What are the roles of technology in improving student statistical literacy?

Suhermi and D B Widjajanti
Mathematics Education, Graduate Program, Universitas Negeri Yogyakarta, Indonesia
E-mail: suhermi.2018@student.uny.ac.id

Abstract. The use of technology in the learning process has provided positive benefits in improving students' abilities. One of the abilities of students that can be improved through the application of technology in statistical learning is statistical literacy. Technology in statistical learning is a tool used in the teaching and learning process of statistics that aims to improve student statistical literacy. This literature research aims to examine what are the roles of technology that can be used in the statistical learning process so as to increase student statistical literacy. The key word in the study literature is technology in statistical learning. The literature used in this study is 22 articles written in the last 5 years that examine the use of technology in statistical learning. The results of this study conclude that the use of technology in the form of computers and smartphones makes it easy for teachers and students to access websites, online learning sites and statistical software that can be used in the statistical learning process to improve student statistical literacy. The use of websites and online learning sites in the process of learning statistics can act as a source of learning and a source of data that can improve students' ability to understand and interpret statistical data. While the software plays a role in presenting and processing data that can improve students' abilities in presenting and communicating statistical information.

1. Introduction
The development of science and technology has provided positive benefits in various fields of life. One of them is in the field of education. The educational process that takes place through learning at school is expected to improve the abilities needed by students to solve problems in everyday life, help students to become familiar with technology and be able to process information, that is information in the form of data so as to be able to deal with increasingly competitive digital era changes. Thus the application of technology in delivering a subject matter, especially mathematics, is an appropriate step to take.

One mathematical material that is statistics is one material that is closely related to data information that can be found in students' daily lives. This is due to the large amount of information currently presented in the form of statistical information. So understanding statistics is important to be a concern in learning statistics. In its development, statistical learning has now integrated technology in the learning process so that the expected competency of statistical learning, namely statistical literacy can be achieved [1].

Statistical literacy is an ability to understand and use statistical information as an ability that must be possessed by every individual [2]. Statistical literacy includes the ability to understand basic terms in statistics [2]–[4], interpret and communicate statistical information [5]–[8], concludes and makes
decisions based on statistical information in various contexts [2], [9] and critically evaluates statistical information [2], [5], [9], [10].

The importance of understanding statistical information in various sectors of life makes statistical literacy competencies not limited to individuals who teach statistics or who are interested in statistics, but all parties including students, who in the future will become producers and consumers of data [1]. So that all parties including students are expected to have a sufficient statistical understanding that is able to interpret any data or message information contained in a statistical information presented in various forms of tables, diagrams or graphs, which can be interpreted properly [11]. The benefits of statistical understanding for every individual including students include among others the basic skills of students in making decisions in a study in further studies or in the workplace, to be able to read and evaluate journals or articles, develop critical and analytical thinking skills, to become individuals or consumers who knowledgeable and to know when to need help outside statistics [12].

Given the importance of statistical literacy, statistics learning at the school level should pay more attention to students' statistical abilities and how to teach statistics to students so that statistical literacy as a goal of statistical learning in the classroom can be achieved. True statistical learning is statistical learning that emphasizes the ability of statistical literacy that views statistics not only by the presentation of numbers in the form of numbers, but with numbers in context [13]. So the information conveyed through numbers in statistical information can be interpreted properly. A good understanding of statistical information is expected to be better with the use of technology in the statistical learning process.

Technology as a tool in statistical learning is expected to help in increasing student statistical literacy. Nevertheless this is inseparable from the teacher's skills in using technology in statistical learning. The use of technology in mathematics learning has been widely carried out, including its application in statistical learning, where one of the seven principles in statistical learning namely calculators and computers must be used to help students visualize and explore data, not only to follow algorithms for predetermined purposes [14]. Then the use of technology has also expanded the range of graphic and visualization techniques to provide powerful new ways to help students explore and analyze data and think about statistical ideas, enabling students to focus on interpreting results and understanding concepts rather than on computational mechanics [15]. Besides the role of technology can strengthen student learning by providing numeric, graphic and symbolic content without spending time to calculate complex computing problems manually [16].

The technology itself can be interpreted as a tool, method, technique or process created to facilitate human work. Technology is all the human way of making everything that is around it practically [17]. Technology includes 1) basic knowledge sub-systems; 2) technical support systems (software); and 3) capital technology (hardware). This perspective views that technology recognizes the need to identify various technological elements of certain parts that are complementary and mutually reinforcing. As educators it is important to emphasize that good technology helps students to learn [18]. Based on this, it is important for teachers to choose and be able to integrate technology in the learning process. One of them is in statistical learning.

Application of technology in statistical learning can be classified into several types, namely: statistical software tools, educational software, worksheets, applets, graphic calculators, multimedia materials and data repositories [19]. Tishkovskaya and Lancaster [15] outlines a complete range of software and applications that can be utilized in statistical learning. Technologies that can be used in statistical learning include statistical software packages, learning software, worksheets, applets, graphing calculators, multimedia materials and data sources [19].

Utilization of technology in learning is not a new thing to do and is proven to improve student learning outcomes. Such learning using blended learning methods is effective in improving student learning outcomes [20]–[22] and the use of tablets in learning helps teachers to innovate in learning and provide learning settings new for students [23]. In addition, students who are given computer-based learning in mathematics have better learning achievement compared to students who are taught using conventional methods [24]. But in the application of learning mathematics, especially statistics
on the use of computers and internet connections is still not much done. Today's statistical learning still emphasizes the decline in formulas making it difficult for students to understand it and statistical learning has not utilized technology [13]. This emphasizes the need for changes in the implementation of statistical learning by utilizing information technology such as the use of computers and smartphones [23] in statistical learning, through website access, on-line learning sites and the use of statistical software.

The use of smartphones, through the whatsapp application can also be used as a medium in statistical learning [26]. The application of whatsapp is effective in the field of engineering, the delivery of material and the provision of instructions in the learning process. This does not rule out the possibility to be applied in other learning materials including statistics. Meanwhile the statistical learning process by utilizing the technology, one of them through the e-learning method can work well if all aspects related to the learning process are fulfilled, such as the quality of the learning material, students and teachers [27].

For this reason, it is necessary to conduct a deeper study of the role of technology in statistical learning so that students' statistical literacy skills can be improved. The description includes what technologies can be utilized in statistical learning and how it plays a role in students' statistical literacy skills.

2. Method

Data collected in this study were sourced from journal articles through browsing using Google scholar. The key word used is the role of technology in statistical learning. The selected article is the last 5 years issue. Based on the search it was decided to review 22 articles that use technology in the implementation of statistical learning. The article is presented in Table 1.

Table 1. The use of technology in statistics learning research

| No | Name of the researcher | The kind of technology | Tools |
|----|------------------------|------------------------|-------|
| 1  | Sandra R. Madden       | Software               | Fathom, Tinker Plot |
| 2  | Ben Baumer, Mine Cetinkaya-Rundel, Andrew Bray, Linda Loi and Nicholas J. Horton | Software | R Markdown |
| 3  | Aishah Mohd Noor       | Software               | Microsoft Excel, Minitab, UniMAP |
| 4  | Sharleen Forbes, Jeanette Chapman, John Harraway, Doug Stirling, Chris Wild | Software | iNZight, VIT, GTL, CAST |
| 5  | Elizabeth A. Boyle, Ewan W. MacArthur, Thomas M. Connolly, Thomas Hainey, Madalina Manea, Anne Kärki, Peter van Rosmalen | Application | CHERMUG Game |
| 6  | Edwin P Christmann     | Website                | Online Statistic Course |
| 7  | Juho Oikarinen          | Hardware               | CSCL |
| 8  | Peter K. Dunn, Margaret Marshman and Robert McDougall | Website | Wikipedia |
| 9  | Michael Touchton       | Software               | Software in Flipping Classroom |
| 10 | Rolf Biehler            | Hardware               | Calculator |
| 11 | Tim Erickson and Mariel Triggs | Application | Markov Game |
| 12 | Charalampos Chanialidis | Software               | Shiny, R Markdown |
3. Results and Discussion

3.1. Hardware
Technological tools that can be used in statistical learning are computers [28]–[31] and calculators [32]. Besides the existence of smartphones today can be an alternative to computer replacement for students. The use of computers as a tool in statistical learning helps students to explore learning. Apart from textbooks, the use of computers combined with internet access helps students understand statistical terms. Through internet access, students look for other learning resources through websites or online learning sites. Learning using a computer can also be combined with other learning methods, such as the application of study groups. Learning by the formation of small groups (consisting of 2-5 people) with the help of computers in statistical learning will make learning more meaningful [33].

The use of a calculator in learning is not new to apply. The calculator can help with the calculation and visualization of statistical charts. So that students' ability to interpret statistical information will be better.

3.2. Software
The use of statistical software in learning is very helpful for students in learning statistics. Some software available on the computer can be used and applied easily. Such as the use of Microsoft Excel which is relatively simple is expected to be used as a calculation tool in statistical learning. MS Excel is widely known by the public and students. As is also known in MS Excel there is a spreadsheet program in the processing of multifunctional numerical data. Also provided a combination of up to billions of cells in the form of columns and rows that can be used in data processing. The operation of MS Excel is relatively easy and has also received recognition from various professions for its ability in data processing. From mild to complex data processing, MS Excel can still be used and the expected results are also maximal. The use of MS Excel in processing statistical data can also be done quickly without reducing the accuracy of the results [34], [35]. Even MS Excel users are given the flexibility to do more exercises through a process of trial and error so that it opens many opportunities for maximum results. This gives students the flexibility to practice calculating and processing the statistical data they obtain.
In addition there are also other software that can be used in statistical learning. Among others, SPSS, Minitab, Lisrel and others. The use of SPSS also makes it possible to apply to high school students so students begin to get used to processing software-assisted data. Learning statistics based on practicum SPSS software applications with multimedia assistance helps students understand the basic concepts of statistics, steps of analysis with the SPSS program and how to read the meaning of statistical figures from the results of data processing [36], [37]. It is also possible to apply the use of the SPSS application for secondary school students.

In addition to the software, there is also another software, R software [38]–[40][37]. R software is free software that can be used in Windows, Unix and Macintosh. R software is also easier to use in teaching statistics, so R software is also widely used in academics and research. R Mark down software has proven to be effective in helping statistical calculations. The calculator can also be used as a calculation tool in statistics. It also can help students in simulating and visualizing data so that it can help students interpret statistical data [32].

The use of the PivotTable feature from Microsoft Excel can be used as a means of calculating the number of data frequencies and the series in the form of graphs (charts) [41]. So the way to present graphics is not only limited to using Microsoft Excel. The ability to use the features available in software can help tasks related to statistics in presenting statistical information in the world of work.

The use of Fathom software [42] can foster understanding and statistical reasoning while making comparisons of statistical results. In addition, several learning software such as Inzight, VIT, GTL, CAST, Commuterview, Geovista, Dynamic population Pyramid and Price kaleidoscope can help visualize statistical data, improve the ability to conceptual think and to investigate the real world [43].

3.3. Website
The use of websites in learning has been widely applied and the use of these has proven to be effective in increasing students' insights and knowledge, especially in understanding basic statistical terms. Through the use of the website in the process of learning statistics, can help students in exploring to add insight and knowledge related to the basic terms of statistics. Websites can be used as learning resources and data sources for students. The use of the most useful websites is currently available through the World Wide Web to help support the understanding of statistical terms more effectively. Website-based learning can be seen as an alternative and free tool in statistical education that has the potential to help students to have better insights in understanding basic statistical terms. The basic statistical terms referred to include datum, data, sample, population, variance, standard deviation and so on.

The website can be a statistical learning medium because it contains the following content: (1) statistical learning material and online, (2) studying repositories and teaching materials, (3) Web-based data sources and repositories, (4) statistical textbooks, (5) Statistics literacy, (6) Statistical History, (7) Electronic journals on statistical learning, (8) Data Visualization, (9) Statistics Applets and (10) Other links related to statistics [15].

Website as a learning resource helps students in finding more information on the material being studied and improves the learning process through examples of statistical problems that have been specifically designed in the form of multimedia material, while increasing student motivation in learning statistics [44]. Studying statistics material online through the website helps students understand better than studying statistics material in the classroom. Because the material presented is more complete than the material obtained by students in learning in the classroom.

Additionally the benefits of using websites in statistical learning help teachers to be able to build job opportunities by using real data and computer-based activity simulations because statistics have so many applications in real life [15]. Such activities can help students explore statistical concepts while engaging in data collection and analysis. The use of innovative learning can encourage thinking, reasoning and constructing student knowledge.

The teacher can use the website as a source of real data that can be used in the learning process. Like the use of Google, Wikipedia or data from government agencies and others such as BNSP,
Puskurbuk, UNESCO, and so forth. Some websites can be used as learning resources and data sources in learning statistics. The use of WISE: The Web Interface for Statistics Education has also been shown to improve initial statistical training [45]. Besides AP Programs: Advanced Placement Program can be used as a website in learning statistics [46]. The AP Programs website provides concepts, tools for collecting, analyzing and drawing data conclusions. In addition, OLI-Statistics (The Open Learning Initiative Statistics) is a website that can be used as an open source of learning that has been designed to help students learn statistics independently [47].

Here are some online learning sites that can be used by students and teachers that can be used as learning resources that can help students understand data and help students interpret statistical data. Among them Zenius Education (https://www.zenius.net/), Wikipedia (https://id.wikipedia.org/), Our Classroom (https://kelaskita.com/), KEMDIKBUD Learning House (https://Belajar.kemdikbud.go.id/Dashboard/), Teacher's Room (https://ruangguru.com/), Quipper (https://link.quipper.com/id/), Youtube (http://youtube.com), Wolfram Alpha (https://www.wolframalpha.com/).

By using the OLI Statistics Course website, students can learn without instructors while at the same time describing the abilities students have [47], [48]. In addition, several learning processes using statistical software can also help students understand basic statistical terms [35]. But in using Dunn revealed not to use Wikipedia in statistical learning [49].

3.4. Application
Technological developments have resulted in new things that can be applied in learning. One of them is the existence of game applications that can be utilized in learning. The use of games in learning statistics is something new to be applied. Such as CHERMUG Game [50], Markov Game [51] and Game Characteristics [52]. Through games students can improve their ability to connect, think and understand the concept of probability.

4. Conclusion
Technology is a tool, method, technique or process that can be used to facilitate human work. The use of technology in learning in schools, one of which in statistical learning theoretically has a positive impact on students' statistical abilities, namely statistical literacy. Technologies that can be utilized in statistical learning include the use of calculators, computers and smartphones. The use of computers combined with internet access can be used to access websites, online learning sites and statistical software. In the learning process, the website acts as a source of learning and a source of data for students. Then online learning sites can play a role in helping students understand statistical material and interpret data. While the use of software in statistical learning plays a role in helping students present and process data. Besides the use of websites in statistical learning can also increase student motivation to learn statistics. The role of technology in statistical learning is illustrated in the Figure 1.
From this result of the study, there are a number of suggestions that can be made both for teachers and other researchers. First, the results of this study can be used as a reference for other researchers who want to further study about the use of technology in teaching and learning statistics. Second, the results of this study can be a source of information for teachers to use various kinds of technology that can be integrated in the statistical learning process. Third, the use of technology in statistical learning can be adjusted to the facilities and infrastructure of the school. Fourth, the results of this study can be a source of information for the government to better equip learning facilities and infrastructure for increasing student competency.

5. References

[1] M. Hafiyusholeh, “Literasi statistik dan urgensinya bagi siswa,” \textit{Wahana}, vol. 64, no. 1, pp. 1–8, 2015.
[2] K. K. Wallman, “Enhancing Statistical Literacy: Enriching Our Society,” \textit{J. Am. Stat. Assoc.}, vol. 88, no. 421, pp. 1–8, 1993.
[3] J. Garfield and D. Ben-Zvi, \textit{Developing Students’ Statistical Reasoning: Connecting Research and Teaching Practice}. Minneapolis: Springer, 2008.
[4] J. M. Watson, \textit{Statistical Literacy at School: Growth and Goals}. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2006.
[5] I. Gal, “Adults ‘ Statistical Literacy : Meanings , Components , Responsibilities,” \textit{Int. Stat. Rev.}, vol. 70, no. 1, pp. 1–51, 2002.
[6] M. Schield, “Statistical literacy,” no. 1, pp. 1–6, 2002.
[7] J. M. Watson, “Assessing Statistical Thinking Using the Media,” \textit{Assess. Chall. Stat. Educ.}, vol. 1997, pp. 107–121, 1997.
[8] L. Ziegler and J. Garfield, “Developing a Statistical Literacy Assessment for the Modern Introductory Statistics Course10,” \textit{Serp}, vol. 17, no. 2013, pp. 161–178, 2018.
[9] J. M. Watson, “Statistical Literacy at the School Level : What Should Students Know and
Do ?,” 2002.

[10] H. S. Lee and K. F. Hollebrands, “Characterising and developing teachers’ knowledge for teaching statistics with technology,” in Teaching Statistics in School Mathematics - Challenges for Teaching and Teacher Education A Joint ICMIASE Study, vol. 14, no. January, C. Batanero, G. Burrill, and C. Reading (Eds), Eds. Springer, 2011, pp. 359–369.

[11] S. Murray and I. Gal, “Preparing for Diversity in Statistics Literacy: Institutional and Educaitonal Implications,” Ictos6, pp. 1–8, 2002.

[12] L. S. Center, “Topic # 2 : Why Study Statistics ?,” Ithaca, New York, 2016.

[13] M. A. Tiro, M. Nusrang, and M. Ahsan, “Eksplorasi Pembelajaran Literasi Statistika dalam Paradigma Konstruktivisme Mahasiswa Program Magister PPs Universitas Negeri Makassar.” Makassar: Lembaga Penelitian Universitas Negeri Makassar, 2015.

[14] J. Garfield, “How Students Learn Statistics,” Int. Stat. Rev., vol. I, pp. 25–34, 1995.

[15] S. Tishkovskaya and G. A. Lancaster, “Statistical Education in the 21 Century : A Review of Challenges , Teaching Innovations and Strategies for Reform,” J. Stat. Educ., vol. 20, pp. 1–56, 2012.

[16] S. C. Neto, “Combining Distance and Traditional Learning: A Study of the Use of Virtual Learning Environment Objects and Massive Online Open Courses in Statistics Class,” Int. J. Inf. Educ. Technol., vol. 7, no. 1, pp. 1–5, 2017.

[17] U. M. Franklin, “The real world of technology,” in Journal of Chemical Information and Modeling, 1999, pp. 1–20.

[18] G. Burrill, “6 . Discussion : How Technology Is Changing the Teaching and Learning of Statistics in Secondary Schools,” in Research on the role of technology in teaching and learning statistics, 1997, pp. 71–74.

[19] B. Chance, D. Ben-Zvi, J. Garfield, and E. Medina, “The role of technology in improving student learning of statistics,” Technol. Innov. Stat. Educ. J., 2007.

[20] S. Freeman et al., “Active learning increases student performance in science , engineering , and mathematics,” PNAS, vol. 1, no. April, pp. 1–6, 2014.

[21] N. Kemp and R. Grieve, “Face-to-face or face-to-screen ? Undergraduates ’ opinions and test performance in classroom vs online learning,” Front. Psychol., vol. 5, no. 12 November, pp. 1–11, 2014.

[22] B. Means, R. Murphy, and M. Baki, “The Effectiveness of Online and Blended Learning : A Meta-Analysis of the Empirical Literature,” TCR-Teacher Coll. Rec., vol. 115, no. March, 2013.

[23] H. Montrieux, R. Vanderlinde, T. Schellens, and L. De Marez, “Teaching and Learning with Mobile Technology : A Qualitative Explorative Study about the Introduction of Tablet Devices in Secondary Education,” PLoS One, vol. 10, no. 12, pp. 1–17, 2015.

[24] Masduki and A. G. Nugroho, “Pembelajaran Matematika dengan Media Berbasis Komputer ditinjau dari Aktivitas Belajar Siswa.,” no. 14 Mei 2011, pp. 159–164, 2011.

[25] N. Nishfani, H. Kusmanto, and R. O. Akbar, “The Use of Big Data for Education & Kontribusi Matematika dalam Mempertahankan Nilai Budaya dan Sastra ANALISIS TINGKAT KEMAMPUAN LITERASI STATISTIK SISWA SMA SEDERAJAT BERDASARKAN MUTU SEKOLAH,” Pros. PROCEEDIAMATH, 2017.

[26] S. Gon and A. Rawekar, “Effectivity of E-Learning through Whatsapp as a Teaching Learning Tool,” MVP J. Med. Sci., vol. 4, no. June, pp. 19–25, 2017.

[27] W. Härdle, S. Klinke, and U. Ziegenhagen, “e-Learning Statistics - A Selective Review,” SFB 649 Econ. Risk Berlin, 2006.

[28] E. Gil and A. L. Gibbs, “Promoting modeling and covariational reasoning among secondary school students in the context of big data,” Stat. Educ. Res. J., vol. 16, no. 2, pp. 163–190, 2017.

[29] J. Oikarinen, “Finnish upper secondary students’ collaborative processes in learning statistics in CSCL environment,” Oulun Yliopisto, 2012.
[30] R. Reaburn, “Introductory statistics course tertiary students’ understanding of P-values,” Stat. Educ. Res. J., vol. 13, no. 1, pp. 53–65, 2014.
[31] W. Wei and Z. Qiao, “Effects of Tablet PCs on Students’ Learning in an Introductory Statistics Course,” Int. J. Sci. Educ. Res., vol. 3, no. 2, pp. 1–11, 2019.
[32] R. Biehler, “Professional Development for Teaching Probability and Inference Statistics with Digital Tools Upper Secondary Level,” in 13th International Congress on Mathematical education, 2016, no. 24–31 July, pp. 1–8.
[33] E. P. Christmann, “A comparison of the achievement of statistics students enrolled in online and face-to-face settings,” E-Learning Digit. Media, vol. 14, no. 6, pp. 323–330, 2017.
[34] H. Patmawati and S. Santika, “Penggunaan Software Microsoft Excel sebagai Alternatif Pengolahan Data Statistika Penelitian Mahasiswa Tingkat Akhir,” Semin. Nas. Mat. x, pp. 124–129, 2016.
[35] A. M. Noor, “The Art of Communicating Statistics: Why Simulation and Graphical Presentations Are Important Tools for Understanding Statistical Concepts.,” in Assessment for Learning Within and Beyond the Classroom, S. F. Tang and L. Logonathan, Eds. Singapore, 2016, pp. 397–408.
[36] S. Riyanto and F. Nugrahanti, “Pengembangan Pembelajaran Statistika Berbasis Praktikum Aplikasi Software SPSS dengan Bantuan Multimedia untuk Mempermudah Pemahaman Mahasiswa terhadap Ilmu Statistika,” J. Comput. Inf. Technol., vol. 1, no. 2, February 2018, pp. 62–67, 2018.
[37] I. Weir, R. Gwynlyw, and K. Henderson, “Using Technology To Inspire and Enhance the Learning of Statistics in a Large Cohort of Diverse Ability,” Edulearn15 7Th Int. Conf. Educ. New Learn. Technol., no. July, pp. 803–812, 2015.
[38] L. Paura and I. Arhipova, “Advantages and Disadvantages of Professional and Free Software for Teaching Statistics,” VERSITA Inf. Technol. Manag. Sci., vol. 15, 2012.
[39] B. Baumer, M. Cetinkaya-Rundel, A. Bray, L. Loi, and N. J. Horton, “R Markdown : Integrating a reproducible analysis tool into introdutory statistics,” arXiv Prepr. arXiv1402.1894., 2014.
[40] C. Chanialidis, “The Use of Technology and Social Media in Teaching Statistics,” ICOTS, vol. 10, pp. 1–3, 2018.
[41] Subagyo, “Manfaat fitur ‘Pivot Table’ dari Microsoft Excel untuk pengolahan data statistik perpustakaan.,” J. Pustak. Indones., vol. 10, no. 1, pp. 13–22, 2007.
[42] S. R. Madden, “Designing technology-rich learning environments for secondary teachers to explore and prepare to teach statistics. In Sustainability in Statistics Education.,” in the Ninth International Conference on Teaching Statistics (ICOTS9), 2014.
[43] S. Forbes, J. Chapman, J. Harraway, D. Stirling, and C. Wild, “Use of Data Visualisation in the Teaching of the Statistics: A New Zealand Perspective,” Stat. Educ. Res. J., vol. 13, no. 2, pp. 187–201, 2014.
[44] O. Umugiraneza and D. North, “Exploring teachers ’ practices in teaching Mathematics and Statistics in KwaZulu-Natal schools,” South African J. Educ., vol. 37, no. 2, pp. 1–13, 2017.
[45] C. L. Aberson, D. E. Berger, E. P. Emerson, and V. L. Romero, “WISE: Web Interface for Statistics Education.,” Behav. Res. Methods, Instrum. Comput., vol. 29, no. 2, pp. 217–221, 1997.
[46] College Board, Statistics: Course Description. 2010.
[47] M. Lovett, O. Meyer, and C. Thille, “The Open Learning Initiative : Measuring the Effectiveness of the OLI Statistics Course in Accelerating Student Learning,” JIME, pp. 1–18, 2007.
[48] O. Meyer, “The Open Learning Initiative (OLI) Online statistics Course: How Statistics Education Helped Define Promising Directions for the Use of Technology Enabled Instructions in Higher Education,” ICOTS, vol. 10, pp. 1–6, 2018.
[49] P. K. Dunn, M. Marshman, and R. McDougall, “Evaluating Wikipedia as a Self-Learning
Resource for Statistics: You Know They’ll Use It,” *Am. Stat.*, vol. 1305, no. November, pp. 1–8, 2018.

[50] E. A. Boyle *et al.*, “A narrative literature review of games, animations and simulations to teach research methods and statistics,” *Comput. Educ.*, vol. 74, pp. 1–14, 2014.

[51] T. Erickson and M. Triggs, “An Early Look at Rich Learning Statistics: Statistics Students Playing ‘Markov,’” *ICOTS*, vol. 9, pp. 1–6, 2014.

[52] E. Novak, T. E. Johnson, G. Tenenbaum, and V. J. Shute, “Effects of an instructional gaming characteristic on learning effectiveness, efficiency, and engagement: using a storyline for teaching basic statistical skills,” *Interact. Learn. Environ.*, pp. 1–16, 2014.