CREATING E-LEARNING TOOLS FOR SELF-TEACHING BY ADULT USERS

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This paper investigates two different e-learning tools designed to be used by international adult learners: web applications in official statistics (Measuring Price Change, Comparing Populations, and Graphing in Excel) hosted on the International Statistical Literacy Project website; and a United Nations Institute of Training and Research Massive Open Online Course, "Understanding Data and Statistics Better—For More Effective SDG Decision Making." The paper reports on commonalities in their design, including having diverse members on their development teams. Both tools have been used by many learners from a variety of countries. Challenges that remain for these types of tools include their longevity and currency (in terms of up-to-date teaching material) and issues related to the use of online assessment, particularly for certification.

BACKGROUND

Many adult users of statistics, including government advisors, have limited mathematical and statistical skills but still need to use and interpret statistical information. One way of upskilling these users is through self-teaching online tools, where they can develop the knowledge they need when they need it and without requiring a high level of either mathematics or programming skill. The author was one member of the team that designed three web applications (apps) in official statistics hosted on and freely available for use from the International Statistical Literacy Project (ISLP) website at http://iase-web.org/islp/Resources.php?p=Apps. She separately provided draft content material for the United Nations Institute of Training and Research (UNITAR) Massive Open Online Course (MOOC), *Understanding Data and Statistics Better—For More Effective SDG (Sustainable Development Goals) Decision Making*, which can be accessed at https://learnatunitar.org/course/view.php?id=498. These two types of e-learning tools are examined for commonalities in the way they were designed, the challenges each faced, how effective they are (in terms of numbers and diversity of participants), and longer-term issues including their potential life-times. This paper builds upon and extends work done previously for a paper published in the *Statistical Journal of the IAOS* (Forbes & Harraway, 2021).

DESCRIPTION OF THE TOOLS

Web Apps

Creating web apps in official statistics was a joint project between New Zealand academics and the United Kingdom Royal Statistical Society Centre for Statistical Education (SSCSE) located at Plymouth University in the United Kingdom. The first stage in the design process was the prioritization of three topic areas for development: demographic and population studies, measurement of price change, and graphics. All of the web apps were intended primarily as teaching tools, written in HTML5 and designed to be functional for mobile, tablet, and desktop use, with learners able to come in and out at will to access learning relevant to them. The design of the first two apps included a range of instructional strategies such as introductory videos, commentary about usage, interactive and/or dynamic graphs, direct links to other websites as appropriate, and instructions for using the apps (Figure 1). Specific teaching material was delivered using a structured learning approach (Figure 2), starting with simple exercises and then getting progressively more difficult. As Yang (2017) states, these pedagogical strategies are ones that most teachers would agree with, whether the material was being taught online or in person. The online responses to exercises such those displayed in Figure 2 were informal formative assessments designed to help learners make decisions about their next learning step(s), as described by Dolin et al (2018).

The Graphs web app had a structure that differed from the other two by containing video presentations about the history of graphs, how to use graphics to aid decision making (particularly newer dynamic and interactive graphs, maps, and integrated maps and graphs), and the features of good and bad graphs. These videos were followed by datasets and video instructions on how to create graphs in Excel (the most common spreadsheet available to government employee learners).

In S. A. Peters, L. Zapata-Cardona, F. Bonafini, & A. Fan (Eds.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11 2022), Rosario, Argentina.* International Association for Statistical Education. iase-web.org

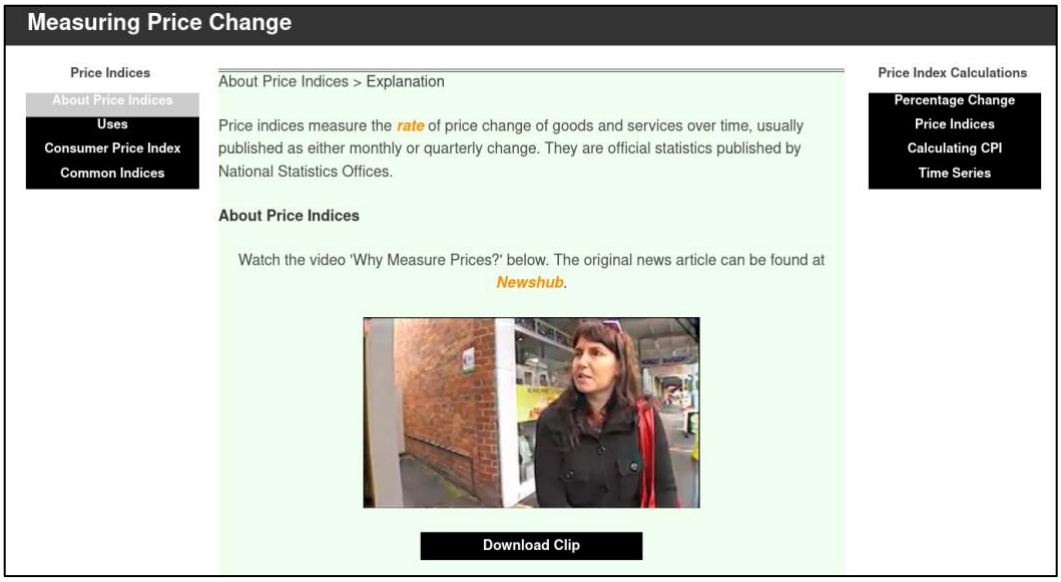

Figure 1. Screen shot of Prices web app home page

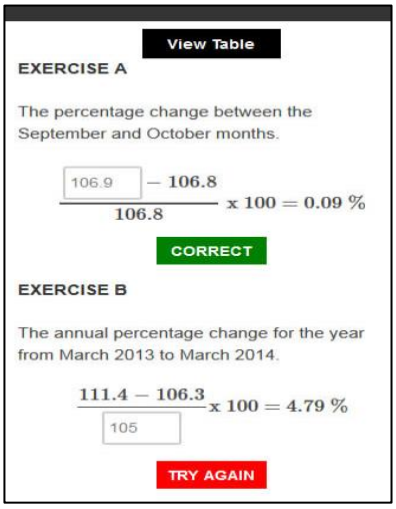

Figure 2. Structured learning in Prices web app for calculating percentage change

The resulting web apps are hosted on the ISLP website and are freely available to all users.

1. *Measuring Price Change* (Prices) focuses on the Consumer Price Index (CPI), with users working with price indices, changing base years, time series (with the CPI), and policy uses of price indices.
2. *Comparing populations* (Populations) involves users making comparisons over time, between countries, and between groups within countries. The content includes demographic concepts (fertility, mortality, migration, life tables), age standardisation, and odds ratios.
3. *Graph It in Excel* (Graphs) includes a history of graphs, data presentation, and instructions for the creation of simple graphs in Excel.

Although intended for individual users, the web apps have also been used in classroom teaching for a data course with policy analysts, an across-university statistics honours course, and a third year sociology course in New Zealand. For example, the Graphs web app was used in an assessment assignment requiring the creation of population pyramids in an honours course (Forbes et al., 2018).

UNITAR e-learning Course

The UNITAR programme, *Understanding Data and Statistics Better—For More Effective SDG Decision Making*, was designed specifically for users to report on progress towards the 17 United Nations SDGs (https://sdgs.un.org/goals) but could also be used to teach how data can be used to inform

public policy more generally. There is no fee for this self-paced course, originally intended to run from April 2020 (when it opened online) to December 2020 with the progressive rollout of the following five modules, each with an estimated learning time of 2–5 hours. However, the final module was not available to users until the end of 2021, and the course remains open.

- Module 1. Statistical literacy (basic statistical skills up to simple bivariate measures)
- Module 2. Interpreting and assessing the fitness of or purpose of data (focusses on the interpretation of metadata and data about the data)
- Module 3. Communicating with data (using words, tables, and visualisations)
- Module 4. Data sources for SDG indicators
- Module 5. Policy formulation, monitoring, and evaluation (includes population, inflation, and other economic measures)

Real world examples are used to introduce sections of the course. These examples include: *Estimating the Global Burden of Disease: Rotovirus*; *What's Wrong With Smoking?—One Country's 180° Turn in 50 Years of Smoking Policies; and COVID: The Situation in Switzerland.* Each module contains questions and hands-on exercises similar to the web apps but with more variety (e.g., using online flip charts and games). Each module also has a final assessment consisting of 10 randomly selected questions. Learners can gain either a Certificate of Participation by completing four of the five modules or a Certificate of Completion by passing a final test.

COMMONALITIES BETWEEN THE TOOLS

Although written only in English, both tools are targeted at an international body of learners (rather than being online versions of classroom programmes). They are free for learners to access and use whenever and wherever they choose, and both use integrative pedagogy in which some theory is given, then practical skills are developed, and end with learners reflecting on the content and engaging with individual explorations of the material (Kumari, 2014). Both tools also are mastery-based and student-centred (Peterson, 2018). Each tries to capture the essence of statistics: sourcing and evaluating the quality of data, understanding and exploring chance and variation in data, and exploring patterns and trends in data. The emphasis is on de-mathematising statistical content in favour of developing conceptual understanding. Official statistics, including data and reports from government agencies, are at the heart of both tools. Official statistics are the focus of the first tool and a major source of data for indicators of progress towards SDGs, particularly social and economic ones, in the second tool. Case studies, or real-world stories, are used in both to motivate learners with exercises based on real data. Teaching material is re-used from a wide variety of sources, including research publications and links (URLs) to online statistical calculators, simulators, and statistics teaching packages.

Another key common element was their development by large, multiskilled, cooperative design and development teams. As stated, the web apps were a collaborative project between academics, an IT specialist (from Victoria University and the University of Otago), and SSCSE staff, who provided both teaching material and the project webmaster. The UNITAR e-learning programme also had a diverse development team that included persons from different countries and with different skill sets, including statistics education, course design, and country-specific expertise. The major contributors were either academics or UNITAR staff (led by Elena Proden).

DIFFERENCES BETWEEN THE TOOLS

Differences between the tools include the type of assessment used (formative or summative), learners' ability to move easily around course material, the number of teaching examples from different countries, and the spread of countries with learners accessing the tools. Only formative assessment (to assist learning) is used in the web apps, but the UNITAR course also gave learners a choice of summative assessment (leading to a Certificate). The structure of the web apps makes it easier for learners to find and explore only the material they want, whereas after learners have accessed a module in the UNITAR course, the module is designed with the expectation that they will work through it from beginning to end. However, there is much greater international variety in the examples presented in the UNITAR course, which also has much more focus on metadata and data quality together with discussion of a greater range of data types including big data and spatial data. This helps learners to know what type of data is best for their particular problem, where it can be sourced, how to determine

its quality, and what can be learned from it (using statistical tools to explore patterns and trends and the impacts of chance and variation in the data). Both tools investigate the policy uses of statistics, but only the UNITAR course explicitly looks at the relationship between data outputs and long-term outcomes in the real world.

CHALLENGES

Good online courses can be developed by individuals (as has been shown in the recent COVID-19 pandemic), but having multiskilled design teams that include varied technical skills and different cultural perspectives can help to develop content applicable to an international audience. It is easy to underestimate the time involved in creating online teaching tools. The web apps took almost a full year to develop, and the final UNITAR module was uploaded almost two years after the first. Having large teams involved in the design and creation of e-learning tools comes with significant costs and makes funding such projects an ongoing challenge. Their effectiveness in terms of use, longevity, and keeping teaching material current is a concern.

Usage

Both of these tools have been used by a large number of learners from a wide variety of countries. The Prices web app was accessed 18,931 times between November 2017 and March 2022; Populations was accessed 15,569 times; and Graphs was accessed 20,023 times. As Figure 3 shows, usage was fairly consistent over the entire time period. About half (47%) of the visits can be identified as being from countries that had 100 or more visits over this period. The country with the greatest number of users was the US (over 10,000), followed by a wide range of mainly Australasian, Asian, European, and a few African countries.

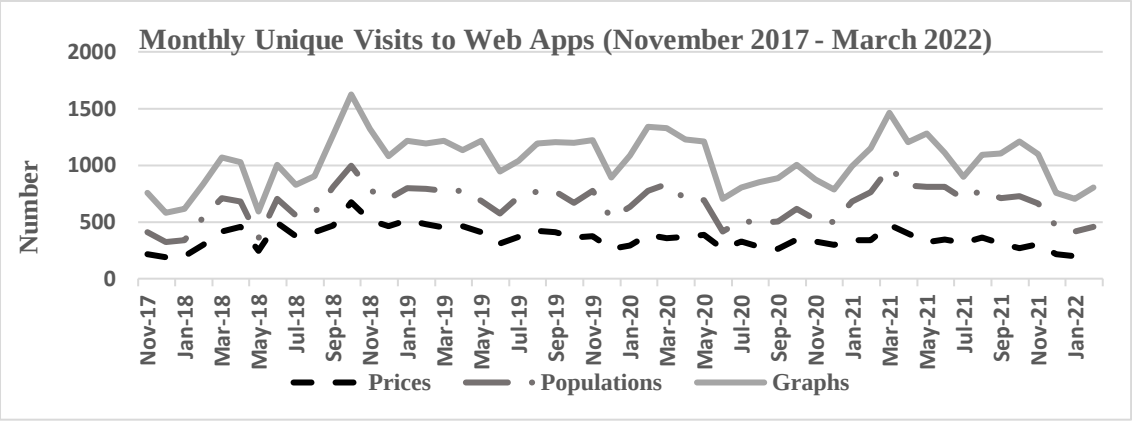

Figure 3. Unique visits to web apps

In the two years since the opening of the UNITAR course in April 2020, over 1,100 learners enrolled in the course. Although new enrolments were still taking place, many learners had not accessed the course for over a year, probably because of delays in the availability of the modules. Learners from more than 50 countries accessed the course, including learners from Africa (in particular Nigeria and Ghana), Asia (especially India), and most European, Middle Eastern, and South American countries as well as Canada, the US, and the Pacific. The major difference between users of the tools was that the UNITAR course had a much larger number of African participants than the web apps.

Longevity and Currency

As shown above, both tools are more than single year events, but keeping material up-to-date and relevant to learners is a challenge because development teams are disbanded or move on to other projects. Although both tools could continue to be used for a number of years, their effectiveness in terms of currency will diminish over time. For example, for how long will links to COVID-19 graphics be relevant? Both tools make use of web links to material on other websites, such as national statistics offices, who make their own decisions about maintaining particular tools. (For example, the Populations

app includes a link to the Statistics New Zealand dynamic population pyramid, but this content is no longer available.) Tracking the most-accessed areas in these tools could assist future e-learning developments.

Assessment

As detailed by the New Zealand Qualifications Authority (2022), assessment done online (as well as face-to-face) should meet the standard requirements of validity (assess the knowledge learned), reliability (repeatability), sufficiency (having enough evidence to make a judgement), authenticity (the learner's own work), and fairness (equitable to all learners). As Adri et al. (2021) state, we can often overlook necessary changes for moving from paper-based assessments to online assessments. They recommend a four-phase testing approach for online assessments (unit testing, integration testing, system testing, and acceptance testing). Yang (2017) suggests that course design often drives the instructional strategies adopted for online courses, and this may well be the case for the assessments used in both of these tools. In practice, some aspects of good assessment (for example, authenticity) can be hard to achieve in an online environment. There is research evidence that even reading comprehension can be affected in a digital environment (Eyre, 2017), and care needs to be taken to ensure that skills other than statistics are not being tested (unless they are part of the targeted learning). For example, for the assessment item in Figure 4 (from the UNITAR course), a high level of English language is required, which can compromise the validity of this item designed to assess learners' knowledge of different types of bar graphs for learners for whom English is not their first language.

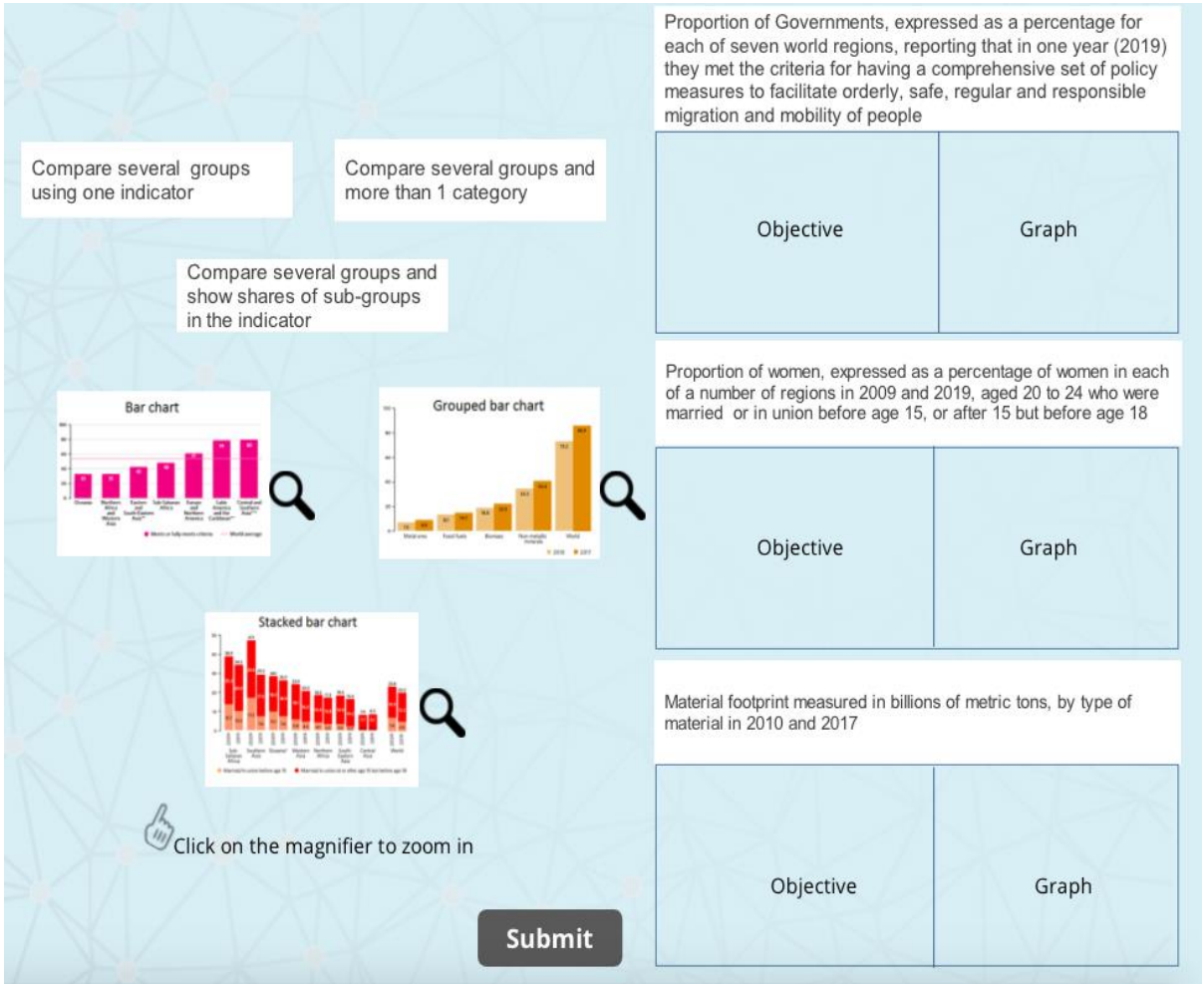

Figure 4. Bar graph exercise from the UNITAR course

Validity (in terms of demonstrating statistical understanding) can also be compromised if learners' technical skills are inadvertently evaluated as part of statistics assessments. Formative assessment is a standard part of structured self-learning. Although summative assessment and certification can act as an incentive for learners to complete courses, further research is needed to evaluate its effectiveness as a device to ensure long-term competency.

Both tools use visualisations to demonstrate concepts by providing links to dynamic and interactive graphs and maps (e.g., cartograms, population pyramids) and dashboards such as the World Health Organization's (WHO) Coronavirus Disease (COVID-19) Dashboard (https://covid19.who.int/), but more use could be made of visual tools to demonstrate statistical concepts such as the mean as the centre of gravity of a set of data or percentage change as a proportion of the original value. As an example, Forbes (2012) used three-dimensional scatterplots to teach the concept of interaction in simple regression.

CONCLUSION

The two e-learning tools described in this paper are targeted to policy and decision makers with limited mathematical skills. They both provide free access and self-paced learning for many statistics learners across many countries simultaneously. However, as time passes, real world examples lose relevancy, and up-dating to keep material current becomes an issue, particularly if ongoing funding to maintain these e-learning tools is not available. There are also other challenges, including developing good and valid assessments, that need to be addressed. As the demand for online learning increases, we need to increase our knowledge about the advantages, disadvantages, and appropriate uses of online learning in comparison with face-to-face teaching.

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