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ABSTRACT

This high technology quality assurance and statistics training module is a part of the statistics unit for an algebra I or algebra II course. This module fits into high school math classes in which students compute and display measures of central tendency and variability. The module contains a description, objectives, and content outline--phase I (quality assurance introduction), phase II (statistical techniques and formulas), and phase III (quality assurance activity). The following attachments are included: graph-generating roster and graphs, additional questions for stem and leaf plots, 13 resources, and pre-evaluation and post-evaluation. (NLA)

High-Technology Training Module

Module Title: QUALITY ASSURANCE AND STATISTICS

Unit: STATISTICS

Course: ALGEBRA I OR ALGEBRA II

Grade Level (s): 9 - 12

Developed by: WILLIAM WIRSBINSKI

Date: OCTOBER 9, 1989

School: OSSEO-FAIRCHILD HIGH SCHOOL

13TH AND FRANCIS STREET, OSSEO, WI 54758

In Touch with High Tech

Developed as a part of the High-Technology Training Model for Rural Based Business and Industry, Technical Colleges and Local and State Educational Agencies under Grant No. V199A90151.

TITLE: QUALITY ASSURANCE AND STATISTICS

SCHOOL: OSSEO-FAIRCHILD, WILLIAM F. WIRSBINSKI

DESCRIPTION:
The module I have designed will fit into a high school math class where the students have the ability to compute and display measures of central tendency (means) and measures of variability (range, variance, standard deviation). This module would be most appropriate in an algebra course and would fit well into a unit on statistics. There could be some articulation with other departments in the school when collecting data. This module will use scales from the science department and possibly doughnut holes from the Home Ec. Dept.

OBJECTIVES:
Upon completion of the module, students will be able to:

1) Successfully answer questions concerning the history of quality assurance and the importance of quality.
2) Compute and understand means, medians, modes, ranges, upper and lower quartiles, outlier borders and outliers, variances, and standard deviations.
3) Display collected and computed data using scatter plots, histograms, line plots, box and whisker plots, and stem and leaf plots.
4) Identify and label the type of distribution that the graph suggests.
5) Successfully work in a group situation and collect the data that is needed for this project.

CONTENT OUTLINE:

This project will be in 3 phases:

I. Quality Assurance Introduction
II. Statistical Techniques and Formulas
III. Quality Assurance Activity

Phase I. Quality Assurance Introduction

A. Dr. W. Edwards Deming
   1. Quality in Japan
   2. Quality in U.S. (30 yrs. to accomplish what the Japanese have done)
   3. "Quality is whatever the customer needs and wants"
   4. Demings 14 points for management

B. Joseph M. Juran
   1. Quality work in Japan
   2. Juran Institute ('79 - quality training seminars)
   3. "Fitness For Use" vs. "Conformance to Specifications"
   4. Jurans 10-steps to quality improvement

C. Philip B. Crosby
   1. Zero defects idea
   2. Philip Crosby Associates
   3. "Quality is conformance to requirements, and it can only be measured by the cost of non-conformance"
   4. Crosby's 14 steps to quality improvement

D. William E. Conway
   1. Nashua Corp.
   2. Conway Quality, Inc. (founded 1983)
   3. "Deming disciple"
   4. Conways 6 tools for quality improvement

E. Examples of the Importance of Quality
   1. Japanese edge in manufacturing
   2. How to make it right the first time
   3. Ford Motor Company Example (Bus. Week 6/8/87)
      a. Taguchi Method
      b. Design the manufacturing process, not the product
      c. Statistical procedures to reduce the number of options and change variables

F. Quality Circles (brief description)

G. S.P.C. (statistical process control)

(NOTE: The purpose of this first phase is to introduce students to the history of quality assurance and what quality really means. A few examples and a little background on the important figures on the quality scene should take care of this.)

Phase II. Statistical Techniques and Formulas
(Displaying the data)

Prior knowledge students will need and background concepts students should understand:

1. Students should be able to compute means, medians and modes.
2. Students should be able to construct stem and leaf plots, box and whisker graphs and other graphs.
3. From above graphs, students should be able to determine the minimum, maximum, median, and the upper and lower quartiles (5 number summary).
4. Summation notation should also be familiar to them.

(**NOTE** For my setting, students should have seen the above concepts in previous classes. However; I will review the process of finding the items listed above. It just will not be as if they are seeing it for the 1st time.)

New concepts to be covered within Phase II of module.

1. Compute interquartile range (IQR) and determine outliers.
2. Compute variance (V).
3. Compute standard deviation (SD).
    a. Explanation of what SD is used for and how it differs from variance
    b. Explanation of why a square root is used to determine SD
4. Analyze the mean and standard deviation of a set of data and the median and outlier borders of the same set of data. Study the relationships.
5. Distribution of data (symmetrical vs. skewed for example).

A day by day schedule of the activities and methods used during Phase II follows:

DAY 1: Give students some data that they are familiar with. I chose a roster from a football program and decided to concentrate on the weights of the players. A copy of the roster is enclosed in this material.

EVENTS FOR THE DAY (We will do these activities together in class):

1. Stem and Leaf (make 2 plots, the 2nd one being in numerical order)
    a. Compute median, quartiles, minimum, maximum

    $$\text{median} = \frac{n+1}{2} \qquad \text{Quartile Pos.} = \frac{\text{median pos.}-(\text{fraction})+1}{2}$$

    (The "-(fraction)" notation might be a good time to talk about the greatest integer function - perhaps at least mention it.)
    b. Compute interquartile range ($IQR = Q_3 - Q_1$)
    c. Compute outliers:

    MILD outlier $= Q_3 + 1.5(IQR)$ / $Q_1 - 1.5(IQR)$ WILD outliers $= Q_3 + 2(1.5)(IQR)$ / $Q_1 - 2(1.5)(IQR)$

2. Box and Whisker plots using the information from above

(The computations and graphs from Day 1 events are on the next page.

A copy of the roster also follows.

This is a copy of the roster students used to generate the graphs.

INDIANS

NO	NAME	YR	WT	POS	No	Name	Yr	Wt	Pos
1	SEAN MCNAMARA	10	140	HB	58	*JODY BENSON	12	172	C
2	*TOM LAHR	12	140	FL	60	*JEFF LESNIAK	12	185	NT
3	SCOTT SWIDERSKI	10	140	E	62	CHAD HOLSTAD	10	130	LB
4	*BRUCE JAMROZ	11	132	QB	64	*DAVE ZEBRO	11	150	C
5	*PAT KOSS	11	138	FB	65	KEVIN ORTEL	12	158	G
6	*MIKE KYHOS	12	151	FB	66	*DEAN KOWALSKI	11	168	G
8	*STEVE LEWENS	11	154	QB	68	*KEVIN FRISINGER	12	172	G
9	*CHRIS MORAN	11	150	FL	69	*ANDY FLAMINGO	11	150	G
20	SCOTT CISEWSKI	10	136	HB	70	*DANE MARTIN	11	172	T
21	GARY COLBERT	10	121	FL	71	*DUANE CLAUSEN	11	168	T
22	STEVE DULAK	10	140	FB	73	*RANDY ZORBAK	12	190	T
24	SHANNON BURNELL	10	162	HB	75	KURT BABCOCK	11	160	T
25	SHANE KRAUCYK	10	127	HB	76	JIM RAYMOND	10	160	T
26	*TONY KORDUS	11	164	HB	78	BART UNERTL	10	225	T
27	ALAN GBUREK	11	140	HB	79	JASON FRANK	10	201	T
28	*KURT CHEYKA	11	165	FB	80	*TODD STEPAN	12	167	E
29	JEFF DAHLKE	10	122	HB	81	*DAN DULAK	12	172	LB
32	TIM DULAK	12	160	FB	83	JOHN REINERTSON	10	131	E
33	DAN KUDLA	10	125	FB	84	SEAN STUBBE	10	178	E
34	*JODY SOYKA	11	122	DB	85	TIM HANSON	11	160	E
51	*MARK MALISZEWSKI	11	153	G	86	*SCOTT STROYNY	11	175	FL
52	LAVERN MEISSNER	10	163	C	88	GLEN KRAMER	10	172	E
53	*OTTO GRESEN	11	186	T	89	*JOHN STIKO	12	150	E
55	*TODD BRINER	12	175	C	90	AL MEISSNER	12	176	E

TRICIA BOHMAN
JODI BUSH
VICKI COOK
NANCY LARY
AMY MEYER

HEAD COACH: C. KUNTZ
ASST. COACH: B. WESTPHAL
J.V. COACH: P. NIEVINSKI
T. RAYMOND
FRESHMEN: J. BUDNIK
D. GREENWOOD

* RETURNING LETTERMEN

Pos - II

STEM AND LEAF (not ordered)
FIGURE SL1

```
12 | 1 7 2 5 2
13 | 2 8 6 0 1
14 | 0 0 0 0 0
15 | 1 4 0 3 0 8 0 0
16 | 2 4 5 0 3 8 8 0 0 7 0
17 | 5 2 2 2 2 8 5 2 6
18 | 6 5
19 | 0
20 | 1
21 |
22 | 5
```

13|2 denotes 132

STEM AND LEAF (ordered)
FIGURE SL2

$n = 48$

```
12 | 1 2 2 5 7
13 | 0 1 2 6 8
14 | 0 0 0 0 0
15 | 0 0 0 0 1 3 4 8
16 | 0 0 0 0 2 3 4 5 7 8 8
17 | 2 2 2 2 2 5 5 6 8
18 | 5 6
19 | 0
20 | 1
21 |
22 | 5
```

median $= \frac{n+1}{2} = \frac{49}{2} = 24.5$

quartile position $= \frac{\text{med. pos} - (\text{fraction}) + 1}{2}$

$= \frac{24.5 - .5 + 1}{2}$

$= 12.5$

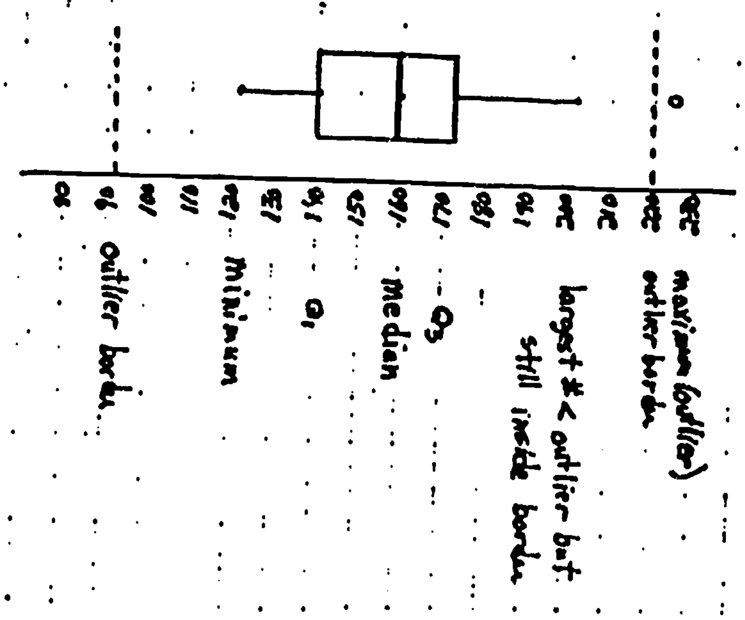
minimum = 121
Q_1 = 140 (count 12.5 from minimum)
median = 160 (count 24.5 from minimum)
Q_3 = 172 (count back 12.5 from maximum)
maximum = 225

IQR = 32

Mild Outliers: $Q_3 + 1.5(IQR) = 172 + 1.5(32) = 220$
$Q_1 - 1.5(IQR) = 140 - 1.5(32) = 92$

Wild Outliers $Q_3 + 2(1.5)IQR = 172 + 3(32) = 268$
$Q_1 - 2(1.5)IQR = 140 - 3(32) = 44$

BOX AND WHISKER GRAPH
FIGURE BW1



POSSIBLE ADDITIONAL QUESTIONS:

1. How can you explain all of the zeros on the stem and leaf plots?
2. What kind of a distribution does the data suggest?
3. What percent of the data is inside the "box" on the box plot?
4. How much would a player have to weigh in order to be a mild outlier on the light end?
5. How much would a player have to weigh in order to be a wild outlier?
   (2 answers)
6. Which one of the wild outliers do you think is more likely? Why?

DAY 2: Introduce the concept of variance and standard deviation. Use the same data that was used to make the previous graphs and compute the mean, variance, and standard deviation. Plot the mean and standard deviations on a simple graph and compare it to Figure BW1 (which was a box and whisker plot of the same data).

Points to emphasize when going through this process:

1. Variance formula:

$$v = \frac{\sum (x-\bar{x})^2}{n-1}$$

$\sum$ ="summation" or "sum of"
$\bar{x}$ = mean
n = number of items
x = the individual weight

   a. Explain why $(x-\bar{x})$ is squared. It is at least partly because some of the differences will be negative and some will be positive. But when the difference is squared, the result is always positive.
   QUESTION: If a student should ask, "Why not take the absolute value of $(x-\bar{x})$? That would be a positive number." First of all, tell the student to stop asking stupid questions. Seriously, tell the student that such a formula exists and it is called the Mean Absolute Deviation (MAD), which according to *Dr. Lund is what you will be if you use this formula on a large set of data. It is also very difficult to develop theory when absolute values are involved.

   b. Explain why the formula tells you to divide by (n-1) -instead of by (n).
      aa. divide by (n-1) if you are dealing with a sample of the population.
      bb. divide by (n) if you are dealing with the entire population.

2. Standard Deviation formula: (take the square root of the variance)

$SD=\sqrt{V} = \sigma$ (sigma) population = S $\rightarrow$ Sample

* Dr. Lund is a University of Wisconsin-Eau Claire Mathematics Instructor.

a. Explain why a square root is used. If you do not take the square root, then you have changed your uni . Furthermore, in the case of weights of football players, you are dealing with square pound before you take square root. What is a square pound?

b. Ask students this question: "If standard deviation uses the symbol σ, (S) what symbol do you think is used to indicate variance?" (σ^2) (S^2)

c. Explain to students that if the data is within 2 standard deviations of the mean (4σ), this is where you can expect about 95% of the distribution to be. (Identify any data items that are not within this range).

d. Using the mean and standard deviation that have been computed for the weights of the football players, make a simple graph and compare the results to Figure BW1. Discuss the results.

(*****The following contains the computation of the mean, variance and standard deviation. It also contains the graph mentioned above and other comments.***)

$$\text{MEAN} = \bar{x} = \frac{\sum x}{n} = \frac{7548}{48} = 157.25$$

$$\text{VARIANCE} = \frac{\sum (x-\bar{x})^2}{n-1} =$$ (We will compute the first few sums together in class. Then I will have the students compute the rest of the sums. I will probably assign a couple sums to each student and then pull our answers together and come up with the total sum needed in the numerator.)

for 140 pounds: $(140 - 157.25)^2 = (-17.25)^2 = 297.5625$

for 176 pounds: $(176 - 157.25)^2 = (18.75)^2 = 351.5625$

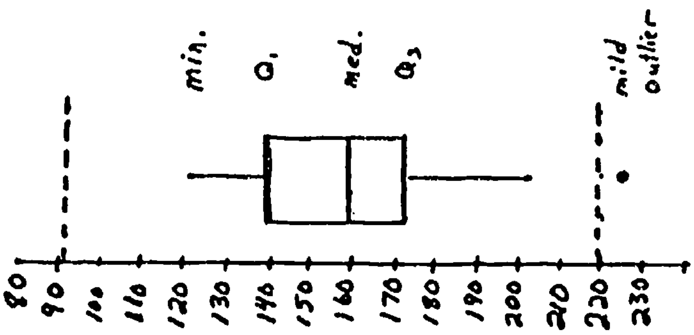
(I intentionally picked the two examples above so I got a negative difference in one and a positive difference in the other. This would be a good time to explain why the difference is squared. After we have completed the procedure above for all 48 weights, we would compute the final answer.)

$$\text{VARIANCE} = \frac{\sum (x-\bar{x})^2}{n-1} = \frac{22619.12}{47} = 481.25787$$

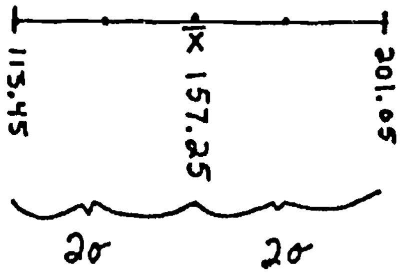
$$\text{STANDARD DEVIATION} = \sqrt{\text{VARIANCE}}$$

$$= \sqrt{481.25787} = 21.93759 \doteq 21.9$$

FIGURE BW1



SIMPLE GRAPH



$\sigma \doteq 21.9$

$\bar{X} \doteq 157.25$

As was stated early, you can expect 95% of the data to be within two standard deviations of the mean. This statement is supported by the data in this case. The only data item out of the 4σ range is the 225 pounder.

Additional questions to consider:

1. What are the similarities between the two graphs above?
2. Are the mean and the median equal to each other? Why or why not? Which one is a better representation?
3. If standard deviation is referred to as σ , what would variance be referred to as? (This was mentioned earlier).
4. What is the worlds fastest land animal?

Phase III. Quality Assurance Activity

A. Divide the class into groups of two and have each group buy a bag of doughnut holes from a local baker. (If money is a problem, it might be possible to have the home economics department make some doughnut holes)

B. Instruct each group to weigh each doughnut hole individually. Use scales from the science department - probably weights in grams)

C. Following procedures similar to those explained in Phase II of this module, instruct each group to find the median, maximum, minimum, upper and lower quartile, range, interquartile range, and the outliers. Generate a stem-n-leaf plot and a box-n-whisker plot from this information

D. Instruct students to find the mean, variance, and standard deviation for their groups set of data.

Generate a <u>simple graph</u> from this information and compare it to the box and whisker plot from step C above. (This was done in Phase II also)

(Discuss the results of the computations and comparisons above and ask similar questions as were asked during Phase II of this project).

E. Using the means that were computed in step D, make a histogram of this data. (This would be an activity for all of the students)

1. Find the mean of the means
2. Compute the variance and standard deviation for the means
3. Using the means and ranges from each group, plot this data on a Statistical Process Control Chart. (The chart enclosed is from Chippewa Valley Technical College)
4. Discuss the variability from the group mean

F. Look at what was done and consider how this relates to quality
   1. Should all the doughnut holes be the same?
   2. What accounts for this variability?
   3. If the doughnut holes were sold individually, would all consumers be treated fairly
   4. What could be adjusted to reduce the variability?
   5. Consider other examples where quality is involved (possibly try to sample these situations)

CONCLUSION AND CLOSING COMMENTS

As stated earlier, the purpose of this module is to introduce students to quality assurance (Phase I), enrich their statistics and data analysis skills (Phase V), and apply what was learned in an activity (Phase III). The activities included within this module will accomplish this goal. Certain modifications might be necessary depending on prior knowledge, but the basic structure is there.

An extension to this module might include another application of quality assurance and statistics a possibility would be to take a case of pop and compute the volume (or mass) of each can. Find out how much variability there is in a case and make conclusions from this. Maybe follow the same procedures with several cases from several different stores. The students would find this topic interesting because it is something that they are familiar with.

(Another possible addition to this project would be to show the video series: "Against All ~Odds: Inside statistics". The series will be available in the fall of 1989 (and also on PBS). This would tie into the topic beautifully!)

RESOURCES:

1. Quantitative Literacy Series, Dale Seymour Publications, P.O. Box 10888, Palo Alto, CA 94303.
   A. Exploring Data
   B. Exploring Probability
   C. Exploring Surveys and Information from Samples
   D. The Art and Techniques of Simulation

2. Business Week, "Special Report: The Push for Quality", June 8, 1987, pages 130-144.

3. "Americas Quality Coaches", Advertising Insert from CPI Purchasing. Sponsored by Dow Chemical Company. Written by James Gagne.

4. "Basic Elements in Quality", Orville Nelson, UW-Stout. High Technology Training Model Project, June, 1989.

5. Quality Appendices C&D. Basic Statistics and Control Chart Problems with Illustrations Run on MINITAB. UW-Stout. June, 1989.

6. Business and Industry Interview Sources:
   Jeff Carlson, Jeff Highbarger, Quality Specialists, Phillips Plastics, Eau Claire.
   Diane Wengelski, Software Engineer, SSI
   Mark Hendrickson, CVTC Instructor (Teaches some Quality)

7. "Statistics: A Guide to the Unknown", 3rd Edition. Wadsworth & Brooks/Cole Statistics/Probability Series, Wadsworth, Inc., Belmont, CA 94002. 1989.

8. Statistical Thinking, John L. Phillips, Jr., 2nd Edition. Copyright 1982 by W. H. Freeman and Company, San Francisco, CA.

9. Mathematical Statistics, 3rd Edition. John E. Freund, Ronald E. Walpole. Prentice-Hall Inc., Englewood Cliffs, New Jersey, 07632.

10. Statistics by Example: Finding Models. Addison-Wesley Publishing Co., Inc., 1973. Reading, MA and Menlo Park, CA.

11. Quality Progress, Dec. 1986. "Quality Engineering by Design: Tagushi's Philosophy". Thomas B. Barker.

12. Plastics Engineering, July, 1987. "Troubleshooting Technique Shortens Path to Quality". James Schleckser, Rogers Corporation, Manchester, CT.

13. Dr. David R. Lund, University of Wisconsin-Eau Claire, Mathematics Instructor.

EVALUATION:

The main evaluation component used will be based on the students work completed dealing with the data collected, computations made and graphs generated. I will collect each groups work and grade it accordingly.

The evaluation of students knowledge of introductory quality assurance will be limited to oral discussion and questioning. I don't plan on getting involved in depth in this area so I don't think I will make a big test at this time. This would certainly be a good place to expand on this project in the future. If the area of of quality assurance were covered in more detail in this module, then a test on this knowledge would be very appropriate.

QUALITY ASSURANCE AND STATISTICS
PRE AND POST-EVALUATION

Note: There will be evaluation used throughout this module. The graphs, charts and calculations that students do during the module will all be considered.

STUDENT PERFORMANCE EVALUATION

1. Dr. W. Edwards Deming, Joseph M. Juran, Philip B. Crosby, and William E. Conway have been important figures on the Quality Assurance scene. For each of these individuals, name their most important contribution to the area of Quality and Quality Assurance.
2. Give an example of what Quality Assurance is and why it is necessary in todays business world.
3. What does S.P.C. stand for and what is it?
4. What are Quality Circles?
5. Give your own definition of "Quality". (in your own words)

USE THE DATA BELOW TO COMPLETE THE QUESTIONS THAT FOLLOW:

The following numbers represent the volumes (in ml) of a random sample of pop cans.

352, 354, 357, 354, 351, 341, 349, 352, 362, 356, 356, 354, 353, 353.

6. Construct an ordered stem-n-leaf plot.
7. Construct a spread out stem-n-leaf plot.
8. Compute the minimum, maximum, median, interquartile range, upper quartile, lower quartile, mild outlier borders and wild outlier borders.
9. Using the calculations from number 8, construct a box-n-whisker plot.
10. What factors might account for an outlier?
11. What percent of the data is in the box on the box-n-whisker plot?
12. What kind of distribution does the data suggest?
13. Compute the mean, variance, and standard deviation for the same set of data that was used above.
14. Using the calculations from number 13, construct a simple graph and compare it to the box-n-whisker plot constructed for number 9.
15. What percent of the data do you expect to be within two standard deviations of the mean?
16. What are similarities between the two graphs?
17. Which graph is a better representation of the data?

END

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