2020 [14]. Table modified from the Department of Business, Economic Development & Tourism, Research and Economic Analysis Division, Hawaii State Data Center.

So where there were concerns that many students did not have access to devices, it seems from Census data that the devices are present in a good number of Hawai‘i households. However, more detail is needed to investigate if those households with devices are available to children, are perhaps too few for the number of users in the household, or have the capacities needed for schoolwork. Further, closer review of the 7–8% of households that do not have any computer devices is needed so that those families in households with school-aged children are provided as much support as possible so that the children have high quality opportunities to learn and thrive.

We note that hundreds of millions of children across the globe between 8–15 years old represent the largest online age group, spending hours weekly in hundreds of immersive animated virtual worlds, playing with near and distant friends and family [27], acquiring virtual skills. Hawai‘i is likely not very different. Some studies identify some problematic areas of internet use by adolescents such as stress [28] and sleep [18], as well cautions to universities that these youth will enter college expecting digital environments to be virtual and immersive [6, 12]). According to the 2010 MacArthur Foundation report on Digital Media and Learning [11, p. 37] "Not only is educational gaming starting to be perceived as a viable alternative to formal education, other types of virtual environments and massively multiplayer online games are being recognized for their educational components."

2.3 K–12 online instruction in Hawai'i's K-12 schools

The K–12 public school system in Hawai'i offers E-School for its students, which is described as distance- and online-learning opportunities. These 148 courses, 20 of which are advanced placement courses, are available through online charter schools or partnership programs with local community colleges and universities (see http://hawaiipublicschools.org/). In findings reported by Nguyen [39], establishing an understanding of youth perspectives and their habits was critical as K–12 teachers grappled with the advent of more computer use in face-to-face classes and gaming into formal classroom environments. Curriculum that use gaming approaches like Scratch, Makey Makey, and Dash and Dot Robots were reported as used by Hawai'i computer science teachers [41]. Youths considered gaming to be "their online world" and questioned if adults knew how to effectively engage them through gaming. Teachers had their initial foray into augmented cognition-based instructional design. With many of these technologies being hosted on servers rather than personal computers, they were able to identify time spent on different tasks to determine challenge level and were able to adjust support and instruction based on personalized student needs. Several researchers have urged teachers to help youth develop strategies to uphold responsible behaviors using computers and to view computers as not only as gaming tools but learning tools [5, 29, 38, 70]. Prensky [47] has long seen gaming as a positive strategy for engagement and Yee [71] advocated for game play's positive motivating influences by drawing upon social interaction, a sense of achievement, and immersive experiences. Moreover, the reward structures of games [49] sustain interest and interaction.

The shift from being consumers of technology to producers of information that lead towards mastery of knowledge is seen clearly in the revisions of the International Society for Technology in Education's (ISTE). Originally written in 1998 as the National Educational Technology Standards with a focus on operations [36], a major reformulation to information fluency occurred in 2007 [37] and to digital collaboration and creativity in 2015 [8]. Since 2016, the focus continues to strive to empower student voice and ensure that learning is a student-driven process. Overall, there are now 29 ISTE standards for more than just students. In addition to student standards, there are teacher, administrator, coaches, and computer educator standards too.

The ISTE students standards state that educators should strive to enable empowered learners, digital citizens, knowledge constructors, innovative designers, computational thinkers, creative communicators, and global collaborators. The need has moved from simply teaching students and instructors how to use technologies to how to be effective stewards of technologies, including instruction in ethics [40]. Fostering learning in inclusive classrooms that support culturally and linguistically diverse needs for learners can benefit from implementation of the Universal Design for Learning (UDL) framework, designed to help educators to "improve and optimize teaching and learning for all people based on scientific insights into how humans learn." The UDL framework can be used to address the different students' needs to engage with the learning, understand the through various representations, and express their learning in various ways [44, 50, 51, 64]. Furthermore, supporting students to demonstrate their learning in novel ways has included gaming. And gaming has been an integral part of innovative designs from the students as well as the teachers in K–12 education.

2.4 Moving to Online Instruction During Covid-19

In March and April, 2020, all public K–12 instruction and university-level instruction moved online in Hawaiʻi, as a precautionary measure for protecting its students, families, instructors and others. Since the use of distance education had previously begun out of necessity, as we have described earlier, due to inter-island geographic isolation, the current transition, at least at the university level was seamless for many units already operating with online classes, or hybrid courses (both face-to-face and online components). For example, in the University of Hawaiʻi at Mānoa's College of Education, many courses were already offered online and the college has a separate unit solely devoted to assisting faculty with instructional support for teaching online. The Department of Information and Computer Sciences started 20 years ago online when the department received a Sloan Foundation grant to develop an inexpensive online learning environment. A professor who used the system twenty years ago and has continued online instruction since then transitioned seamlessly to COVID instruction. In a Fall 2020 semesters' evaluation, a student commented the following:

"He is one of my favorite professors of all time. His style of collaboration and constant questioning and reasoning made me not only excited for this class, but it has been contagious in all my classes. Additionally, he is the only teacher that did not seem to have an emotional breakdown over the changes in the teaching format (in person to online). He seemed to embrace it and used it to motivate me to be a better student. He is my favorite teacher at UH so far!! "

At the University of Hawaiʻi at Mānoa campus, a report was released in August 2020 by a Student Learning Working Team that identified the changes to academic programs and educational activities [56]. Overall, no instructional rooms allowed for enough social distancing for courses with more than 71 students. Three rooms could have been used for courses with 50–70 students, 15 rooms for courses with 30–49 students, 18 rooms for courses with 20–29 students, 106 rooms for courses with 10–19 students, and 21 rooms for courses with 4–9 students. About 86% of courses transitioned to online, 10% to hybrid (a combination of in-person and online instruction), and 4% in-person either in a classroom or in an alternate education space. Instructional design support and professional development sessions were offered by the university, with engagement strategies that supported student voice and choice as well as increased relevance garnering high interest [56]. These sessions presented many strategies that incorporated gaming features to increase motivation in student learning.

In the Hawai‘i Department of Education (HIDOE), which serves about 84% of Hawai‘i’s approximately 210,000 school-aged children [63], all public schools transitioned to online learning. Some small private, independent schools were able to maintain face-to-face teaching by adjusting their schedules. In the HIDOE, teachers incorporated choice boards to support at-home learning [22]. The activities were designed to serve as reinforcement and enrichment rather than meeting specific learning outcomes. Many of these enrichment activities incorporated games for younger children, with the word “play,” for example, appearing in 13 of 60 activities across five days. In a survey of K–12 teachers in March 2021, 65 (13.9%) respondents (n=468) indicated in early results that a positive aspect of teaching online was becoming more confident with technology and being able to incorporate more interactive games as formative assessment or temperature checks during instruction [42]. The sudden transition to online learning due to COVID-19 has brought forward game-like instructional and assessment tools such as Kahoot [13, 68], Socrative [15, 34], Quizlet [16], Poll Everywhere [55], Mentimeter [53,66], and Flippity.net, which have all gained traction during the pandemic with K–12 teachers. Additionally, teachers are supporting students in developing immersive gaming experiences in Minecraft (see Minecraft.net) and Scratch (see https://scratch.mit.edu/) that allow for students to program their own paths and play.

In the swift emergency transition, both K–12 and higher education had similar tests in instruction, access, engagement, and equity concerns for the students. Challenges in domains such as physical education, music, art, or dance included not just providing video-based instruction, but in observing and assessing students’ performances. Other problems in teaching sciences, fashion and design-related courses, sciences involving labs and other work with realia and actual specimens needed to be reasonably met.

Additional personal challenges were faced by students and faculty with the stay-at-home orders. Some students did not have dedicated effective WiFi or computer equipment as they had been accustomed to using on-campus computers at libraries and elsewhere. Many students were faced with job-loss and economic hardship. Graduate students described challenges of working at home or in healthcare or education-related work, while educating their own children at home (some with special needs), and sometimes taking care of older parents and grandparents; in Hawai‘i, many families lived together as larger ‘ohana (families) that typify Pacific Island communities rather than nuclear family units that are prevalent in much of the continental US.

In Fall, 2020, the second author taught an online course on university teaching to graduate students. The transition to fully online teaching when the shelter-in-place order was enacted in Hawai‘i had been relatively seamless as she was experienced in online instruction and had anticipated that all instruction would go fully online as the pandemic accelerated. In sharing technologies for learning, the graduate students eagerly took the lead and shared online games that they successfully used with their own students, such as Kahoot quizzes for reviewing material, Canva, and Mural for brainstorming and visual design, and simulations of the Jeopardy television show that students created online themselves. In her own instruction for future professors and teachers-in-training, she emphasizes that the inclusion of games in instruction should have clear instructional goals related to content learning. A good metric for inclusion of games could be comparisons to Bloom's Taxonomy [7], subsequently revised in 2001 [3]. The taxonomy relates to aspects of learning in the cognitive domain from remembering (the lower, more rote level), to understanding, applying, analyzing, evaluating, and creating (the highest level). Many of the games her students employ (e.g., Kahoot, Jeopardy) involve testing for information retrieval at the lower levels, while brainstorming and visual design aspects involve higher cognitive skills. These approaches aligned well with initial teaching training for the use of augmented cognition in instructional settings. Many of these games included tracking of students' accuracy and time (effort) to identify individual differences in learning through gamification. Many were able to use this information to diagnose the difference between confidence (speed) and accuracy (correctness). These games gave educators on a larger scale the ability to use augmented cognition-based approaches to refine learning opportunities which would have been more difficult to implement without the use of gamification approaches to learning. It is noteworthy that students enjoy taking on teaching or leading roles in facilitating games for review purposes with their classmates. Instructors working on improving their technology skills in online instruction can profitably incorporate students' leadership and collaboration in adopting aspects of serious games into their classes.

At this writing, we completed the 2019–2022 COVID-19 academic years (celebrated with online graduations) and are approaching the completion of the 2023–2024 academic year. Although we cannot foretell what the future holds in this rapidly changing era, we are optimistic about the further adoption of aspects of gamification into our online classes, particularly with the availability of open-source AI software, both for serious learning about instructional content and for supporting students as they navigate their educational progress.

3 Discussion

We see online instruction that leverages gaming models for engagement with critical analysis with augmented cognition-based approaches towards their intended effectiveness as growing. As game platforms improve, Gaming has been reviewed as an effective educational approach for instruction and assessment because it increases motivation, and commitment of students [30], particularly with use of spoken text and conversational prompts [32] and perceptual attention and mental rotation in math, science, and second-language studies [32]. As we work to develop instructional approaches that incorporate game play for serious learning, we have the following recommendations.

Instructors: should:

- Use AI-inspired virtual resources, and games with high quality content that serve central, rather than peripheral roles in instruction. These resources should be incorporated gradually, often with students' assistance, as they become adept using them.
- Be trained to use augmented cognition-based approaches to analyzing game-based learning data, such as time on task and accuracy depending

on the challenge level. This data can complement other approaches to learning and while giving instructors the ability to adapt their instruction.

- Develop ways to leverage students' high levels of interest in gaming by incorporating appropriate aspects of gaming for content learning rather than viewing games as merely entertainment and online distraction.
- Facilitate learning online through games and social and cultural collaborations across geographic and other boundaries. Games and simulations offer ways to bridge and unite participants with mutual educational goals such as science and language learning.
- Be made aware of various crowdsourced, governmental, and scientific ventures that enable students as gamers to contribute to genuine scientific advances using gaming skills, as in the Foldit game described by Anderson and Rainie [1].
- Become aware of and use game-play strategies in the classroom that increase interactions of students with each other, with the content, and with the instructors.
- Facilitate learning online through games and social and cultural collaborations across geographic and other boundaries. Games and simulations offer ways to bridge and unite participants with mutual educational goals such as science and language learning.
- Seek ways to foster a safe space for play to occur as they challenge students with content and design experiences to pique additional curiosity.

Students should:

- Learn to be productive participants in gaming and online gaming communities by skillfully evaluating their own and others' contributions as well as by evaluating the information accuracy, views, and potential biases that the games may be convey.
- Create collaborative instructional games online to review course content, as test preparation, and to teach each other.

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References

1. Anderson, J., & Rainie, L. (2012). Gamification: Experts Expect 'Game Layers' to Expand in the Future, with Positive and Negative Results; Pew Research Center's Internet & American Life Project: Washington, D.C.
2. Anderson, J., Rainie, L., & Vogels, E.A. (2021). Experts Say the 'New Normal' in 2025 Will Be Far More Tech-Driven, Presenting More Big Challenges, Pew Research Center: Washington, D.C., USA.

3. Anderson, L. W. & Krathwohl, D. R. (2001). A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition. Longman: New York, USA.
4. Ashworth, D. & Stelovsky, J. (1989). Kanji City an exploration of hypermedia applications for CALL. CALICO Journal 6, 27 - 39.
5. Berson, M., Berson, I., Desai, S., & Falls, D. (2008). The role of electronic media in decision-making and risk assessment skill development in young children. In the Society for Information Technology and Teacher Education International Conference (SITE) 2008, Las Vegas, NV.
6. Blascovich, J. & Bailenson, J. (2011). Infinite Reality: Avatars, Eternal Life, New Worlds, and the Dawn of the Virtual Revolution. HarperCollins e-books: New York City, USA.
7. Bloom, B. S. (1956). Taxonomy of Educational Objectives Book 1: The Cognitive Domain. 2nd ed.; Addison Wesley Longman: New York, USA.
8. Brooks-Young, S. (2015). ISTE Standards for Students: A Practical Guide for Learning with Technology. International Society for Technology in Education.
9. Csikszentmihalyi, M. (1990). Flow: The Psychology of Optimal Experience. Harper Perennial: New York City, USA.
10. Csikszentmihalyi, M. (1997) Finding Flow: The Psychology of Engagement with Everyday Life. Basic Books: New York City.
11. Davidson, C.N. & Goldberg, D.T. (2010). The Future of Thinking: Learning Institutions in a Digital Age. MIT Press: Cambridge, USA, p. 37.
12. de Freitas, S. (2018) Serious Virtual Worlds: A Scoping Study. JISC e-Learning Programme. Retrieved_from_http://www.jisc.ac.uk/media/documents/publications/seriousvirtualworlds v1.pdf
13. Dellos, R. (2015). Kahoot! A digital game resource for learning, International Journal of Instructional Technology and Distance Learning, 12, 49–52.
14. Department of Business, Economic Development & Tourism, State of Hawai‘i. (2019). American Community Survey 2019, Hawai‘i. State of Hawai‘i. Retrieved from https://census.hawaii.gov/acs/acs-2019/
15. Dervan, P. (2014). Increasing in-class student engagement using Socrative (an online student response system). The All Ireland Journal of Teaching & Learning in Higher Education, 6.
16. Dizon, G. (2016). Quizlet in the EFL classroom: Enhancing academic vocabulary acquisition of Japanese university students. Teaching English with Technology, 16, 40–56.
17. Duggan, M. (2015). Gaming and Gamers. Pew Research Center: Washington, D.C., USA. Retrieved from http://www.pewinternet.org/2015/12/15/_gaming-and-gamers/
18. Ekinci, Ö., Çelik, T., Savaş, N., & Toros, F. (2014). Association between internet use and sleep_problems_in_adolescents,_Noro_Psikiyatr_Ars,_51,_122–128. https://doi.org/10.4274/npa.y6751
19. Gershenfeld, A. (2014). Mind games. Scientific American. 310. 54 - 59.
20. Geisel, T. S. (1990). Oh, The Places You'll Go. Random House: New York, USA, 1990.
21. Hawaii State Data Center. (2016). Highlights of the 2016 American Community Survey 1-year data for Hawaii. Research Economic & Analysis Division, Hawaii State Data Center. Retrieved_from_https://files.hawaii.gov/dbedt/census/acs/ACS2016/ACS2016_1_Year/ Other_Files/ACS_2016_Analysis_DBEDT_final.pdf
22. HIDOE Choice Boards. (2021). Retrieved from https://sites.google.com/k12.hi.us/resources-student-parent/parents-caregivers/choice-boards (accessed January 15, 2021).
23. Iding, M., Vick, R., Crosby, M.E. & Auernheimer, B. (2005). Metacognition knowing about knowing in synchronous on-line chats. In Proceedings of 8th World Conference on

Computers in Education (WCCE). Document Transformation Technologies, Cape Town, South Africa, [CD ROM - Document 194, 1–8].

24. Iding, M. & Crosby, M. (2011). Hawaii: A Pacific Crossroads for Distance Education. In Proceedings of Global Learn Asia Pacific 2011 International Conference, Siew-Mee Barton, John Hedberg, Katsuaki Suzuki, Eds.; Association for the Advancement of Computing in Education: Chesapeake, USA, AACE. 1814 - 1818.
25. Ikehara, C., Crosby, M. & Silva, P. (2013), Combining Augmented Cognition and Gamification. In Foundations of Augmented Cognition: Schmorrow, D. and Fidopiastis, C. (eds.) Springer Lecture Notes in Computer Science (LNCS).
26. Isanders. (2012). PS3 System Software Update (v4.30): View PS vita trophies on your PS3. PlayStation.Blog. Retrieved from https://blog.playstation.com/archive/2012/10/22/ps3-system-software-update-v4-30-view-ps-vita-trophies-on-your-ps3/
27. Kids_and_Tween_Worlds,_KZERO_Worldswide._Retrieved_from_http://www. kzero.co.uk/blog/category/kidstween-worlds/
28. Lam, L.L. & Wong, E.M.Y. (2015). Stress moderates the relationship between problematic internet use by parents and problematic internet use by adolescents. Journal of Adolescent Health, 56, 300–306. https://doi.org/10.1016/j.jadohealth.2014.10.263
29. LaRose, R., Rifon, N. J., & Enbody, R. (2008). Promoting personal responsibility for internet safety. Urban Sensing: Out of the Woods, 51, 71–76.
30. Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M. A., Guerrero-Puerta, L., Aguilar-Parra, J. M., Trigueros, R., & Alias, A. (2021). Between level up and game over: A systematic literature review of gamification in education. Sustainability, 13, 2247, https://doi.org/10.3390/su13042247
31. Mayer, R. E. (2011). Multimedia learning and games. In Computer Games and Instruction, S. Tobias, & J. D. Fletcher, Eds.; Information Age Publishers, Charlotte, US, 281–306.
32. Mayer, R. E. (2019). Computer games in education. Annual Review of Psychology. 70, 531 - 549.
33. McGonigal, J. (2011) Reality is Broken. Penguin Books: New York City, USA.
34. Méndez Coca, D.M. & Slisko, J. (2013). Software “Socrative” and smartphones as tools for implementation of basic processes of active physics learning in classroom: An initial feasibility study with prospective teachers, European Journal of Physics Education, 4, 17–24.
35. Murphy, C. (2011). Why games work and the science of learning. In Interservice, Interagency Training, Simulations, and Education Conference (pp. 260–272).
36. National educational technology standards for students 1998. (1998). International Society for Technology in Education. Retrieved from https://www.iste.org/standards
37. National educational technology standards for students 2007. (2007). International Society for Technology in Education. Retrieved from https://www.iste.org/standards
38. Nguyen, T.T.T. (2008). An Experimental Computer Literacy Course: Is It Needed? University of Hawai‘i at Mānoa: Honolulu, USA.
39. Nguyen, T.T. (2009). Internet safety: Implications for teacher education. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen & D. Willis, Eds.; Proceedings of Society for Information Technology & Teacher Education International Conference 2009. Association for the Advancement of Computing in Education: Charleston, USA, 1660–1665. http://www.editlib.org/p/30854
40. Nguyen, T.T. (2010). Multimedia Juvenile Victimization: Helping teachers understand youth behavior. In Proceedings of Society for Information Technology & Teacher Education International Conference 2010, D. Gibson, B. Dodge, Eds.; Advancement of Computing in Education: Chesapeake, USA, 3174–3174. http://www.editlib.org/p/33858.

41. Nguyen, T. T. T. & Mordecai, M. (2020). Catching Up to Move Forward: A Computer Science Landscape Report of Hawai‘i Public Schools, 2017–2020. University of Hawai‘i: Honolulu, USA; pp.169. http://hdl.handle.net/10125/69382
42. Nguyen, T.T.T., Serna, A.K., Smith, K., Breckenridge, J., & Ho, K. (2021). Teaching During COVID in Hawai‘i: The K–12 Teacher Experiences, Presented at Teaching, Colleges, and Community Conference, Online, USA.
43. Parker, K., Horowitz, J., Igielnik, R., Oliphant, B., & Brown, A. (2017). America’s Complex Relationship with Guns. Pew Research Center: Washington, D.C., USA, 2017. Retrieved from_https://www.pewresearch.org/social-trends/wp-content/uploads/sites/3/2017/06/Guns-Report-FOR-WEBSITE-PDF-6-21.pdf
44. Ok, M.W. & Rao, K. (2019). Digital tools for the inclusive classroom: Google Chrome as assistive and instructional technology. Journal of Special Education Technology, 34, 204–211, https://doi.org/10.1177/0162643419841546
45. Perrin, A. (2018). 5 Facts About Americans and Video Games. Pew Research Center: Washington, D.C. Retrieved from https://pewrsr.ch/2vbbMxD
46. Pew Research Center. (2019). Internet/Broadband fact sheet. Pew Research Center. Retrieved from https://www.pewresearch.org/internet/fact-sheet/internet-broadband/
47. Prensky, M. (2003). Digital game-based learning. Computers in Entertainment, 1, 21. https://doi.org/10.1145/950566.950596
48. Plass, J.L., Homer, B.D., & Kinzer, C.K. (2015). Foundations of game-based learning, Educational Psychologist. 258 - 283. https://doi.org/10.1080/00461520.2015.1122533
49. Przybylski, A., Rigby, C.S., & Ryan, R.M. (2010). A motivational model of video game engagement.Reviewof_General_Psychology,14,154–166.https://doi.org/10.1037/a0019440
50. Rao, K. & Meo, G.J. (2016). Using Universal Design for Learning to design standards-based lessons. Sage Open, 6, 1–12. https://doi.org/10.1177/2158244016680688
51. Rao, K. & Skouge, J. (2015). Using multimedia technologies to support culturally and linguistically diverse learners and young children with disabilities. *In Young Children and Families in the Information Age: Educating the Young Child,* Vol 10; Heider, K., Jalongo, M.R., Eds.;. Springer: New York City, USA, pp. 101–115. https://doi.org/10.1007/978-94-017-9184-7_6
52. Robinson, R., Rubin, Z., Márquez Segura, E., and Isbister, K. (2017) All the Feels: Designing A Tool that Reveals Streamers' Biometrics to Spectators. In Proceedings of the 12th International Conference on the Foundations of Digital Games (FDG ’17). ACM, New York, NY, Article 36.
53. Rudolph, J. (2018). A brief review of Mentimeter – A student response system. Journal of Applied Learning & Teaching, 1, 35–37.
54. Salen, K. & Zimmerman, E. (2004). Rules of Play: Game Design Fundamentals. Cambridge, Massachusetts: MIT Press.
55. Shon, H. & Smith, L. (2011). A review of Poll Everywhere audience response system, Journal of Technology in Human Services, 29(3), 236–245.
56. Student Learning Working Team. (2020). Educational Activities & COVID-19 at UH Mānoa. University of Hawai‘i at Mānoa: Honolulu, USA. 2020. pp. 27. Retrieved from https://manoa.hawaii.edu/wp/wp-content/uploads/2020/07/fall-2020-student-learning-plan.pdf
57. U.S. Census Bureau. (2012). Number and percentage of persons 3 years old and over using the Internet and percentage distribution by means of internet access from home and main reason for not having high-speed access, by selected characteristics of students and other users: 2010. Retrieved from https://nces.ed.gov/programs/digest/d12/tables/dt12_018.asp

58. U.S. Census Bureau. (2013). Number and percentage of persons 3 years old and over using the Internet and percentage distribution by means of internet access from home and main reason for not having high-speed access, by selected characteristics of students and other users:2012. Retrieved from https://nces.ed.gov/programs/digest/d13/tables/dt13_702.10.asp
59. U.S. Census Bureau. (2018). Percentage of persons age 3 and over who use the Internet anywhere and who use the Internet at selected locations, by selected characteristics: 2011 and 2017. Retrieved from https://nces.ed.gov/programs/digest/d18/tables/dt18_702.30.asp
60. U.S. Census Bureau. (2019a). Estimates of resident population, by age group: 1970 through 2019. Retrieved from https://nces.ed.gov/programs/digest/d19/tables/dt19_101.10.asp
61. U.S. Census Bureau. (2019b). Number and percentage of households with computer and internet access, by state: 2018. Retrieved from https://nces.ed.gov/programs/digest/d19/tables/dt19_702.60.asp
62. U.S. Census Bureau. (2020). QuickFacts: Hawaii. Retrieved from https://www.census.gov/quickfacts/HI
63. U.S. Department of Education, National Center for Education Statistics. (2018). Common Core of Data (CCD), "Private School Universe Survey (PSS)", 2017-18 ; "Public Elementary/Secondary School Universe Survey", 2017-18 v.1a; "State Nonfiscal Public Elementary/Secondary Education Survey", 2017-18 v.1a.
64. Universal Design for Learning Guidelines version 2.2. Retrieved from https://udlguidelines.cast.org/
65. Vande, D. (2010). Folding@home. Distributed Computing. Retrieved from http://pinus.ptkpt.net/_lain.php?_lain=8630
66. Vallely, K. & Gibson, P. (2018). Engaging students on their devices with Mentimeter. Compass: Journal of Learning and Teaching, 11.
67. Vick, R.M. & Crosby, M.E.; Ashworth, D.E. (2000). Japanese and American students meet on the web: Collaborative language learning through everyday dialogue with peers, Computer Assisted Language Learning, 13, 199–219. https://doi.org/10.1076/0958-8221(200007)13:3;1-3;FT199
68. Wang, A.I. & Tahir, R. (2020). The effect of using Kahoot! for learning – A literature review, Computers & Education, 149. https://doi.org/10.1016/j.compedu.2020.103818
69. Wouters, P., van Nimwegen, C., van Oostendorp, H., van der Spek, E.D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. Journal of Educational Psychology, 105, 249–265. https://doi.org/10.1037/a0031311
70. Ybarra, M.L., Mitchell, K.J., Finkelhor, D., & Wolak, J. (2007). Internet prevention messages: Targeting the right online behaviors. Archives of Pediatrics & Adolescent Medicine, 161, 138–145.
71. Yee, N. (2006). Motivations for play in online games. Journal of CyberPsychology and Behavior, 9, 772–775. https://doe.org/10.1089/cpb.2006.9.772