# ACTIVE AND EXPERIENTIAL LEARNING OF STATISTICS @ LIBRARY

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## ABSTRACT

This project was a collaborative effort by the Department of Mathematics and Science, the Library and the Educational Development Unit of Singapore Polytechnic. The primary objective was to help students sharpen their research skills and rectify statistical misconceptions through clarification of ideas. The secondary objective was to develop their confidence in interpreting and synthesizing information for classroom sharing. A total of 51 students from the Diploma in Information Communication Technology and the Diploma in Computer Engineering participated in the project. The study adopted a team-based approach whereby learning activities were designed around a common theme and the whole learning process took place within the library. Upon the completion of the learning tasks, the students then gathered in the library's Media Viewing room to present their findings. After the sharing session, students were asked to blog about their experiences. All these activities were candidly captured on video so that students could reflect on their learning. The whole exercise not only reinforced their fundamental knowledge in data collection and data analysis, it also enhanced their interest in learning statistics. Most importantly, the students enjoyed learning in a new environment and they were able to relate mathematical learning to real life applications.

## KEYWORDS

research skills, statistical misconceptions, team-based approach, library, real life applications

## INTRODUCTION

This project involved an integration of active and experiential learning, which was in line with CDIO™ Standard 8 on Active Learning. Active learning differed from traditional teaching in that students were required to do meaningful learning activities and in the process, learnt to think about what they were doing [1]. The benefits of active learning could be two-fold [2, 3]. First, it allowed students to examine questions that were both fundamental and pragmatic. Second, it eliminated the need to study the effectiveness of every instructional technique. The essence of active learning lay in the introduction of student activity to promote student engagement so that they could develop a deeper understanding of important ideas [4]. According to Soh [5], students learnt better through exploration, interaction and working collaboratively with others. Engaged learning could be carried out through active involvement, especially if students were given the opportunity to show what they had learnt. The role of the teacher was more to generate maximum participation, and to encourage them to search for solutions by getting them to ask questions. In sum, active learning helped learners gained ownership of their learning experience and made them aware of the desired learning outcomes.

## CREATING WORKSPACE FOR ACTIVE LEARNING

The creation of an active learning experience at the library also satisfied CDIO™ Standard 6 on Workspaces. Educational pedagogies described the creation of spaces as a tool for empowerment and liberating student voices. Based on this epistemology, Povey [6], a British mathematical educator, identified three characteristics for creating a good mathematics classroom. They were:

1. The learners made the mathematics.
2. Mathematics should involved thinking about a problem-centered curriculum.
3. Learners' difference and individuality should be respected.

On the discussion of student voice and participation, Gustavson [7] proposed the concept of creating classroom as "spaces of mutual work" (p. 151) to develop authentic relationships of living mathematics. This shift required teachers to share their mathematical passion with students as in our everyday lives. One way to do this was to integrate mathematics with issues in our communities and help students develop the mathematical skills and concepts necessary for their applications in real life [8]. Helfenbein [9] also addressed the importance of finding new ways to support the creation of mathematical place so that students could engage in meaningful and purposeful exchanges while they spent their time there. According to Lefebvre [10], we could think of the concept of space as not in the space itself, but more on what was particularly important about this space of learning and teaching that we were creating with our students. To enact and create meaningful space, we could focus our thinking on some critical features of this space that would make the experience metaphorically analogous to the space itself. Lefebvre [10] reckoned that student participation could take on different forms. For example, we could divide students into small groups and leave what and how they produce it to the group to decide themselves. Alternatively, we could structure the space into class time periods where students take responsibility for their learning without the teacher directing the experience. In either way, the challenge was to ensure that learners were engaged in creating their understanding of the workplace itself.

## DESIGNING AN ACTIVE LEARNING EXPERIENCE

How we relate to the space would determine how we would be experiencing that space. Hence, a major part of the design process was in finding a workplace so that students' interest in learning statistics could be heightened. According to Freeman [11], the library functioned as an extension of the classroom for students to engage in collaborative learning and refine their critical thinking. The library was also chosen for the following reasons:

1. It allowed students to take on learning assignments that were modelled after a real life environment.
2. It had a rich source of information and ideas which could facilitate the teaching of descriptive statistics.
3. The ready stream of library users created opportunities for students to engage in meaningful dialogue and conduct face-to-face interviews.
4. The Media Viewing zone provided a good setting for reflective critique and feedback from both peers and facilitator without disturbing other users.

To ensure that learning activities could be completed within the planned curriculum hour, students were divided into four groups and each group comprised four to five members. Since the venue for data collection varied according to task, the groups were assigned to different levels within the library to conduct their surveys. Each group was advised to collect at least 10 sets of data. At the end of the data collection, each group must justify why they chose to use mode, median or mean to draw their conclusions. The learning tasks for each group was specified below (details were provided in Appendix A).

1. Group A – the most preferred library materials used by students which included periodicals, DVDs and music CDs.
2. Group B – the most preferred library facilities used by students which included PC facilities, study facilities and loan facilities.
3. Group C –the number of hours spent weekly in the library by male students.
4. Group D –the number of hours spent weekly in the library by female students.

After the briefing, the students were naturally excited as the thought of learning statistics in the library was a novel idea to them. The Media Viewing zone was soon abuzz with enthusiasm as each group presented their findings and blogged about their learning experiences. The whole learning process was captured on video to allow students to review one another's work. The students were delighted to watch themselves in action. They were at ease in sharing problems they had encountered in the learning process. Interviewing the students thereafter also injected new ideas on how to make the whole learning process more meaningful.

## LEARNING THEORY AND CONCEPTUAL MODEL

To facilitate a common understanding, the theory of action/reflection introduced by Dilworth [12] was incorporated as a conceptual model for statistics at the library (see figure 1). According to Dilworth [12], action/reflection learning employed the following formula:

L (Learning) = P (Programmed Knowledge) + Q (Questioning) + R (Reflection)

L (Learning) was built around the principles of active learning and reflective dialogue. Each tutorial class was assigned to a specific time slot at the library. Students then organized themselves into groups of 4 or 5 members and the lecturer briefed every group on its specific learning tasks. P (Programmed Knowledge) focused on strengthening the fundamental knowledge of the measures of central tendency and the construction of stem-and-leaf diagrams. Q (Questioning) emphasized the importance of inquiry-based learning and the techniques of conducting interviews with library users. R (Reflection) helped students rectify their statistical misconceptions and blogging the experience allowed them to document what and how they had learnt in the process.

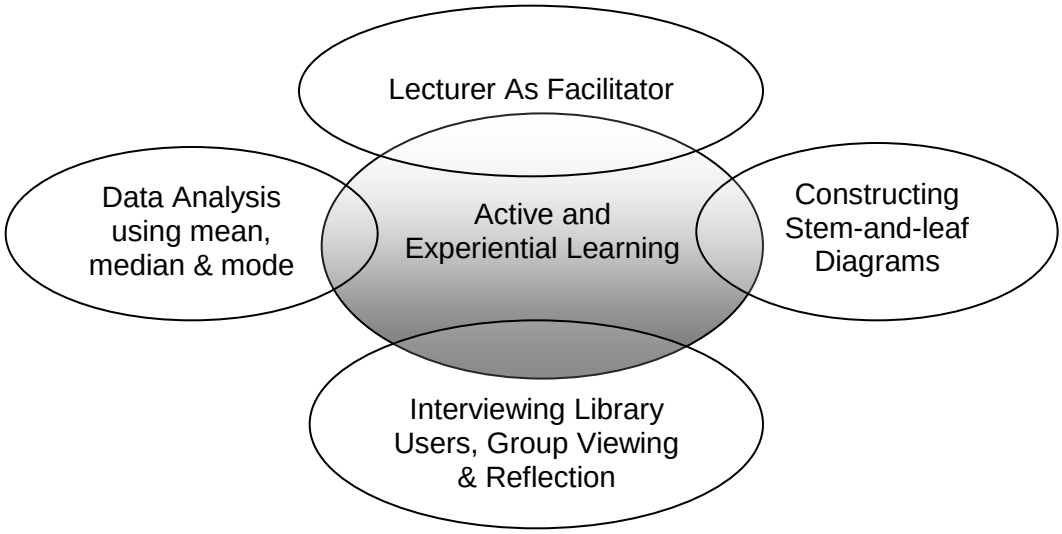


Figure 1 – A Conceptual Model of Statistics @ Library

## AN OVERVIEW OF THE STUDENTS' FINDINGS OF LIBRARY

Group A was asked to approach library users for their preference of the library's collections of periodicals, music CDs and DVDs. Group B was asked to interview library users for their ratings on library's facilities. Group C and D were asked to gather feedback on library usage patterns and compare their findings in a back-to-back stem and leaf diagram for the number of hours male and female students spent weekly at the library. The findings were summarized below:

- **Library Materials**

  Students chose DVDs as their most preferred library materials as videos were more entertaining, the range of DVDs was wide and they were well organized. Most importantly, they were easily accessible at Level 2 near the library entrance.

  Music CDs was the second preferred choice although sometimes they had difficulties in finding them from the shelves. In addition, some respondents also said that they never borrowed music CDs as they were not keen in listening to music.

  Periodicals were the least preferred choice as participants found that these materials were not as entertaining as DVDs and Music CDs.

- **Library Facilities**

  Study facilities was the most preferred library facilities as respondents felt that the library provided an environment conducive for learning. In addition, they expressed that there were not enough study facilities in their school and they would like to have more project rooms in the library.

  PC facilities was the second preferred choice as most of the students had their own laptops and did not need to use the PCs in library PC labs. Loan facilities were the least preferred choice among the three options as respondents commented that they did not have time to read books due to their busy schedule. Some respondents said that when they study in the library, they would use the books in the library instead of borrowing them home.

- **Usage Pattern of Female and Male Students**

  The usage patterns of male and female students were similar as both genders spent an average of 3 hours per week in the library. However, for female students, their main activity was study and for male students, they would normally visit the library during their break time. Interestingly, this finding was similar to Group B's finding that library study facilities were their most preferred choice.

## Misconceptions and Post Quiz Results

Although the learning experience at the library presented some misconceptions regarding the appropriate use of mean, median and mode, it was necessary to correct these misconceptions as they could lead to faulty thinking or poor understanding. Misconceptions could surface in many forms, particularly with regard to statistical decisions and interpretations of data-based findings. According to Mevarech [13], sometimes misconceptions were so deeply ingrained in a student's underlying knowledge base that mere exposure to a more advanced course in statistics was insufficient to overcome them. In the article entitled *"How students learn statistics"*, Garfield [14] found that students were resilient and slow to change their misconceptions even though they were confronted with evidence that their beliefs were incorrect. Callaert [15] reckoned that to eliminate students' misconceptions, teachers could design instructional interventions to generate a deeper understanding of these misconceptions.

To validate these concerns, a post quiz (see Appendix B) was conducted to test students on their analytical reasoning of data presented in a case study and stem-and-leaf diagrams. Students had to (i) compute mean, median and mode; (ii) comment on each company profile based on the salary distribution survey of three companies; (iii) complete a concept map on organizing data and the appropriate use of the measures of central tendency; and (iv) go through a checklist of questions to indicate if they had understood and achieved the desired learning outcomes. Surprisingly, there was a vast difference in the performance for each item. Although 100 percent of the students was able to compute mean, median and mode as well as analyse data presented in stem-and-leaf diagrams; only 20 percent could give accurate accounts of the profile of each company. Despite affirming that they had understood and were able to achieve their expected goals, 43 percent still could not distinguish the purpose and use of mean, median, mode. These results supported earlier evidence that some students were resilient and slow to change their misconceptions.

## Conclusion

This project was successful in that it added an innovative and refreshing dimension to learning statistics outside the classroom. Student feedback indicated that such learning experience not only reinforced their fundamental knowledge in data collection and data analysis, it also stimulated their interest in learning statistics and raised their awareness of the real-life application of descriptive statistics. The survey findings revealed that students used the library for their projects and assignments. They viewed the library as a space conducive for independent study and collaborative learning. Although the project achieved the desired outcomes, designing an active learning curriculum required careful planning and a substantial amount of time and resources. Future work could build on the conceptual model and extend its applicability to other faculties of learning. The authors hoped that the teaching and learning of statistics at the library would motivate more teaching staff to explore the library for collaborative learning. The new library extension would be an interesting communal teaching and learning space as it offers a magazine reading lounge, board games room, Media theatre, Media Viewing booths and a café.

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### *Biographical Information*

Ms Theo Bee Leng is a Senior Lecturer at the Department of Mathematics and Science, Singapore Polytechnic. She has 20 years of teaching experience and she received her Excellence in Teaching Award in 2001. She has co-authored two papers for Journal of Teaching Practice for Excellence in Education and Teaching Convention 2006 and 2007. They are titled "Cognitive Engineering of a Kaya Maker" and "Implementing PBL in Mathematics". She is also the President of Magellan Thinking Club for Cross-Disciplinary Projects. Her current academic interests are in “Economic Reasoning for Demand and Supply” and “Research Methods for Behavioural Science”.

Cher Sen Keuk obtained her Master of Science in Information Management from the University of Sheffield in 1993. She joined Singapore Polytechnic Library as an academic librarian more than 16 years ago and she is now the Manager of Reference & Information Services Section with the polytechnic. Her areas of responsibilities include providing library information services, organising and facilitating access to information resources to support teaching, learning and research at the polytechnic.

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**Appendix A**

## Active and Experiential Learning of Statistics @ Library

In this lesson, students will gather at the library's Media Viewing room to learn how to interpret and analyze data using mean, median and mode. They will also learn to present their findings using stem-and-leaf diagrams.

### Objectives

1. To encourage students to reflect on subject content and to deepen their understanding of the use of statistics.

2. To help students sharpen their research skills through clarification of ideas and group learning.

### Learning Tasks

Students are briefed on how to carry out their learning tasks before they are divided into four groups. Each group consists of 4 - 5 members. They are given an hour to carry out their learning tasks and another half an hour to share their findings and blog about their learning experiences.

Group A & B

Group A and B will watch a 10-min video on "Distribution Curves". Group A will have to carry out a survey to gather feedback on library's periodicals, Music CDs and DVDs. Group B has to conduct a survey to gather feedback on library's facilities. Both groups have to complete the survey within 20 minutes and come back to the Media Viewing room to interpret the data using mean, median and mode.

Group C & D

Group C will conduct a survey to find out the number of hours that **male** students spent weekly at the library. Group D will conduct a survey to find out the number of hours that **female** students spend weekly at the library. They have to complete their survey within 20 minutes and meet at the Media Viewing room to watch a 10-min video on the techniques of creating a stem-and-leaf diagram. They then use a Back-to-Back stem-and-leaf diagram to compare the data collected for male and female students.

**Constructing a Back-to-Back Stem-and-Leaf Diagram**

A back-to-back stem-and-leaf diagram is useful when comparing distributions of two sets of data simultaneously. Using the two classes of data:

| Class A | | | | |
|---|---|---|---|---|
| 5 | 7 | 48 | 18 | 30 |
| 19 | 31 | 27 | 35 | 12 |
| 44 | 4 | 29 | 16 | 23 |
| 41 | 25 | 39 | 9 | 21 |

| Class B | | | | |
|---|---|---|---|---|
| 22 | 11 | 6 | 9 | 44 |
| 23 | 39 | 28 | 32 | 26 |
| 14 | 46 | 8 | 17 | 41 |
| 45 | 6 | 21 | 38 | 485 |

Step 1: Decide which place values are to be used as the stems and leaves.

Identify the lowest score and highest score (e.g. 5 and 48).

Hence the stems are the tens digits 0 to 4 and the leaves are the one digits.

Step 2: Draw a vertical stem-column in the centre and label the 2 classes as the leaf-columns on each side of the stem in proper order. Provide a key for each class.

| Class A | | | | | | Class B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 7 | 5 | 4 | 0 | 6 | 6 | 8 | 9 | |
| | 9 | 8 | 6 | 2 | 1 | 1 | 4 | 7 | | |
| 9 | 7 | 5 | 3 | 1 | 2 | 1 | 2 | 3 | 6 | 8 |
| | 9 | 5 | 1 | 0 | 3 | 2 | 8 | 9 | | |
| | | 8 | 4 | 1 | 4 | 1 | 4 | 5 | 6 | |

Key: Class A: 8 | 4 means 48

Class B: 2 | 1 means 21

**Learning Task for Group A**

**Name of Group Leader:**

**Name of Members:**

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**Collect data from at least 10 polytechnic students to find out their preference of library's periodicals, music CDs and DVDs. Based on the data, calculate the mean, median and mode for each category. Identify which is the most preferred choice based on appropriate use of the three measures.**

***Use tally count to record participants' response**

**1- Least Preferred ----------5- Most Preferred**

| **Rating Scale** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Periodicals | | | | | |
| Music CDs | | | | | |
| DVDs | | | | | |

| **Results** | Mean | Median | Mode |
|---|---|---|---|
| Periodicals | | | |
| Music CDs | | | |
| DVDs | | | |

**Conclusion & Justification:**

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**Learning Task for Group B**

**Name of Group Leader:**

**Name of Members:**

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**Collect data from at least 10 polytechnic students to find out their preference of library's facilities. Based on the data, calculate the mean, median and mode for each category. Identify which is the most preferred choice based on appropriate use of the three measures.**

***Use tally count to record participants' response**

**1-Least Preferred ----------5- Most Preferred**

| **Rating Scale** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PC Facilities | | | | | |
| Study Facilities | | | | | |
| Loan Facilities | | | | | |

| **Results** | Mean | Median | Mode |
|---|---|---|---|
| PC Facilities | | | |
| Study Facilities | | | |
| Loan Facilities | | | |

**Conclusion & Justification:**

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**Learning Task for Group C**

**Name of Group Leader:**

**Name of Members:**

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**Conduct a survey to find out how many hours MALE students spend weekly at the library. Using the data, construct a stem-and-leaf diagram and provide a key for reading. Identify any gap or cluster.**

| No. of Hours Spent Weekly | Tally | No. of Male Students |
|---|---|---|
| | | |
| | | |
| | | |
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| | | |

Stem-and-Leaf Diagram

**Comment on Your Findings:**

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**Learning Task for Group D**

**Name of Group Leader:**

**Name of Members:**

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**Conduct a survey to find out how many hours FEMALE students spend weekly at the library. Using the data, construct a stem-and-leaf diagram and provide a key for reading. Identify any gap or cluster.**

| No. of Hours Spent Weekly | Tally | No. of Female Students |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
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| | | |
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| | | |

Stem-and-Leaf Diagram

**Comment on Your Findings:**

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**Appendix B**

## POST QUIZ

1. Which of the following is the best representative of the data set: 1, 1, 2, 3, 3, 10 and 1?
   (a) mean (b) median (c) mode (d) all of them ( )

2. For the stem-and-leaf diagram given, find the mean, median and mode.

| Stem | Leaf |
|---|---|
| 1 | 3 5 7 7 |
| 2 | 1 2 2 3 3 5 5 6 7 8 |
| 3 | 0 1 4 5 9 |
| 4 | 2 3 8 |
| 5 | 1 |

   Key: 1 | 3 represents 13

3. The back-to-back stem-and-leaf diagram represents the test scores of Tom and Jane:

| Tom | | Jane |
|---|---|---|
| 2 1 | 1 | *3* |
| 2 5 6 | 2 | 2 5 |
| 1 1 1 | 3 | 3 4 5 |
| *x* | 4 | 5 5 7 |

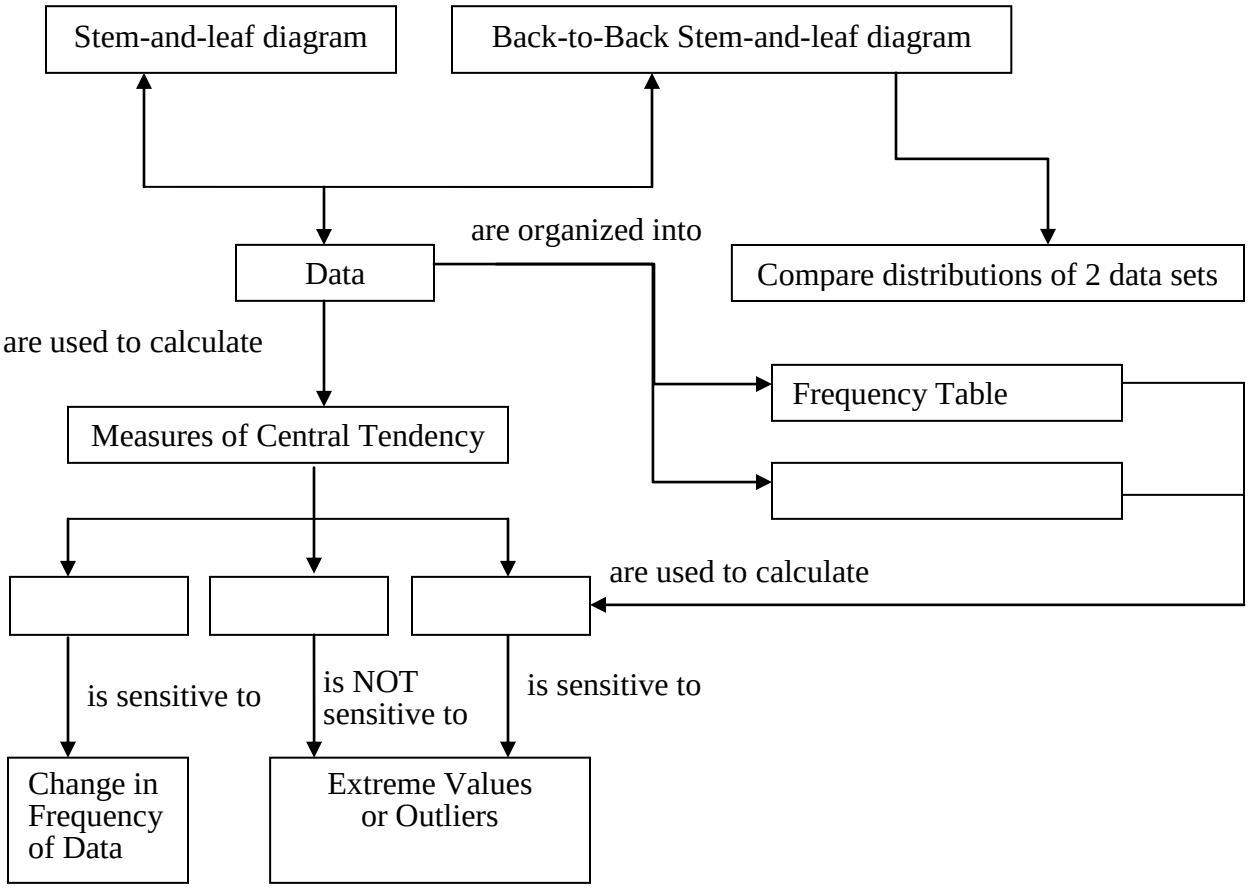
   Key: Tom - 2 | 1 represents 12 marks
   Jane - 2 | 5 represents 25 marks

   (a) How many tests did they each participate in?
   (b) If Tom's highest score was 3 less than Jane's highest score, find the value of *x*.
   (d) Which score occurred most often?

4. The mean, modal and median salary of a salary distribution survey conducted on three companies are displayed as follows. Study the results carefully and comment on the profile of each company.

| Salary Range | Number of Employees | | |
|---|---|---|---|
| | Company A | Company B | Company C |
| < $20 000 | 0 | 1 | 16 |
| $20 000 - $30 000 | 2 | 46 | 21 |
| $30 000 - $40 000 | 93 | 31 | 22 |
| $40 000 - $50 000 | 5 | 18 | 15 |
| $50 000 - $60 000 | 0 | 2 | 8 |
| $60 000 - $70 000 | 0 | 2 | 5 |
| >= $70 000 | 0 | 0 | 12 |
| Mean | $35 000 | $35 000 | $45 000 |
| Median | $35 000 | $33 700 | $37 400 |
| Mode | $35 000 | $31 100 | $25 900 |

5. Fill up the missing boxes in the Concept Map below:




6. Complete the checklist with a tick.

| I understand and am able to .... | | Yes | No | Not sure |
|---|---|---|---|---|
| (i) | interpret and analyse stem-and-leaf diagram | | | |
| (ii) | find the mean, median and mode from a set of values | | | |
| (iii) | find the mean, median and mode from a frequency table | | | |
| (iv) | calculate the mean and standard deviation for group data | | | |
| (v) | distinguish the purpose and use of mean, median and mode | | | |
| Comments (if any) | | | | |