TLEF Project – Final Report

Report Completion Date: (2021/05/31)

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	Flexible Learning in Introductory Statistics		
Principal Investigator:	Nancy Heckman		
Report Submitted By:	Nancy Heckman		
Project Initiation Date:	04/01/2015	**Project Completion Date:**	12/30/2018
Project Type:	☐ Large Transformation ☐ Small Innovation ☒ Flexible Learning ☐ Other: [please specify]		

1.2. Project Focus Areas – *Please select all the areas that describe your project.*

☒ Resource development (e.g. learning materials, media)

☒ Infrastructure development (e.g. management tools, repositories, learning spaces)

☒ Pedagogies for student learning and/or engagement (e.g. active learning)

☐ Innovative assessments (e.g. two-stage exams, student peer-assessment)

☐ Teaching roles and training (e.g. teaching practice development, TA roles)

☐ Curriculum (e.g. program development/implementation, learning communities)

☐ Student experience outside the classroom (e.g. wellbeing, social inclusion)

☐ Experiential and work-integrated learning (e.g. co-op, community service learning)

☐ Indigenous-focused curricula and ways of knowing

☐ Diversity and inclusion in teaching and learning contexts

☒ Open educational resources

☐ Other: [please specify]

1.3. Final Project Summary

Introductory statistics is taught in many departments across UBC. Typically, instructional resources and expertise are not shared across units, resulting in duplication of efforts or underuse of valuable material. Previous calls to build collaborations and share resources for teaching introductory statistics (for instance, as recommended by the 1999 committee struck by the VP Academic and Provost) were never implemented.

We developed a model for cross-faculty collaboration to support introductory statistics instruction, bringing together instructors from the Faculties of Science, Arts, and Medicine to develop, adapt, and use instructional resources that address conceptually challenging topics in introductory statistics. Resources developed through this project are being used on an ongoing basis in courses offered through the Departments of Statistics, Biology, Political Science, and the School of Population and Public Health. We are making further efforts to sustain these partnerships, e.g. by reaching out to other instructors in these departments, and by working on new projects with current team members.

We developed a suite of open instructional resources, interactive web visualizations, videos, WeBWorK questions, interactive engagement (iClicker) questions, and in-class activities. These resources are adaptable to specific courses and areas of study, having been used in twelve courses in UBC's Faculties of Science, Arts, and Medicine; they are also consistent in look and feel, and grounded in existing research on learning and statistics. Some resources (web visualizations, videos) were developed in consultation with students, and their use in classes at UBC has been assessed through in-class observations and focus groups. In collaboration with programmers from UBC's CTLT and Science Centre for Learning & Teaching, we created an online repository called StatSpace, where these resources are made openly available for use by instructors and students at UBC and beyond. Finally, we increased UBC's faculty-level capacity for identifying, evaluating, adapting, and developing statistics learning resources.

1.4. Team Members – *Please fill in the following table and include **students**, undergraduate and/or graduate, who participated in your project.*

Name	Title/Affiliation	Responsibilities/Roles
Nancy Heckman	Professor, Statistics	Principal Investigator
Bruce Dunham	Professor of Teaching, Statistics	WeBWorK resource lead, assessment
Eugenia Yu	Senior Instructor, Statistics	iClicker question resource lead, adaptation of video resources to include multiple-choice questions
Mike Whitlock	Professor, Zoology	Web visualization resource lead
Doug Bonn	Professor, Physics and Astronomy	Assessment
Joss Ives	Instructor, Physics and Astronomy	Physics integration lead
Mike Marin	Instructor, School of Population and Public Health	Video resource lead
Leslie Burkholder	Senior Instructor, Philosophy	Case studies co-lead
Diana Whistler	Research Associate and Sessional Lecturer, Vancouver School of Economics	Case studies co-lead

David Green	Professor and Director, Vancouver School of Economics	Case studies co-lead
Fred Cutler	Associate Professor, Political Science	Classroom activities co-lead
Andrew Owen	Instructor, Political Science	Classroom activities co-lead
Participants who were not co-applicants		
Melissa Lee	Lecturer, Statistics	Discipline-based education expert, StatSpace curator, assessment
Darren Irwin	Assistant Professor, Zoology	Discipline-based education expert
Gaitri Yapa	Science Teaching and Learning Fellow, Statistics	Discipline-based education expert
Noureddine Elouazizi	Strategist, Teaching & Learning Technologies, Science Centre for Learning & Teaching	LT needs analysis and solution design
Davor Cubranic	Statistical Programmer, Statistical Consulting and Research Laboratory, Statistics	StatSpace programming
John Hsu	Programmer Analyst 1, CTLT	StatSpace programming
Clarence Ho	Programmer Analyst, CTLT	StatSpace programming
Dennis Sandy and Peter Mitchell	Co-op students	StatSpace programming
Gillian Gerhard	Science Faculty Liaison, CTLT	Project manager, curriculum consultant
Caitlin Donnelly	Instructional Designer and Program Administrator, Science Centre for Learning & Teaching	Project manager, assessment
Ghazal Nikjou	Undergraduate Academic Assistant	Adaptation of video resources to include multiple-choice questions
Andy Leung	Graduate Academic Assistant	Classroom activities
Nelson Chen	Graduate Academic Assistant	Coding for the WeBWorK questions
Sonja Isberg	Graduate Academic Assistant	Assessment support

1.5. Courses Reached – *Please fill in the following table with **past**, **current**, and **future** courses and sections (e.g. HIST 101, 002, 2017/2018, Sep) that have been/will be reached by your project, including courses not included in your original proposal (you may adapt this section to the context of your project as necessary).*

FROM APRIL 2015 TO DEC 2018

Course	Sections	Academic Year	Term (Summer/Fall/Winter)
STAT 200	101, 103, 202, 921	2015/2016 – 2018/2019 And future	Fall, Winter, Summer
STAT 203	103	2016/2017 – 2018/2019 And future	Fall
STAT 241	101, 201, 921	2016/2017 – 2017/2018	Fall, Winter, Summer
STAT 251	101, 201, 921	2016/2017 – 2018/2019 And future	Fall, Winter, Summer
STAT 302	201, 202, 921	2016/2017 – 2018/2019 And future	Fall, Winter, Summer
ECON 325	001, 002	2015/2016 – 2017/2018	Fall
SPPH 400	001, DL1	2015/2016 – 2018/2019 And future	Fall
SPHA 555	002	2016/2017 – 2018/2019	Winter
POLI 380	001, 002	2015/2016 – 2018/2019	Fall, Winter
BIOL 300	100, 201	2015/2016 – 2018/2019 And future	Fall, Winter
DSCI 552	001	2016/17	Winter

2. OUTPUTS AND/OR PRODUCTS

2.1. *Please **list** project outputs and/or products (e.g. resources, infrastructure, new courses/programs). Indicate the current location of such products and provide a URL if applicable.*

Product(s)/Achievement(s):	Location:
StatSpace repository, including most of the resources developed through this project	https://statspace.elearning.ubc.ca/
Four web visualizations and three R shiny apps	http://www.zoology.ubc.ca/~whitlock/Kingfisher/KFhomepage.htm https://statspace.elearning.ubc.ca/handle/123456789/42 https://statspace.elearning.ubc.ca/handle/123456789/76 https://statspace.elearning.ubc.ca/handle/123456789/75 https://statspace.elearning.ubc.ca/handle/123456789/326
Three concept-focused video lectures	https://www.youtube.com/playlist?list=PLqzoL9-eJTNA0zQ5pZ6f1qr8R9z_ZhYQb https://statspace.elearning.ubc.ca/handle/123456789/77 https://statspace.elearning.ubc.ca/handle/123456789/78 https://statspace.elearning.ubc.ca/handle/123456789/120
We received support from the SoTL Seed Fund (70 hours of a SoTL specialist, and $300), to study the effect of the placement of questions in videos on student learning.	https://isotl.ctlt.ubc.ca/2019/09/27/impact-of-placement-of-questions-within-videos-on-student-learning/
One classroom activity lesson plan	https://statspace.elearning.ubc.ca/handle/123456789/327
We received $9800 in funding from the Skylight Development grant, in partnership with the Departments of Botany and Zoology	"User enhancements to StatSpace and BioSpace repositories" https://skylight.science.ubc.ca/skylight-development-grants-spring-2018
Consultations on DSpace repositories	We were consulted about current and (potential) future projects to develop other DSpace repositories at UBC: - BioSpace (https://biospaceverf.elearning.ubc.ca/) - A large TLEF proposal through Earth, Ocean, and Atmospheric Sciences Repositories planned by UBC Arts Instructional Support and Information Technology

2.2. Item(s) Not Met – *Please list intended project outputs and/or products that were not attained and the reason(s) for this.*

Item(s) Not Met:	Reason:
Three – four case studies with accompanying data sets	There was some difficulty in coming to a consensus on case studies: notably, in selecting topics that were broadly applicable to the diverse courses reached by this project. Also, it was challenging to develop case studies that were modular, as they are rather different from the other resources (which are short, contained, and conceptual). Resources were therefore diverted to support other projects, particularly the development of the StatSpace repository. However, Leslie Burkholder did develop one case study before leaving the project. This is potentially useful, although lesson integration resources still need to be developed before it can be used in class.
Five – six classroom activity lesson plans	We developed drafts of two activities, but only fully completed and posted one of them. Evaluation of the other indicated that extensive revisions were required. We have assessed and posted - "Understanding confidence intervals" (evaluated in POLI 380 and STAT 200) We assessed but did not revise for posting - "Introducing the sampling distribution and the normal model" (evaluated in POLI 380)
Six – eight screencast video lectures with lesson integration resources	We originally planned for our video resource lead (Mike Marin) to produce a larger number of screencast-style video lectures, as he has previously produced many such videos (available on his YouTube channel, "MarinStatsLectures"). We decided to instead produce a smaller number of videos with a different style. We produced three videos, each using puppets and simple, visually appealing graphics. This allowed us to provide more clear visual explanations of abstract concepts than a simple screencast-style video would, while also promoting student engagement. Because production of this style of video is more time- and resource-intensive, we made fewer videos than originally planned.

	Evaluation: introductory statistics students were consulted during the development of these videos, through focus groups. Students had broadly positive attitudes towards the videos, and there was evidence for learning gains (comparing pre- and post-test results) from one of the three videos. **Lesson integration resources**: we developed pre-requisites, learning objectives, and suggested tips for instructors. We are currently working on a SoTL Seed Fund project to integrate multiple-choice questions into each of the videos, with plans to evaluate the effect of the videos on student learning. Some of the project was completed pre-COVID, with the remainder to be completed when classes meet in person.
Evaluation of lesson integration resources for the interactive web visualizations	**Evaluation**: Three of the four web visualizations were assessed in focus groups with students from BIOL 300, STAT 200, and STAT 251.
Use of resources in Physics & Astronomy and Philosophy courses	Team members from these departments had too many demands on their time and were not able to participate fully.

3. PROJECT IMPACT

3.1. Project Impact Areas – *Please select all the areas where your project made an impact.*

☒ Student learning and knowledge

☐ Student engagement and attitudes

☐ Instructional team-teaching practice and satisfaction

☐ Student wellbeing, social inclusion

☐ Awareness and capacity around strategic areas (indigenous, equity and diversity)

☐ Unit operations and processes

☐ Other: [please specify]

3.2. What were you hoping to change or where were you hoping to see an impact with this project? – *Please describe the intended benefits of the project for students, TAs, instructors and/or community members.*

Our goals were as follows.

a) To develop an open collection of vetted educational resources in introductory statistics, based on active learning techniques and targeting key topics in introductory statistics. For easy adoption by instructors across campus, resources would be modular and would include surrounding material: learning objectives, guiding questions clearly defined for learners, and suggested uses, tips, and discoveries to help the instructors. Benefits for instructors and students include providing material for instruction using a "flipped" class, thus freeing up class time for working through activities and answering students' questions, rather than simply lecturing. Students also benefit from well-vetted resources that are based on evidence-based pedagogical techniques.

b) To develop a framework for partnerships to support introductory statistics education, including team development of educational resources with cross-discipline and cross-faculty teams. Statistics is taught across many disciplines to students with a wide range of interests and backgrounds. Communication among instructors across disciplines results in better resources: instructors can draw on the wider range of teaching experiences, resources can be developed with examples and language that are accessible to that wide range, and, when appropriate, subject specific examples can be shared across disciplines.

c) To create partnerships with introductory statistics educators. Some of the benefits here are similar to those in b). Additional benefits include the sharing of information so that instructors do not reinvent the wheel, but rather build on each other's work. Also, partnerships are valuable to facilitate communication on the development of any new statistics courses, either within the Statistics Department or within other departments.

d) To increase UBC's faculty-level capacity for identifying, evaluating, adapting, and developing future statistics learning resources. The experience gained in these areas allows for continued work in resource development and assessment.

3.3. Were these changes/impacts achieved? How do you know they occurred? – *How did you measure changes/impacts? (e.g. collected survey data, conducted focus groups/interviews, learning analytics, etc.) Describe what was learned from this process. You are encouraged to include copies of data collection tools (e.g. surveys and interview protocols) as well as graphical representations of data and/or scenarios or quotes to represent and illustrate key themes.*

The changes/impacts are indexed according to part 3.2 above.

a) Our developed materials are available on the open online repository StatSpace (statspace@elearning.ubc.ca). Resources developed during the project period focus on the core concepts of sampling distribution and inference. They are: iClicker questions, classroom activities, web visualizations, videos and WebWorK questions with integrated R code.

b) We successfully developed a cross-disciplinary framework for the development of resources, as evidenced by the posted material on StatSpace, with contributors from a range of departments and faculties.

c) Strong partnerships were formed between most of the team members, and we anticipate that some of these will continue. For instance, Mike Marin worked with Nancy Heckman to submit a TLEF which, unfortunately, was not successful. Unexpected partnerships have also developed. For instance, because of conversations concerning StatSpace, Steve Hallam of Microbiology and Immunology partnered with a Statistics faculty member, providing teaching release, on statistics curriculum for students training in Dr. Hallam's CREATE-funded program ECOSCOPE. The curriculum used StatSpace resources. Partnerships have moved beyond UBC to include curriculum development and training for BC's new STAT 12 course. Bruce Dunham has been heavily involved, including developing and offering professional development workshops using StatSpace resources. This partnership has the added benefit of guiding the current StatSpace team in the development of new resources.

d) The team gained experience in developing, evaluating and adapting learning resources, skills that can carry through to future work. For instance, members are expert with intricacies of BREBs and with setting up and running focus groups. In some cases, we learned what NOT to do. We learned that our chosen style of videos was extremely expensive and that the videos are difficult to assess during the lengthy development process. With the web visualizations, we learned that the coding of the original visualizations required some expertise that is not always readily available. We recommend instead using RStudio's Shiny for this type of resource.

Specifics of Assessment

Assessment of created resources occurred at several levels, and typically led to resource improvements or to the need for further study. Throughout, student experience and feedback were key.

- Students assessed resources through focus groups which not only allowed students to directly comment on their experiences, but also allowed members of the team to observe how students used (or misused) the resources. For instance, student feedback led to improved clarity and functionality of the web visualizations: we edited some of the statistical terminology and modified parts of the interface. For the videos, student focus groups provided feedback on rough cuts, so that changes could be implemented before the expensive process of moving to final development.
- In a post-course focus group, Stat 203 students commented overall on the various resources used in the course.
- To study the impact of videos on learning, students were given pre- and post-viewing quizzes based on a commonly used Statistics Concept Inventory. This work will continue, with a video with questions inserted at various points. The impact of question placement on student experience and learning is being carried out with the support of a SoTL expert through the SoTL seed fund.
- Classroom activities were discussed in two ways: by a student survey on the helpfulness of the activity and by two educational experts, one of whom observed the class while the other used COPUS tools. Students were positive about the activities, but also suggested improvements. Based on this information, the educational experts wrote a report that contained suggestions for improvement, which were then implemented.

- Using their own teaching experience, all team members assessed and discussed modifications of resources throughout the entire process: during development, during use in their classes, and after student focus groups and class observation reports.

See Supplementary Material (appended) for some of the material related to assessment, specifically

- Supplementary Material A: Focus group protocols from BREB
- Supplementary Material B: Interview protocol for focus group on web visualization Sampling from the Normal Distribution
- Supplementary Material C: Interview protocol for focus group on web visualizations: Confidence Intervals for the Mean
- Supplementary Material C: Survey questions on video rough cut

3.4. Dissemination – *Please provide a list of **past** and **upcoming** scholarly activities (e.g. publications, presentations, invited talks, etc.) in which you or anyone from your team have shared information regarding this project. Be sure to include author names, presentation title, date, and presentation forum (e.g., journal, conference name, event).*

Upcoming

Past

Lee, M., Dunham, B., and Donnelly, C., StatSpace: a repository for teaching and learning resources in introductory statistics, UBC Skylight Supper Series, Vancouver. January 2019.

Dunham, B. "Why Statistics?" *Vector, The Official Journal of the BC Association of Mathematics Teachers*, 61 (2), 2018, 10-13.

Dunham, B. Comparison of testing and evaluation methods for new resources in statistical education; 10th International Conference on Teaching Statistics, Kyoto, Japan. July 2018.

Dunham, B., Lee, M., and Yapa, G.: "Comparison of testing and evaluation methods for new resources in statistical education." Invited paper for 10th International Conference on Teaching Statistics, Kyoto, Japan, July. 2018. (https://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_8D3.pdf)

Dunham, B. Workshop for high-school teachers, 'Statistics 12: A new beginning for statistical education in BC.' Facilitated by the BC Association of Mathematics Teachers, Burnaby. April 2018.

Lee, M. StatSpace: A platform for sharing and evaluating introductory statistics teaching resources. UBC Learning Technology Hub Teaching with Technology Showcase. December 2017.

Dunham, B. Workshop for high-school teachers, 'Statistics 12: A new beginning for statistical education in BC'. BC Association of Mathematics Teachers Annual Conference, Burnaby. October 2017.

Heckman, N., Lee, M., and Dunham, B. The Flexible Learning Introductory Statistics Project; Department of Statistics seminar series, University of British Columbia. October 2017.

Yapa, G., Lee, M., Dunham, B., Gerhard, G., and Heckman, N. Introductory Statistics Flexible Learning Project: Resource suites to further enhance student learning; Teaching and Learning Enhancement Fund Showcase, University of British Columbia. May 2017.

Yapa, G., Lee, M., Dunham, B., Gerhard, G., and Heckman, N. Introductory Statistics Flexible Learning Project: Resource suites to further enhance student learning; Science Education Open House, University of British Columbia. April 2017.

Dunham, B. Investigating how students interact with simulation-based applets; Statistical Society of Canada annual conference, Brock University, Ontario. June 2016.

Lee, M., Yapa, G., Dunham, B., Yu, E., Gerhard, G., and Heckman, N. Introductory Statistics Flexible Learning Project: Development and evaluation of statistics educational material; Teaching and Learning Enhancement Fund Showcase, University of British Columbia. May 2016.

Yapa, G., Lee, M., Dunham, B., Gerhard, G., and Heckman, N. Introductory Statistics Flexible Learning Project: Resources and student interactions with web visualizations; Science Education Open House, University of British Columbia. April 2016.

4. **TEACHING PRACTICES** – *Please indicate if **your** teaching practices or those of **others** have changed as a result of your project. If so, in what ways. Do you see these changes as sustainable over time? Why or why not?*

Bruce Dunham: "As regards impact on my own teaching practices, I'm probably in the `preaching to the converted' category when it comes to active learning and suchlike. One thing I have taken though is that exposure to a neat applet that may look super-intuitive to an expert may not, without further materials by way of scaffolding, have the desired impact on a learner. I think we've seen that through students' interactions with our applets."

Melissa Lee: "This project shaped my teaching practices quite a bit. Listening to experienced instructors from multiple departments discuss and debate best practices for teaching specific statistics topics was fundamental to developing my teaching practices. I use many of the resources developed from the project. Particularly, the web visualizations have been very helpful for teaching the more challenging, more nuanced topics."

Mike Marin: "I've used the videos I've created, and the simulations Mike Whitlock has created, in SPPH 400 and SPHA 555. The videos and the simulations have helped with a transition to a flipped classroom model for the course, both allowing for more student interaction time, and less `traditional lecturing'."

Eugenia Yu: "I have adopted many of the resources to enrich the active learning experience for my students in introductory courses. The videos, coupled with clicker-like questions, are prescribed before class to provide an introduction to certain statistical concepts. I then use applets during lecture to illustrate

these statistical concepts. Students also interact with these applets and work on related activities in labs. The clicker questions and activities have allowed students to apply and test their knowledge right after learning them in class."

5. **PROJECT SUSTAINMENT** – *Please describe the sustainment strategy for the project components. How will this be sustained and potentially expanded (e.g. over the next five years). What challenges do you foresee for achieving the expected long-term impacts listed above?*

Sustainment centres around StatSpace, specifically, on StatSpace use increasing and on increasing the number of resources posted. For resource contributions, we will encourage others beyond the core team to contribute, including those outside of UBC. We will guide that process, vetting submissions and suggesting modifications. These goals involve bringing visibility to the platform. Bruce Dunham brings visibility to StatSpace through networking in his official roles in the Statistics Education Section of the Statistical Society of Canada and in BCCUMPS (the British Columbia Committee on the Undergraduate Program in Mathematics and Statistics). We have posted a link to StatSpace on Merlot, a site with curated online learning and support materials and, recently, on the Open UBC resource site. Further visibility comes from team members attending the annual meeting of the Statistical Society of Canada and the International Conference on Teaching Statistics (held every 4 years), presenting papers related to StatSpace.

For financial support, the Statistics Department will contribute $5,000/year, to be used for teaching release for group members. We have also received funding from the Statistical Society of Canada for improvements of the StatSpace interface, and anticipate applying for further funding in the future.

During the project, StatSpace received excellent LT/IT support and anticipate receiving ongoing "maintenance level" support. However, support for any new initiatives, such as improving the UI/UX, may be a challenge. Technological initiatives typically take a high level of effort from team members and LT/IT support.

Supplementary Material A: Focus Group Protocols from BREB

Two types of focus groups are proposed, labelled type 1 and 2 here. For each, a facilitator from the study group will commence by welcoming the participants, thanking them for their attendance, and then give a brief overview of the purpose and structure of the session. Participants will be reminded of the confidentiality assured, and that their involvement cannot affect any past or future course grades.

Type 1

The purpose of this type of focus group is to expose learners to a learning tool (such as an on-line video) and attempt to assess their responses to the tool, in terms of their individual views and learning, and the views when shared with a group of peers.

Initially participants will complete a concept survey, to gauge their understanding of the statistical concept related to the learning tool. This will take approximately ten minutes. After this, the participants will engage with the learning tool (for example, watch an instructional video on-line), before completing the on-line survey about the resource. This should take about fifteen minutes. After this, participants are invited to engage with the learning tool again, and complete the concept survey once more, which should only take about five minutes as the participants have seen the questions before. After this, a facilitator will review the answers to the concept questions with the whole group.

In the focus groups following the exposure to a learning tool, participants will be requested to form small groups of three or four. Within these groups, participants will be encouraged to discuss their thoughts about the learning tool, sharing whatever views they have for approximately ten minutes. A prompt to guide the discussions will be provided by a facilitator via some questions that the participants may wish to address, though these are not intended to limit the discussions. For instance, in the case of a video, the prompts will be as follows:

Which part of the video, if any, do you think most improved your understanding of [*statistical concept*]?
Which part of the video, if any, do you think was confusing or unclear in explaining [*statistical concept*]?
What things, if any, did you like about the video?
What things, if any, did you dislike about the video?

During the final part of the session, each small group will be invited to nominate a spokesperson to share some of the thoughts of their group with everyone in attendance. This feedback session will take approximately ten minutes, depending on the number of participants. Only this part of the session will be recorded.

Type 2

The goal of the second type of focus group is to have students reflect on their learning at the end of an introductory statistics course, with a particular focus on when and how they made use of particular learning tools. It is of interest to explore how students perceived tools to be helpful to their learning, and how the impact of a tool interacted with other resources.

The focus group will be facilitated by at least one member of the study team, but will not involve the instructor of the course from which participants are recruited. A facilitator will introduce themselves and outline the nature and purpose of the focus group, thanking the students for attending and inviting questions. Students will be invited to introduce themselves to the group, in part to encourage all group members to participate. The entire session will be recorded.

It is hoped that the group discussions will be only lightly guided by a facilitator, but for each major learning tool used during the course (such as in-class activities, on-line homework, on-line videos, and web visualization tools) feedback will be sought on at least some of the following questions:

1. How often did you make use of [*learning tool*]?
2. At what part of the course did you make most use of [*learning tool*]?
3. Did you find [*learning tool*] helpful to your learning? If not, why do think that was? If yes, can you say why it helped?
4. Did you find [*learning tool*] complemented any other learning resources you used?
5. Any other comments on [*learning tool*]?

It is proposed each major learning tool be discussed for up to ten minutes. Time permitting, participants will also be encouraged to discuss other aspects of their learning during the course, such as topics they found particularly difficult, and suggestions for learning resources they would have liked to have seen but were not provided.

In the event that only a small subset of the participants present actively contribute to a discussion, a facilitator may at times intervene and ask if other participants share the views being expressed. No-one will be directly coerced into giving their opinions, however.

Supplementary Material B: Interview protocol for focus group on web visualizations: Sampling from the Normal Distribution: Interview Protocol Form

Title of Resource: Sampling from a normally distributed population

Date:
Time:
Location:
Interviewer:
Interviewee:
Release Form signed?

Notes to interviewee:
Instructions (opening statements) to interviewee:
Approximate length of interview:
Purpose of research:
Methods of disseminating results:
Pre Questions:

- Describe what a sampling distribution would look when sampling from a normal population. (Based on shape, center and spread)
- Do you think the width of the distribution of sample means will be more variable, less variable or about as variable as the population distribution?

Activity:
Student works through resource while talking aloud
URL: http://www.zoology.ubc.ca/~whitlock/kingfisher/SamplingNormal.htm
Post Questions:
CAOS/ARTIST questions?
Closure:
Thank you to interviewee
Reassure confidentiality
Ask permission to follow-up if necessary

Supplementary Material C: Interview protocol for focus group on web visualizations: Confidence Intervals for the Mean Interview Protocol Form, as in Supplementary Material B but

Title of Resource: Confidence intervals for the mean

Pre Questions:

- Which is larger (i.e. has a broader interval) a 95% or a 99% confidence interval? Why?
- How does sample size affect the width of the intervals?

Activity:

URL: http://www.zoology.ubc.ca/~whitlock/kingfisher/CIMean.htm

Student works through resource while talking aloud

Supplementary Material D: Survey questions on video rough cut

1) Please provide your subject ID:
2) Have you met the concept of [*statistical concept*] before?

a) Yes
b) No
c) Not sure

3) How confident do you feel about your understanding of [*statistical concept*]?

a) Not at all confident
b) A little confidence.
c) Quite confident.
d) Very confident.

4) Please watch the rough cut video below. Please remember that this is not the final version, and animations are not as they will appear when the video is completed. Text onscreen may denote or explain transitions or animations currently missing**.**

5) Have you watched the video in full?
6) How confident do you feel about your understanding of [*statistical concept*] after watching the video?

a) Not at all confident.
b) A little confidence.
c) Quite confident.
d) Very confident.

7) Which part of the video, if any, do you think most improved your understanding of [*statistical concept*]? (You may refer to time points on the video if you wish.)
8) Which part of the video, if any, do you think was confusing or unclear in explaining [*statistical concept*]? (You may refer to time points on the video if you wish.)
9) In your opinion, the length of the video was

a) Too short
b) About right
c) Too long

10) In your opinion, the pacing of the video was

a) Too slow
b) About right
c) Too fast

11) What things, if any, did you like about the rough cut video?
12) What things, if any, did you dislike about the rough cut video?
13) How, if at all, do you think the video should be changed to improve its teaching effectiveness?
14) Please provide any other comments or suggestions you may have about the rough cut video.

Thank you for taking the time to provide your feedback.