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Submission on the Draft Statistics Curriculum

This submission on the draft statistics curriculum has been prepared following eight joint video conferences linking Statistics New Zealand offices in Wellington and Auckland.

People participating in these discussions were:

Statistics New Zealand:	Mike Camden, Pauline Stuart, Lesley Hooper Lauren Wood, Bronwyn Weston
Massey University:	Dr. Alasdair Noble, Prof. Jeff Hunter, Prof. Steve Haslett
Victoria University:	Prof. David Vere-Jones
NZCER:	Alex Neill
NZ Correspondence School:	Derek Smith
The University of Auckland:	
Dept of Statistics:	Prof. Chris Wild, Dr. Maxine Pfannkuch, Dr. Rachel Fewster, Dr. Ilze Ziedins, Matt Regan,
Faculty of Education	Peter Hughes, Gillian Frankcom
Team Solutions	Pip Arnold
Auckland Univ. of Technology:	Murray Black
St Cuthbert's College:	Jeanette Saunders
Kowhai Intermediate:	Lisa Darragh

[Prof. Wild is Past-President of the Int. Assoc. for Statistics Education, Alex Neill is Convenor of the Ed. Committee of the NZ Statistical Association (NZSA) and most other Committee members are also included. Profs Hunter and Haslett are former Presidents of NZSA, Gillian Frankcom is President of the Auckland Mathematical Association. Six group members are currently in NZ schools or were until very recently and 2 others have had leadership roles in NZ schools.]

Executive Summary

This curriculum should aim to put New Zealand at the forefront of statistics education, and thereby raise the level of statistical literacy within our society which is important from a socio-economic perspective.

We acknowledge the wonderful opportunity that this curriculum review process provides, but are also very mindful of the huge cost to teachers, students, and to the economy and society in general if the document fails to capture best teaching, learning and statistical practices.

Our recommendations for changes to this draft curriculum have drawn on a very broad spectrum of expertise on current statistical practice, statistics education research and statistical pedagogy, all of which have developed extensively since the publication of the last curriculum in 1992, and on extensive experience in New Zealand classrooms.

We have two main recommendations:

1. That our proposed changes to the objectives are adopted in full.
2. That a very high level of ongoing professional support is provided for teachers; this includes written and electronic resources, relevant software, on-the-job professional development, and pre-service teacher education.

Contents

Section 1: General Comments

Introduction

The current statistics curriculum statement was published 15 years ago. Over this period of time most facets of our society have undergone significant changes. There have been huge advances in technology. On a daily basis, we have at our disposal an ever-increasing amount of information, a large proportion of which is statistical in nature. We need to make sense of and use such information: to make better decisions, to evaluate claims, and to communicate reasoned opinions. We should aim to be more informed citizens through becoming better information consumers and better users of statistically based information. There are economic and social benefits to be gained through raising the levels of statistical competency and statistical literacy. Indeed these statistical skills are essential to the economic and social well-being of a complex modern society. It is timely that the New Zealand statistics curriculum statement is undergoing a review and we very much welcome this 1-in-15 year opportunity to play our part in this process.

The 1992 statistics curriculum was regarded as being a world leader by international statistics education researchers such as Professor Jane Watson. The direction and focus of the draft statistics curriculum will continue to place us at the forefront.

We are excited by the evolving nature and direction of this statistics curriculum. We very much approve and very much support the following features of the draft:

1. The promotion of statistics within the curriculum.
2. The reinforcement and further development of statistics from the previous curriculum.
3. The logical structure of the statistics statement and its similarity to and relationship with the mathematics structure.
4. The strong links between:
   - statistical investigation, statistical literacy and probability
   - the mathematics and statistics objectives.
5. The easy-to-identify progression from level to level.
6. The greater emphasis throughout the entire curriculum on:
   - statistical thinking and statistical reasoning
   - probabilistic thinking
   - statistical literacy
   - the overall role of the statistical enquiry cycle across the three threads
   - the use of graphics
   - intuitive and common sense ideas.
7. The addition of new content reflecting both the changing nature of statistical practice and the type of statistical information that is prevalent in every day life.

Professional development

We are pleased to see that one of the five key competencies of the New Zealand Curriculum is thinking. Embedding thinking and reasoning within the statistics curriculum requires a new approach to teaching and new ways of thinking about how to reason statistically. Fortunately within the statistics profession and statistics education research, the need to develop students' statistical thinking and what that entails has been actively discussed and researched since the late 1990s. There is now an increasing body of new knowledge on the pedagogical change required and the content knowledge requirements for teachers in order to enhance and promote statistical thinking.

We know from our own experience and research in New Zealand classrooms that teachers will need considerable assistance in implementing the statistics curriculum. We feel very strongly that professional development on a long-term basis is necessary for all teachers to become statistically

literate themselves and to become confident in teaching statistics. The curriculum should be implemented gradually through the levels so that teachers have time to adjust to new ways of teaching and thinking about statistics.

This professional development should be via a well thought out process where facilitators need to up-skill their content knowledge, especially at the primary level, and teaching approaches need to be trialled and tested before implementation. The design of the professional development should involve teachers, teacher educators and statisticians working together and pooling their varied expertise to develop a shared understanding of statistical practice and thinking for the 21st Century and effective pedagogical approaches.

The professional development should be: sustained by involving teachers in a coherent effort to explore and integrate new ideas into their classrooms; content-focused by engaging teachers in experiences that build their own content knowledge and statistical thinking; based on understanding what content and thinking is important for students to learn and why; and be collaborative and relevant. To develop students' statistical thinking, a key competency of the New Zealand curriculum, teachers' statistical thinking must be developed through a substantial investment in professional development.

Furthermore, a statistically literate society is economically useful for New Zealand. A UK governmental report (Wilson & Green, 2001[1]) stated the occupational grouping "Business and Statistical Professionals" was the third largest growth area for the current decade. The two higher growth areas were the groupings "Legal Professionals" and "Leisure and Travel Service", which makes *statistics* the single highest occupational growth area among school-taught subjects. Such a growth in the need for statistically literate people has been recognized in the public sector in New Zealand, which has resulted in the recent development of courses to up-skill employees in interpreting statistics for evidence-based justifications. At the university level, more students are now studying statistics than mathematics. For NCEA Level 3, Statistics and Modelling is the second most popular subject after English. Statistics has infiltrated nearly every discipline and hence professional development is not only needed for mathematics teachers but for all teachers across the curriculum such as biology and social studies teachers who use statistics in their subject areas.

The mathematics teaching force has a substantial level of turnover, with new teachers and new overseas arrivals joining the profession. Often the new arrivals have not taught statistics before or even formally studied statistics. Therefore in-service professional support needs to be ongoing. We are also very concerned about pre-service courses for teachers devoting less and less time to improving statistical knowledge. This fact alone suggests the need for these teachers to continue their statistical development through in-service courses.

There has been a huge investment in the numeracy project. A similar investment needs to be made in statistics. Statistics involves a way of thinking which is different from the deterministic approach of mathematics, and, in particular, different from the type of thinking promoted in the numeracy project as currently scoped.

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[1] *Wilson, R. and Green, A. E. (2001) Projections of Occupations and Qualifications: 2000/2001: Research in Support of the National Skills Taskforce. Sheffield: Department for Education and Employment.*

Resourcing the implementation of the curriculum

The statistics curriculum cannot be implemented without access to technology. We strongly recommend that the Tinkerplots and Fathom software be purchased at the national level by the Ministry of Education so that this software is available to all students in all schools.

In statistics, there is always a huge need for datasets, their stories and guides for what to do with them. The ministry should commission a website of New Zealand datasets together with background information. Ideally, the data should be recent, local, from interesting contexts and give students the opportunity to make interesting discoveries within them.

The proposed second tier curriculum material is essential. This material needs to be plentiful, accurate, attractive to teachers and students, inter-active and of high quality in every way. The statistics curriculum must be supported with exemplary activities that demonstrate how the objectives should be interpreted. These exemplary activities should be online and accessible to all teachers. The teachers' notes should be written using dynamic re-creation voice-driven technology that makes the intentions of the curriculum and the new ways of thinking clear to teachers, particularly those teachers in small schools. It is very important that these materials are available at least one year before the implementation of each new part of the curriculum.

The second tier should: include a glossary which would expand on the 1992 glossary;
exemplify group activities and teamwork; lead teachers into making links across threads, strands and learning areas; and include clear statements about new directions, rationale and pedagogy.

To support NCEA assessment the second tier material should exemplify achieved, merit and excellence performance levels within an activity. The support material needs to interpret the objectives as well as interpret performance levels within an objective. One of the purposes of the support material should be to interpret the curriculum and the assessment industry should not be expected to guess the hierarchy of levels.

The second tier resource materials need to have a wide input from many people in terms of brainstorming ideas, acquiring rich data sets with stories, writing, monitoring, trialling, and editing. The pooled expertise from the statistics profession and teachers working together is critical to producing a good, statistically sound product. As a group we are prepared to be involved in the production of the second tier statistics curriculum material to ensure the resources are robust and reflect good statistical practice. Many other teachers are also willing and want to be involved in the development of this material. It is important to get this documentation right and therefore substantial funding will be required.

Section 2: Probability Objectives

General Comments

1. The probability thread should focus on activities that allow students to experience randomness and that draw attention to certain types of random behaviour such as small sample unpredictability.

2. Probability should be presented as being fun and useful. Below are some reasons why probability should be taught and the curriculum should reflect this rationale.

   - **Understanding life's uncertainties**
     - Life, for children and adults, has many situations where the results of our actions are partly out of our control and partly under our influence. Examples abound in PE, health, environment, etc. We study probability to show that we do have some control over what happens, and that we can manage risks where we don't have control.
     - In established probability terminology, life contains 'experiments' that have sets of 'outcomes'. The outcomes have probabilities, and together these form 'distributions'. The probabilities in these distributions are 'conditional' on our actions. There's uncertainty about which outcome of the set will happen, and there's uncertainty in what the probabilities are for outcomes. In short: life is full of uncertainty and variation, but we can control some of this and manage the risk of the rest.

   - **Decision making under uncertainty**
     - Appreciating decision making under uncertainty requires a feel for variation in the form of probability distributions.

   - **Theoretical probability distributions**
     - There are many experiments, games and other situations that can be modelled as theoretical probability distributions. This modelling lends itself to practical applications such as estimating the reliability and variability of a count (e.g. bacteria, accidents).

3. The original second tier material situates probability entirely in coin, dice, and card-drawing scenarios. Probability should be driven by a variety of situations: games involving chance only such as horse racing with dice; games of skill with elements of chance such as throwing a ball in a bin; investigations involving chance combinations. The Australian Curriculum Corporation books on "Chance and Data" provide a good source of ideas for introducing chance to young students.

4. The link between theoretical probability distributions and empirical probability distributions is an important aspect in understanding probability. Therefore from Level 3 onwards the building from simple to more complex theoretical models and comparing empirical results should be the underlying rationale for the achievement objectives.

5. Other ideas for approaching the teaching of probability are:

   - **Underlying teaching ideas**

     Intuition $\longleftrightarrow$ Empirical $\longleftrightarrow$ Theoretical

     - Start with students' intuitions (which may be false impressions) and their own language, do empirical experiments or games, reflect on results and intuitions

and through cognitive dissonance or conflict start to build probabilistic concepts. Move to building theoretical models about Level 3.

- **Context for probability strand**
  - Start with simple activities involving elements of chance and elements of skill (physical or mental), and progress to more complex activities (experiments, investigations and simulations). These will continue to involve elements of chance and skill, and influences that can be identified and/or controlled.
  - The activities include games, competitive ones or otherwise. Some of these activites will extend and challenge students' concepts, and a few should do so through producing counter-intuitive results. Teachers can use cognitive dissonance here to promote learning. Activities should be used to overcome prevalent misconceptions.
- **Statistics strand**
  - In the second tier have a section "Connections to probability" and demonstrate how teachers can build probabilistic ideas from data.

6. We feel that the current wording of the probability objectives is incorrect in two respects. First, one cannot conduct a chance event. A chance event results from an activity involving chance elements. Second, one cannot predict results from a chance experiment. The use of the word *predict* was particularly disliked by the statisticians and probabilists. Therefore we are suggesting a new set of objectives.

7. Reform the current algebraic approach to probability. Make sure that algebra doesn't dominate the teaching approach to probability. The focus of teaching should be on *thinking* probabilistically and *experiencing* probability not on mathematical manipulations.

Probability Levels 1 to 5

Comments

- Besides allowing students to experience randomness, students should also be building up notions of distribution. Up to level 4 use frequency distributions. Only at level 5 introduce probability distributions, using the rationale of comparisons. Different sample sizes will lead to this idea.
- To enable students before level 5 to compare probabilities we suggest for comparative purposes that fractions should be represented as "out of" and that we keep the "out of"s all the same such as all "out of 10" or all "out of 100". The quantification of probability needs to be thoroughly thought through and to be adequately linked with but not governed by number considerations.
- The following is a suggested progression for the quantification of probability:
  - **Level 2**

    Quantification based on small fixed sample sizes. Comparisons between probabilities can be expressed as counts: "Of my 20 sweets, 7 were red". These counts can be compared with other students with 20 sweets. This only requires students to be at the counting stages of the Number Framework.
  - **Level 3**

    Use simple fractions to express probabilities. These have been done at Level 2 Number Knowledge, and as has been seen above, are accessible to Level 3 students. Continue to use fixed sample sizes, in particular 10 and 100. Compare probabilities with fixed denominators, expressing them as fractions. Students need to be advance additive / part-whole thinkers, but do not need to be multiplicative thinkers for this.
  - **Level 4**

    Use fractions and equivalent fractions based on simple basic-facts relationships for probabilities and relate some of these to common percentages and decimals such as 0%, 10% (0.1), 25%, 50% (0.5), 75% and 100% (1.0 or 1). Students need to be advanced multiplicative thinkers for this. These fractions form natural bridges to 1 and 2 digit decimals as well as percentages – the links can be made in Tier 2.
  - **Level 5**

    Describe probability using proportions, fractions, and decimals. Compare probabilities. Students need to be at the advanced proportional reasoning stage for this. Tools for the comparison of probabilities can be generalised at Level 5. Some of the advanced proportion part-whole reasoning ideas involving percentage can continue to be developed at this stage.

Proposed Objectives

Based on our above comments we would like the objectives in the draft to be replaced with the Tier 1: Achievement Objectives listed in the table below. Tier 2 curriculum material needs to take into account our comments listed below under Tier Two.

Level	Tier One: Achievement Objectives	Tier Two
One	Participate in simple activities with elements of chance, record and discuss results.	Links to statistics is important, particularly the real life events.
Two	Strategise about and participate in simple activities with elements of chance, record and display results and discuss strategies	Counts; In tier 2 of statistical literacy introduce the idea that teachers should be discussing media articles with chance elements such as 1 in 100 year floods. That is, chance is part of everyday life experiences.
Three	Investigate activities with elements of chance by counting, listing and displaying outcomes.	Starting to build a model; use simple fractions of 1/2, 1/4
Four	Use simple probability distributions to model chance experiments and activities with elements of chance.	Models, displays, tree diagrams, tables of outcomes, organised lists; percentages can be used as a natural consequence of using "out of 100" (research has shown %s can be taught when the need arises).
Five	Describe probability and variation in chance experiments, using proportions, fractions, decimals and distributions.	Use probability models, 2-way tables, between model and experiment, proportion – small chance events the idea of 3 out of 100,000, . . . , 3/100,000, trying to compare by using common denominator, giving it meaning, turn it back into frequencies, displays; represent probability formally as a number between 0 and 1.

Probability Level 6

Comments

- Generally this level is about looking at/investigating the link/connection between theoretical discrete probability distributions and corresponding empirical probability distributions.
- We need to change the stem of objective as 'investigate chance event' does not make sense.
- It is not clear as to how 'estimating population parameters' fits in to this Probability thread. Does not belong here, as it already occurs in Statistical Investigation Level 7 thread.
- 'Calculating probabilities . . . ' should be clearly linked to and listed under 'Investigate practical situations . . .'
- ' . . . expressing them as percentages' could be interpreted to mean that all probabilities are to be presented as percentages, change to 'expressing them in a number of ways'.
- Tier 2 can contain: sum of two dice, spinner with discrete outcomes, sum of 2 different (discrete) spinners etc. (simple discrete situations)
- We need to note that this section has only about a 2-week teaching period.

Proposed objective

Investigate practical situations involving elements of chance through:

- *comparing theoretical discrete probability distributions and empirical probability distributions appreciating the role of sample size;*
- *calculating probabilities and expressing them in a number of ways.*

Probability Level 7

Comments

- This is an extension of Level 6 but now deals with continuous distributions: empirical distributions (using histograms) and their corresponding theoretical distribution.
- Change stem to include variation as students relate to distributions (e.g., height) which are about variation rather than chance.
- Our discussion on the Normal distribution included what do we want students to know and why? We note the following points:
  - Activities to produce empirical distributions largely focus on variation aspect. (e.g., measurement variability etc). Tier 2 should promote activities that involve sets of values of continuous variables. The distributions of these values are examined, via histograms and dot plots, for their features and for possible underlying continuous distributions. The activities include experiments, surveys and examination of supplied datasets.
  - It is not possible to justify the density expression theoretically.
  - Probability calculations should no longer be by using tables (for a majority of teachers, how to use the tables was the focus in the past).
- There is benefit in knowing there is more than just one continuous distribution (i.e., the normal).

- Uniform distribution:
  - Include the uniform distribution as it is beneficial to realise that there is more than just one continuous theoretical distribution (i.e., the normal).
  - It has the simplest density and it is easy to produce the theoretical distribution.
  - Use spinner (continuous outcome): use practical activity then extend to computer simulation to produce empirical distribution.
- List of tools for calculating probabilities:
  - Promote the use of 2-way tables.
  - Remove Venn diagrams: could be seen as an invitation to really get into set theory and its notation and to lean heavily on rules expressed in the notation. Modern Intro Stats texts use words rather than set theory notation. Venn diagrams can be used in an informal way without any reference to set theory notation, e.g. in conjunction with 2-way table.
- Remove relative risk calculations: will need to be done to understand the terminology (see Literacy thread) but not 'big enough' to be explicitly stated in curriculum stated. It needs to appear in Tier 2 material.
- We have added the geometric distribution to the list of continuous distributions because of its simplicity:
  - The path from the situation to the algebraic expression for the distribution is short and relatively straightforward.
  - It has applications subject to only one assumption.
  - It can be actioned (with tennis balls and bins) and simulated (with dice) easily.

Proposed objective

Investigate practical situations involving variation and elements of chance through: - *comparing theoretical distributions such as the normal, uniform and geometric distributions with corresponding empirical distributions;* - *calculating probabilities using tools such as two-way tables, tree diagrams, and simulations.*

Probability Level 8

Comments

- We would like an explicit statement in Tier 2 about the removal of linear combinations and linear transformations of random variables. The level of applicability in the real world does not warrant its inclusion.
- We want to promote the concept of making the variation of values around the mean visible:
  - We propose that **standard deviation** should replace **variance**, standard deviation allows for *rough measure of average distance* idea.
  - Avoid E(X^2) – E(X)^2 form. Tier 2 to explain appropriate method.
- We do not know what is meant by "applying the central limit theorem". The CLT is not worthy of mentioning in the Probability thread. The appropriate place is in the Statistical investigations thread since the CLT underpins confidence intervals.
  - We propose that the CLT should be removed from the Level 8 Probability thread and added to the Level 8 Statistical Investigation thread.
- Add uniform and geometric to the list of continuous distributions – see Level 7 proposed objective.

Proposed objective

Solve problems and model chance situations by:

- *calculating probabilities of independent, combined and conditional events;*
- *calculating and interpreting expected values and standard deviations of discrete random variables;*
- *applying the Poisson, binomial, normal uniform and geometric distributions.*

Section 3: Statistical Literacy Objectives

General Comments

1. This is the 'data consumer' strand compared with the other two 'data producer' strands, *Statistical Investigation* and *Probability*. This is about looking at someone else's graph/data/investigation.
   There are 3 components to statistical literacy:
   - understanding what others are saying /presenting, e.g., in risk statements, need to understand risk, relative risk or increased risk
   - critiquing or evaluating what they are saying/presenting, e.g., evaluate the choice of data tools (charts/tables/numerical summaries)
   - questioning for clarification and further understanding, e.g., traffic death–rates: deaths/km, deaths/capita, deaths/vehicles?; what is causing change over time?

   Students should progressively build a list of "worry questions" over time.
   Research has shown that 'Statistical Literacy' needs to be *taught*, acquisition of Statistical Investigation and Probability skills does not necessarily give statistical literacy skills.
   Statistical literacy is the conjunction of statistical investigation and probability, i.e., we need to remember that it is about chance statements as well as statistical statements.

2. Statistical literacy skills are needed across all curriculum learning areas (e.g., numerical literacy includes data literacy; statistical literacy is driven not just by Probability and Statistics but also by, e.g., English and Science as well as) so it is important to get this right.
   - Reports can come from peers in the same class or the next door class, media, and scientific studies and can be introduced in this order, e.g., at Level 1 from peers through to Level 8 from scientific studies.
   - We note that Statistics New Zealand produces many reports that are targeted at three levels of audience: public, professional and technical. Other agencies will produce similar ranges. Students can progress through these ranges.
   - The draft curriculum focus is on critiquing displays, but it needs to be about all of the phases in the investigative cycle and probability as well.

3. *What is statistical literacy*?: It was acknowledged that some researchers have widened their view of statistical literacy to include the literacy skills needed for doing and reporting students' own Statistical Investigation and Probability activities. There was consensus that we should confine the Statistical Literacy strand to a 'data consumer' perspective giving an unequivocal message about the importance of the associated set of skills. Considering the widening view of statistical literacy, is there a better name for this thread? We are happy to be consulted on this.

Statistical Literacy Level 1

Comments

- It needs to be clearer that the achievement objective is about both statistical investigation and probability activities (probability examples: critiquing 'with a dice, it's harder to throw a 6 than a 1' or '4 will come up next because it is my favourite number'). Focus should be widened from displays to the whole investigation.

Proposed Objective

Interpret statements made from statistical investigations and probability activities by others.

Statistical Literacy Level 2

Comments

- Use a stem from here on to clarify/stress the intended meaning of statistical literacy.
- This needs to link with the Level 2 Statistical Investigation (Thinking) thread and the Probability Thread.
- Students need to check consistency between findings and data. Students often give findings based on personal experience.

Proposed Objective

Consider the communications of others by: – *comparing statements made about data with the features of simple data displays;* – *questioning whether the findings are based on the data.*

Statistical Literacy Level 3

Comments

- 'Displays' could refer to tables, tree diagrams, graphs, calculations, probabilities etc., use 'methods' instead of 'displays' to better convey this and to invite comment on other aspects of the investigation.
- Students need to be starting to ask "What if" and "Why" questions about the findings.
- We need to target what is being covered in the Statistical Investigation and Probability threads at this level.

Proposed Objective

Consider the communications of others by: – *evaluating the effectiveness of different methods in representing the findings of an investigation.*

Statistical Literacy Level 4

Comments

- The focus needs to be widened from displays to the whole investigation.

Proposed Objective

Consider the communications of others by:

- *making and evaluating statements about the findings including possible causes of variation.*

Statistical Literacy Level 5

Comments

- This needs to be probability inclusive.

Proposed Objective

Consider the communications of others by:

- *evaluating the statistical process used including their sampling methods, measures of centrality and spread, and the validity of their findings;*
- *evaluating findings about probability distributions.*

Statistical Literacy Level 6

Comments

- When comparing Level 6 to Levels 7 and 8 the use of the words *critically evaluate* in Level 6 suggests that these students are expected to operate at a higher level than Level 7 and 8 students.
- We can use the same stem at Levels 6, 7 and 8.
- Chance ideas/probabilities need to be incorporated. These need to be mentioned in the second tier.

Proposed Objective

Consider statistically based reports by:

- *evaluating measures and data displays used in the media, the statistics and probabilities calculated, and claims made.*

Statistical Literacy Level 7

Comments

- Relative risk is very common in media reports.
- Risk ideas are one of the fundamentals with respect to being statistically literate.
- *Risk*, *relative risk*, and *increased/reduced risk* need to be clarified in Tier 2.
- Calculating risk and relative risk from two-way tables and linking to conditional probabilities, fits with proportional thinking.
- At a simple level, when comparing groups, students can use risk ideas in investigations, e.g., boys are twice as likely as girls to break their leg playing hockey.
- The difference between *sampling* and *non-sampling* errors needs to be explained in Tier 2. The word 'possible' should apply to non-sampling errors and not to sampling errors.

Proposed Objective

Consider statistically based reports by:

– *interpreting claims about risk and relative risk;*

– *identifying sampling and possible non-sampling errors in polls and surveys.*

Statistical Literacy Level 8

Comments

- We can use the same stem as Levels 6 and 7
- The sources of the reports used should widen at this level, and not just be from the popular media (daily newspapers) but could include for example, journal-type/technical magazines (e.g., *The Economist*) and the internet.

Proposed Objective

Consider statistically based reports by:

– *evaluating claims from a wide range of sources, involving polls, surveys, experiments, and observational studies;*

– *critiquing causal-relationship claims and interpreting margins of error.*

Section 4: Statistical Investigation Objectives (Levels 6 to 8)

General comments

1. As a group we discussed the statistical investigation objectives in 2005 and gave our comments to Vince Wright, the mathematics and statistics curriculum project director, who largely incorporated our comments into the current draft. However, after discussing the probability thread and having a working day with teachers on Levels 6 to 8 of the statistical investigations thread we recommend some changes.

2. We propose that the strand should carry the name "Statistical Investigation" and remove 'thinking' (define statistical thinking at the beginning of Tier 2):
   - "Statistical Investigation" describes the context in a more concrete way than "Statistical Thinking".
   - "Statistical Investigation and Thinking" is too cumbersome.

Statistical Investigation Level 6

Comments

- Teachers have raised queries about:
  - use of **and/or** in the objective: suggestion to use **and** (instead of 'and/or', 'or') as this is a curriculum objective not an assessment objective.
  - inconsistent use of **data sets** and **datasets** throughout objectives: suggestion to use **data sets**
  - meaning of **'attributes':** also there is a need to clarify the distinctions between *variables, measures* and *attributes* in Tier 2. Our suggestion is to leave the word 'attributes' in objective but attempt to clarify these words in the glossary and Tier 2. Not an issue that the term 'attributes' is not used at Level 7.
  - meaning of '**informal inferences from sample data**' in objective: our suggestion is to include words '**about populations**' to clarify that we are not making an inference from the sample data *about the sample data.*
- *'using a range of sampling techniques'* needs to have its own sub-bullet

Proposed Amended Objective

Plan and conduct surveys and experiments using the statistical enquiry cycle by:
- *gathering multivariate data and accessing relevant data sets;*
- *determining and justifying the attributes and measures selected;*
- *using a range of sampling techniques;*
- *creating multiple displays to identify and communicate trends, relationships between variables and differences within and between distributions;*
- *making informal inferences about populations from sample data and communicating findings.*

Statistical Investigation Level 7

Comments

- We have a query about wording and punctuation in first sub-bullet of the objective: intention is to use random sampling techniques with surveys only, see proposed amendment below.

Proposed Amended Objective

Use the statistical enquiry cycle to investigate phenomena by:

- *conducting surveys using random sampling techniques, conducting experiments and using existing data sets;*
- . . .

Statistical Investigation Level 8

Comments

- We propose that the reference to the central limit theorem should be moved from the Level 8 Probability thread to the Level 8 Statistical Investigation thread.
- It is recommended that Statistical Investigation, Level 8, Tier 2 should include experiments where empirical distributions are skewed and students assess an appropriate model. Example of activity: orbital express expt / darts.
- Some clarification (punctuation, and/or issue) is needed in the first sub-bullet of the first bullet.
- When writing up ideas for experiments at this level should students be expected to recognize and deal with paired comparison situations?
  - Paired-data will often be a 'natural' design method for classroom data collection – *before and after* situations, e.g., pulse rate and exercise
    - Students can analyse the differences – especially important for confidence intervals.
    - Paired-data situations give rise to most one sample situations in reality.
    - Students can explore different plots:
      - dot plots of before and after data on the same axis, showing pairing
      - dot plot/histogram of differences (e.g., is there a difference between *after* and *before*?)
      - scatter plot of *after vs before* (e.g., relationship/connection between *after* and *before*)
- How far do we go in experimental design principles? What about 'blocking' ideas? Tier 2 needs to clarify this. Teachers will need lots of help with this.

Proposed Amended Objective

Use the statistical enquiry cycle to investigate phenomena by:

- *conducting surveys, conducting experiments using experimental design principles and using existing data sets;*
- . . .

Make inferences from surveys and experiments by:

- *determining estimates and confidence intervals for means, proportions and differences, recognising the relevance of the central limit theorem;*
- . . .