Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education

An Online Course for Learning Basic Statistics Concepts in Higher Education: An Evaluation Study

Siu Cheung KONG
The Education University of Hong Kong, Hong Kong
*sckong@eduhk.hk

Abstract: An online course was designed for students in higher education to learn basic statistics concepts, supplementary with four face-to-face tutorials. This study evaluated the designed course, with a focus on students' perceptions of course implementation and course materials, through questionnaire surveys and focus group interviews. The surveys found that students especially recognized the help of the video clips for learning sampling distribution and central limit theorem, and the simulations for understanding confidence interval and sampling distribution. The focus group interviews found that students generally recognized the overall support from the three main types of course materials - video clips, simulations and quizzes - on learning basic statistics concepts. Nearly half of the students indicated their preference to first watch the online video clips and then do the online quizzes and further return to the video clips when they encountered difficulties. This study revealed students' need of face-to-face tutorials along different time points in the blended learning process.

Keywords: Basic statistics concepts, blended learning, evaluation, higher education, online course

1. Introduction

Statistical literacy is essential for students in the higher education sector to understand and perform quantitative and qualitative researches in their daily study (Hahs-Vaughn, Acquaye, Griffith, Jo, Matthews, & Acharya, 2017; Peters, Smith, Middledorp, Karpin, Sin, & Kilgore, 2013). For students in Hong Kong, the learning of basic statistics starts as an extended curriculum module for optional selection, but not a compulsory module for every student, in the senior secondary mathematics curriculum (Curriculum Development Council & Hong Kong Examinations and Assessment Authority, 2017). This makes quite a portion of local students possess inadequate statistical literacy before entering universities for further study. Traditional statistics curriculum has a common emphasis that students do statistics calculations well means students understand statistics concepts well; and thereby overlooking the fact that many students recite and adopt statistical formulas without a solid statistical understanding (Barrios, González-Teruel, Cosculluela, Fornieles, & Turbany, 2014; Peters et al., 2013). This study therefore designed an online course for supporting tertiary students in Hong Kong to flexibly yet effectively develop fundamental statistics concepts.

2. Background of Study

It is essential for students in nowadays society to possess the knowledge and techniques of applying basic statistics, in order to accurately organize, analyze, interpret and present the massive data involved in their everyday pursuits (Hahs-Vaughn et al., 2017; Peters et al., 2013). Higher education institutions over the world have the convention of offering credit-bearing courses on basic statistics as a compulsory curriculum component for students specialized in mathematics, science, and/or engineering streams across undergraduate and postgraduate levels. These formal courses on basic statistics are generally designed to sharpen students' understanding of the fundamental terms and concepts in the topics of descriptive statistics, normal distribution, probability, hypothesis testing

and simple univariate statistics; and are commonly delivered through face-to-face tutorial, supplementary with the practical application of statistical software packages, in a fixed curriculum schedule (Hahs-Vaughn et al., 2017; Peters et al., 2013). The rapid growth of different learning management platforms and varying online learning resources has led the wave of e-Learning in higher education in recent decades (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Poelmans & Wessa, 2015). Alongside the prevalent use of different statistical software packages, traditional statistics education is facing opportunities to ride on the e-Learning trends for a shift of more interactive, more practical, and more problem-solving oriented learning and teaching inside and outside campus (Hahs-Vaughn et al., 2017; Lu & Lemonde, 2013). The blended learning approach is advocated to be potential to realize the suggested shift in statistics education.

The blended learning approach is an instructional strategy that incorporates face-to-face tutorial in classroom and online learning with multimedia resources outside classroom (Poelmans & Wessa, 2015; Scherrer, 2011). It allows a flexibility in selecting the web-based technologies for resources retrieval and learning interactions, and setting the time ratio between online learning and face-to-face tutorial (Bernard et al., 2014; Peterson, 2016). Blended learning courses commonly combine regularly-scheduled face-to-face classes delivered by instructors, and between-classes online work by students via the online learning platforms selected such as Moodle (Lu & Lemonde, 2013; Luo et al., 2017). Students are usually asked to use the online learning platforms selected to watch online videos before and/or after classes, make online discussions and complete online quizzes after classes (Barrios et al., 2014; Hahs-Vaughn et al., 2017). Researchers find it is important for students in the blended learning approach to attend face-to-face classes with two needs - students' heavy reliance on instructors' regular guidance on learning resources and learning flows (Barrios et al., 2014; Scherrer, 2011); and students' strong desire for instructors' extra explanation of knowledge points and assignment solutions (Peterson, 2016; Poelmans & Wessa, 2015).

3. Methodology

This study designed a course named "Basic Statistics Concepts for Higher Education". The course aimed to enhance students' conceptual understanding of basic statistics through the blended learning approach which based on a 16-hour online learning component and was supplemented with a four-hour face-to-face learning component. The designed course focused on four topics: "Sampling Distribution" about the definition and calculation of sampling distribution of sample mean; "Central Limit Theorem" about the definition of central limit theorem and the calculation of probability; "Confidence Interval" about the interpretation and calculation of confidence interval, and the relationship between confidence level and sample size; and "Hypothesis Testing" about the determination of null hypothesis, alternative hypothesis and critical region, and the hypothesis testing for a mean with known variance. The designed course was a non-credit course for all interested undergraduate/postgraduate students of the university. There were a total of 89 student participants in the designed course after the open call-for-enrollment (see Table 1 for the student profiles). The majority of student participants had no background knowledge about statistics, as 61.1% of the student participants had never learned statistics and some of them even had difficulty in understanding statistical terms like mean and standard deviation.

Table 1

Profiles of Student Participants (N=89) of the Online Learning Course for Basic Statistics Concepts

Study level	Study area	N (%)	Sub-total	Total
Undergraduate - Junior grade (Year 1-2)	Arts	5 (5.6%)	19 (21.3%)	89 (100.0%)
	Science	7 (7.9%)		
	Social Science	7 (7.9%)		
Undergraduate - Senior grade (Year 3-5)	Arts	14 (15.7%)	28 (31.5%)	
	Science	3 (3.3%)		
	Social Science	11 (12.4%)		
Postgraduate	Arts	4 (4.5%)	42 (47.2%)	
	Science	6 (6.7%)		
	Social Science	32 (36.0%)		

This course provided a learning pack on the learning management system Moodle for students' online access to self-learn and then consolidate basic statistics concepts according to their own learning progress and needs. The online learning pack provided three types of course-specific digital resources: the video clips which explained and illustrated the terms and procedures related to the target statistics concepts; the simulations which provided students with demonstrations and then opportunities of statistical operations for applying the target statistics concepts; and the quizzes which provided questions for students to check their understanding of the target statistics concepts.

As teacher guidance is important in blended learning, students were set to attend a one-hour face-to-face tutorial session each week together with using the online learning pack to self-learn the statistics concepts. These tutorials aimed to introduce key concepts for each topic that students were to learn that week, and allow students to ask questions on their learning difficulties. In Session 1, students learned about background knowledge about the statistics concepts of mean, standard deviation and probability distributions; and then learned about the course topic of "Sampling Distribution". Session 2 introduced the course topics of "Central Limit Theorem" and "Confidence Interval"; and Session 3 the course topic of "Hypothesis Testing". Session 4 engaged students in hands-on activities to develop the practical knowledge of SPSS operation for data analysis.

Moreover, the designed course provided two supplementary learning resources for students' reference. Firstly, four memory cards, of each summarized each topic in plain language, were created to help students strengthen the memory of key knowledge points. Secondly, a concept map which showed the inter-relationships between different concepts across the four topics was created to help students visualize clearly the connections among the knowledge points. Furthermore, a day-by-day study schedule was designed for guiding students to use the online learning pack to learn step-by-step. It served as a checklist for students who had their own pace yet wanted to make sure they had covered all the key knowledge points before the respective face-to-face tutorials.

A mixed-method evaluation was conducted after the fourth face-to-face tutorial to investigate the views of students on the arrangements and resources of the designed course. Two research questions were focused: (1) What are the students' overall perceptions of the implementation of the blended learning course for basic statistics? (2) What are the students' specific perceptions of the materials in the blended learning course for basic statistics? Two questionnaire surveys and three groups of focus group interviews were conducted to collect the quantitative and qualitative data addressing the two research questions. The two questionnaire surveys involved 49 students upon voluntarily participation. The first survey consisted of nine 4-point Likert scale question items to ask about students' overall perceptions of course implementation; while the second survey consisted of eleven 5-point Likert scale question items to ask about students' specific perceptions of course materials. The Cronbach's alpha coefficients of the two surveys are 0.907 and 0.962 respectively. The three groups of focus group interviews involved 18 students upon voluntarily participation. The students were asked to indicate their overall perceptions of course implementation, with a focus on course arrangements and learning outcomes; and their specific perceptions of course materials, with a focus on the online learning platform and the specific course materials of video clips, simulations, quizzes and other resources.

4. Results and Discussion

4.1 Students' Overall Perceptions of the Implementation of the Blended Learning Course

The students in general positively perceived the overall implementation of the blended learning course, as reflected by the results of the questionnaire survey (see Table 2) and focus group interview (see Table 3). The students in the questionnaire survey agreed that the designed course was well-organized for learning basic statistical knowledge. The students also affirmed the usefulness of the suggested study schedule for learning the four topics in the designed course. The students recognized the overall support from three main types of course materials - the simulations, quizzes and video clips - on helping them to understand more basic statistics concepts. It is noted that the designed courses inspired the students to apply the blended learning approach in future.

Table 2

Survey Results of Students' Overall Perceptions of the Course Implementation

Items	Mean [a]	(SD)
Interactive simulations provided on Moodle helped me understand the knowledge on basic concepts of statistics.	3.16	(0.83)
The quizzes on Moodle enhanced my learning on basic statistics.	3.14	(0.73)
The video clips provided on Moodle well-illustrated the key concepts of basic statistics.	3.14	(0.76)
The suggested study schedule was useful in learning.	3.14	(0.93)
The course enhanced my knowledge on basic statistics.	3.12	(0.75)
Overall, the course was well-organized.	3.00	(0.65)
The course inspired me to apply blended learning in my current/future learning/teaching.	3.00	(0.86)
The four one-hour tutorials facilitated my learning on basic statistics.	2.91	(0.98)
The content covered matched up to my expectations.	2.86	(0.79)

[a] *1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree*

Students' feedback in the focus group interview echoes with the survey results. The students generally satisfied with the quality and potential of the designed course. For the course arrangements, the students considered the designed course well-organized to promote them to integrate theory into practice. The students generally spent two to five hours per week for the designed course; and were managed to learn most of the course contents by themselves online. A student illustrated that he obtained 10% of the knowledge in face-to-face tutorials and 90% through the video clips and quizzes on the online learning platform. Many students affirmed the importance and usefulness of following the suggested study schedule for the successful course completion. They also appreciated that the designed course enabled them to learn statistics with theory-driven practice, as the course delivery started with theories and concepts and then engaged students in the hands-on of statistical software.

For the learning outcomes, most students affirmed the course effectiveness. The students appreciated that the designed course matched their expectation for applying the learned statistical knowledge to their study work, as it was insufficient for them to learn statistics in daily curriculum. Nearly three quarters of the students further expressed their appreciation of the blended learning approach and their willingness to take part in other blended learning courses in future. Few students who were not major in mathematics-related streams commented that the course contents were quite difficult for them and so suggested on dividing students into different groups according to their academic majors for course delivery in future. For course improvement, one-third of the students indicated the need of more practice and review opportunities in face-to-face tutorials, to enhance their target statistical knowledge through real-life data analysis. Half of the students also suggested on extending the length of each face-to-face tutorial; and increasing the time and examples on explaining how to use the target statistical formulas and interpret statistical results meaningfully.

Table 3

Focus Group Interview Results of Students' Overall Perceptions of the Course Implementation

Issues	Major feedback
Course arrangements	• Most students were satisfied with the whole experience of the blended learning course. The students appreciated the opportunities for learner-centered learning in the designed course, as they felt comfortable and flexible to do self-learning of the course contents anytime, anywhere. • The whole cohort affirmed the need of face-to-face tutorials. They appreciated the arrangement for making extra discussion appointments and WhatsApp group communication with instructors to discuss their difficulties in learning the course contents.
Learning outcomes	• Most students found the designed course useful and beneficial, as the course contents supported them to better understand and apply the key concepts and common jargons of basic statistics in their daily study. • Students who were not major in mathematics-related streams commented that the course contents were quite difficult for them and so suggested on dividing students into different groups according to their academic majors for course delivery.

The above results of students' overall perceptions of the implementation of the blended learning course echo with the findings in previous relevant studies including Scherrer (2011) and Peterson (2016) – university students are generally able and comfortable to manage the flexible approach supported by blended learning courses for an effective learning of statistical knowledge.

4.2 Students' Specific Perceptions of the Materials in the Blended Learning Course

The students positively perceived the specific materials for the designed course. As Table 4 shows, the students in the questionnaire survey generally affirmed the learning support from varying course materials, especially the video clips for the "Sampling Distribution" and "Central Limit Theorem" topics; and the simulation for the "Confidence Interval" and "Sampling Distribution" topics.

Table 4

Survey Results of Students' Specific Perceptions of the Course Materials

Items	Mean [a]	(SD)
The video clips in Sampling Distribution topic were useful for learning basic statistics.	4.04	(0.86)
The video clips in Central Limit Theorem topic were useful for learning basic statistics.	4.02	(0.94)
The video clips in Confidence Interval topic were useful for learning basic statistics.	3.92	(0.90)
The simulation in Confidence Interval topic was useful for learning basic statistics.	3.88	(0.85)
The concept map on basic statistics was clear.	3.84	(0.89)
The video clips in Hypothesis Testing topic were useful for learning basic statistics.	3.82	(0.85)
The simulation in Sampling Distribution topic was useful for learning basic statistics.	3.82	(0.94)
Overall, the quizzes helped me learn the basic statistics.	3.67	(0.98)
The concept map on basic statistics was useful for consolidating the learned knowledge.	3.65	(0.94)
The simulation in Hypothesis Testing topic was useful for learning basic statistics.	3.59	(0.09)
The simulation in Central Limit Theorem topic was useful for learning basic statistics.	3.49	(1.09)

[a] *1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.*

As Table 5 shows, students in the focus group interviews affirmed the ease of retrieving course materials of video clips, simulations and quizzes. Most students found the course materials facilitated them much to learn target statistical knowledge, and to realize the importance of statistics in daily study and so motivate them to learn more. Nearly half of the students preferred to first watch video clips and then do quizzes, and when needed return to the video clips for the knowledge points.

Table 5

Focus Group Interview Results of Students' Specific Perceptions of the Course Materials

Issues	Major feedback
Online learning platform	• Most students found the Moodle platform was easy to use for the online retrieval of course materials. • The students considered the video clips and quizzes most helpful and useful in assisting their self-learning.
Specific course materials: -Video clips -Simulations -Quizzes -Other resources	• The majority of the students favored the video clips most. They considered those video clips very useful to be the major source for course learning, with step-by-step explanations of the target statistical operations. • Nearly a quarter of the students found the simulations well-designed, easy to follow, and useful for supporting them to understand the target statistics concepts well. • Many students appreciated the quizzes, as they could repeatedly attempt to answer quiz questions and then learn from the explanations for correct answers when they incorrectly answered the quiz questions. • Many students found concept map, memory card and other resources useful.

Over 25% of the students indicated they could keep concentrated on the precise and concise explanations in the short video clips. Nearly 25% of the students watched the video clips several times if they found difficulty in understanding the concepts. The students also found the simulations helpful to stimulate a deeper thinking of the target concepts. Moreover, most students were satisfied with the design of online quizzes, which were short yet able to provide sufficient explanations to the answer of each question. Many students also appreciated the usefulness of the other resources - the concept maps and memory cards - for knowledge consolidation. It is noted that nearly 40% of the students searched for external online resources for relevant explanations when they found difficulties in understanding the course contents, as they wanted to solve the problems on their own.

Focus group interviews also collected suggestions on course materials improvement. For the video clips, some students commented that more examples and exercises can be embedded, so that they could think more about the target statistical knowledge through practice. Some students expected for more detailed illustrations in the video clips. For example, the main formulas can be shown on one side along with the video content flow, in order to enable them to remember more about the formulas when listening to the description and explanation of the given examples. For the

simulations, some students suggested on the automatic display of more explanations after their question-answering, so that they can immediately check their knowledge level. For the quizzes, some students suggested on adding more questions and expanding the relevant explanations in the online quizzes, so that they could think more about the target statistical knowledge through practice.

5. Conclusion and Implication

This study designed an online course, supplementary with face-to-face tutorials, on basic statistics. The course evaluation by questionnaire surveys and focus group interviews confirmed students' positive perception of the overall course implementation and the specific course materials - video clips, simulations and quizzes. This study echoes the recent work by Hahs-Vaughn et al. (2017) and Luo et al. (2017) that it is practical to engage university students in blended learning courses for learning basic statistics effectively. It also enriches current literature on the preference and pattern of university students for selecting and using certain types of course materials in topic-specific learning of basic statistics. Two implications are made for future blended learning courses on basic statistics.

Firstly, this study found that the students especially appreciated the short video clips which were precise and concise enough for them to focus on the important course concepts, especially the topics of sampling distribution and central limit theorem. The students preferred to first watch the online video clips and then do the online quizzes, and further return to the video clips when they encountered difficulties. Future courses should thus use the repeatable feature of the video clips and quizzes to support students to gradually deepen statistical understanding through exercising.

Secondly, this study found that the students valued the four face-to-face tutorials along with their self-learning process using the online learning pack; and expected to have more practice and review opportunities in face-to-face tutorials in a longer duration. The students indicated their need of more time, examples and explanations for real-life data analysis. Future courses should thus keep instructor-led face-to-face tutorials regularly for giving extra explanation of knowledge points, extra guidance on online resources exploration, and extra opportunities of operational practices.

References

Barrios, M., González-Teruel, A., Cosculluela, A., Fornieles, A., & Turbany, J. (2014). Structure and performance assessment in traditional face-to-face and blended learning statistics courses. *Procedia - Social and Behavioral Sciences, 141*, 1259-1262.

Bernard, R., Borokhovski, E., Schmid, R., Tamim, R., & Abrami, P. (2014). A meta-analysis of blended learning and technology use in higher education: From the general to the applied. *Journal of Computing in Higher Education, 26*(1), 87-122.

Curriculum Development Council, & Hong Kong Examinations and Assessment Authority (2017). *Mathematics Curriculum and Assessment Guide (Secondary 4–6)*. Hong Kong: Government Logistics Department.

Hahs-Vaughn, D. L., Acquaye, H., Griffith, M. D., Jo, H., Matthews, K., & Acharya, P. (2017). Statistical literacy as a function of online versus hybrid course delivery format for an introductory graduate statistics course. *Journal of Statistics Education, 25*(3), 112-121.

Lu, F., & Lemonde, M. (2013). A comparison of online versus face-to-face teaching delivery in statistics instruction for undergraduate health science students. *Advances in Health Sciences Education, 18*(5), 963-973.

Luo, L., Cheng, X., Wang, S., Zhang, J., Zhu, W., Yang, J., & Liu, P. (2017). Blended learning with Moodle in medical statistics: An assessment of knowledge, attitudes and practices relating to e-learning. *BMC Medical Education, 17*, 170 (8 pp.).

Peters, P., Smith, A., Middledorp, J., Karpin, A., Sin, S., & Kilgore, A. (2013). Learning essential terms and concepts in Statistics and Accounting. *Higher Education Research & Development, 33*(4), 742-756.

Peterson, D. J. (2016). The flipped classroom improves student achievement and course satisfaction in a statistics course. *Teaching of Psychology, 43*(1), 10-15.

Poelmans, S., & Wessa, P. (2015). A constructivist approach in a blended e-learning environment for statistics. *Interactive Learning Environments, 23*(3), 385-401.

Scherrer, C. R. (2011). Comparison of an introductory level undergraduate statistics course taught with traditional, hybrid, and online delivery methods. *INFORMS Transactions on Education, 11*(3), 106-110.