The new international adult numeracy survey: the design of PIAAC

Jeff Evans
Middlesex University, London
j.evans@mdx.ac.uk

Sean Close
Educational Research Centre, Dublin

Terry Maguire
Institute of Technology Tallaght, Dublin
terry.maguire@ittdublin.ie

The Programme for the International Assessment of Adult Competencies (PIAAC) is currently being designed under the auspices of the OECD. This large-scale assessment will involve 28 countries, mostly in Europe, in a field trial in 2010 and the full run in 2011 (with results reported in 2013 or 2014). PIAAC aims to build upon earlier surveys such as IALS and ALL, but with some developments. It also is conceptually related to PISA, another OECD assessment focused on 15 year olds.

This presentation from several members of the Numeracy Expert Group for PIAAC will discuss several key issues, selected from among the following:

- *the way of conceptualising numeracy for this study*
- *the methods of assessment, including computer administration*
- *issues of comparability with earlier studies, especially ALL and PISA*
- *fieldwork issues such as cultural adaptation of items*
- *policy issues to be addressed by PIAAC results*

Given the scope of PIAAC and its likely impact on education and training policy in the many participating countries, our presentation will aim to describe the project to the adult numeracy community at ALM, and to invite discussion on issues of interest.

Introduction

Global players in the area of education and economic development are promoting the launching of a further international comparative study of adults' competencies in basic skills, and in mathematics / numeracy in particular. The new survey is PIAAC (the Programme for the International Assessment of Adult Competencies). It joins several series of studies:

- those started in the mid-1960s by the International Educational Association, currently run under the TIMSS projects
- PISA, the series of assessments commissioned by the OECD for 15 year olds
- International Adult Literacy Survey (IALS) and Adult Literacy and Lifeskills Survey (ALL), dating from the mid-1990s and from the early years of this decade respectively, the latter commissioned and managed by Statistics Canada, NCES of the USA, OECD and UNESCO
- TEDS-M, a new survey of mathematical and pedagogical knowledge for trainee teachers.

Our contributions will focus on the development of PIAAC, with which we have been involved. This is currently taking place under the auspices of the OECD, and the project

is being managed by a consortium of organisations in the US and Europe, including Educational Testing Service in Princeton, USA, which leads on the numeracy component. The design of items for the three scales - literacy, numeracy, and problem solving in technologically-rich environments (PS/TREs) - under the leadership of 'expert groups' of academics and educational developers[1], was completed in spring 2009. The field trial is in mid-2010, and the main survey is scheduled for 2011, with results to be available in 2013 / 2014. PIAAC aims to follow earlier versions of such surveys, e.g. IALS and ALL, but with some crucial developments, discussed below. The questions have been designed to allow comparisons within countries over time with results from ALL. It is also hoped that the results can be related to those of PISA, the OECD's assessments for 15 year olds.

In this paper, we aim to provide the basis for discussing several key issues:

- the way of conceptualising numeracy for this study
- the methods of assessment, including computer administration
- issues of comparability with earlier studies, especially ALL and PISA
- the ways in which PIAAC results are likely to be used to address policy issues.

Adult Education and Training Policy and PIAAC

OECD policy-makers present the PIAAC strategy as one that will help the participating countries to:

- Identify and measure differences between individuals and across countries in key competencies and other economic and social outcomes believed to underlie both personal and societal success.
- Assess the impact of competencies on economic and social outcomes, including *individual outcomes* such as integration into the labour market, employment status and earnings, participation in further learning and education throughout the life cycle, as well as *aggregate outcomes* such as fostering economic growth or creating social equity in labour market outcomes and social participation.
- Assess the performance of education and training systems in generating the required competencies at the levels required by social and economic demands.
- Clarify the policy levers that, once 'deficiencies' in key competencies have been identified, lead to enhancing competencies through the formal educational system, in the work-place, through incentives addressed at the general population, etc. (Schleicher, 2008, pp2-3)

PIAAC involves rather more countries than either of the earlier studies of adults. It will involve 28 countries, 22 in Europe, and a slightly larger number of languages (or versions of languages)[2]. In each country about 5000 adults between 16 and 65 will be

[1] The members of the PIACC Numeracy Expert Group are: Iddo Gal (Israel, Chair), Silvia Alatorre (Mexico), Sean Close (Ireland), Jeff Evans (UK), Lene Johansen (Denmark) , Terry Maguire (Ireland), Myrna Manly (USA), and Dave Tout (Australia).

.

[2] Participating countries in the 1st cycle of PIAAC are: Australia, Austria, Belgium, Canada, Chile, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Korea, Malta, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, and United States.

interviewed and tested. The cross-national nature of the project is justified on the grounds of economies of scale, providing a comparative perspective for policy-makers, displaying greater variance in scores and situations, and allowing monitoring of progress towards international (e.g. EU Lisbon declaration from 2000) targets (Schleicher, 2008).

PIAAC is being designed to be repeated, in order to build up time series of information for participating countries. If it can be managed, this longitudinal aspect will facilitate the study over time of the correlation of skills levels with the 'success' of individuals and countries, the extent to which education and training systems generate the competencies surveyed, and the ways in which policy might improve the effectiveness of these systems.

Studies such as PIAAC aim to produce, on an international comparative basis, information to feed into a central theme of educational policy discussions at the current time - those concerned with *'what works'* in classrooms and in adults' use of mathematics.

Conceptualising and Measuring Adult Competencies in Numeracy[3]

Numeracy has been defined for the purposes of designing the items for PIAAC as:

> the ability to access, use, interpret, and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life. (PIAAC Numeracy Expert Group, 2009)

This is an attempt to conceptualise mathematical thinking in context. An expanded definition of 'numerate behaviour' is given, which specifies a number of dimensions of numerate behaviour:

i. Contexts
ii. Response processes
iii. Mathematical Content / Information / Ideas
iv. Representations of Mathematical Information

Contexts

PIAAC identifies four contexts which may incorporate a demand on an individuals' numeracy;

i. Everyday Life (personal, family life, hobbies or personal development)
ii. Work-related (often more specialised than everyday life contexts)
iii. Societal or Community (trends and processes happening in the world)
iv. Further learning (usually more formal aspects of mathematics for academic purposes)

[3] The information in this section is a summary based on the OECD PIAAC Numeracy Framework document compiled by the PIAAC Numeracy Expert Group (Gal et al, 2009). The reader should refer to this document for a more detailed discussion on the numeracy conceptual and assessment framework to be used in PIAAC.

Responses

In real life situations individuals can react with a range of different types of responses and may incorporate more than one response type depending on the life experience of the individual and the situation that they encounter. In PIAAC five main types of responses are considered:

i. Identify, locate or access

(On its own generally requires low-level mathematical understanding, but usually occurs in tandem with other types of response.)

ii. Act upon or use

(An individual performs an action on the mathematical information or uses known mathematical procedures and rules.)

iii. Interpret

iv. Evaluate / analyse

(An individual is required to interpret meaning and evaluate/analyse against some criteria.)

v. Communicate

(An individual is required to communicate about the mathematical information given.)

Mathematical Content / Information / Ideas

A number of different classifications of mathematical information have been documented (e.g. Steen 1990, NCTM, 2000, Gal et al 2005). In PIAAC four areas of mathematical ideas that classify the mathematical demands faced by adults are used:

i. Quantity and Number

ii. Dimension and Space

iii. Data and Chance

iv. Patterns, Relationship and Change

Representations of Mathematical Information

Mathematical information may be available or represented in a range of formats, e.g. concrete objects, pictures, notation and symbols, models, visual display including graphs or maps, and textual elements.

A comparison of the numeracy dimensions of PIAAC compared to those of PISA is outlined in Table 1, and discussed in the next section.

Numerate behaviour does not rely solely on the formal learning acquired in a school context but on the attitudes, beliefs, numeracy-related practises in work, everyday and other settings and the mathematical knowledge of the individual. Consequently numerate behaviour, is understood as 'founded on the activation of several *enabling factors and processes*':

- mathematical knowledge and conceptual understanding
- adaptive reasoning and mathematical problem-solving skills
- literacy skills
- beliefs and attitudes
- numeracy-related practices and experience
- context/world knowledge.

Thus, a feature of PIAAC is the inclusion of a Background Questionnaire that will assess selected attitudes, beliefs and numeracy related practices to seek demographic and attitudinal information, and to explain differences in individual performance, their skill acquisition and level of motivation for further learning. Because of its interest in an 'expanding range of skills', PIAAC will include items not only on numeracy and literacy, but also *problem solving in technologically-rich environments* (PS/TREs).

The ability of an assessment to capture, evaluate and, subsequently, score a response of real life numeracy tasks – sometimes called its *validity* – is dependent on the form of assessment and on the technical aspects of that assessment.

International assessment of adult numeracy has developed from IALS, (1997) through ALL (2005) to PIAAC. Furthermore, these past international surveys have identified a number of design principles in assessing adult numeracy. These expectations include:

- Task authenticity and realism

  (Tasks should be as similar as possible to the way adults encounter mathematics in different life contexts.)

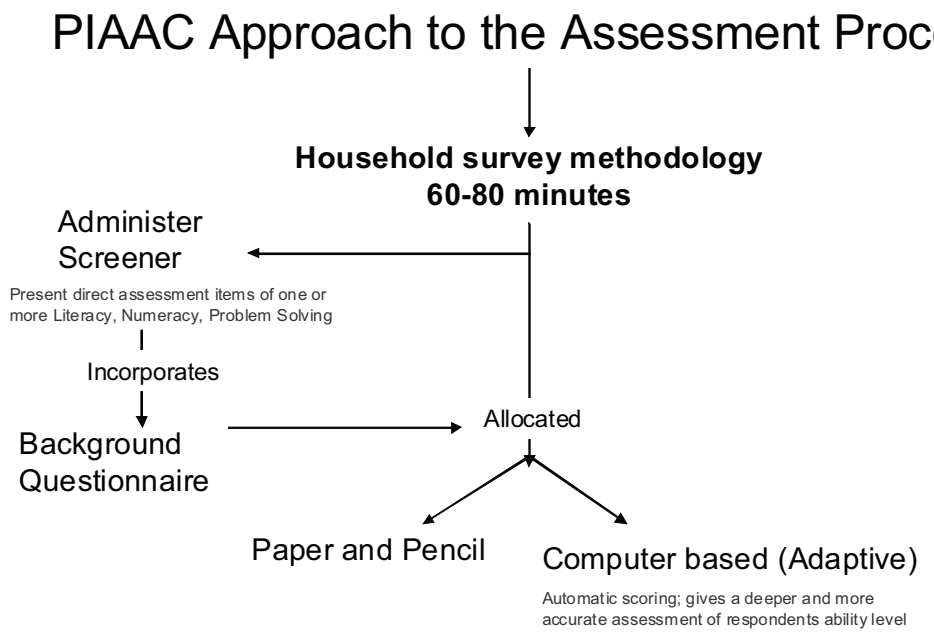
- Task format

  (There is a general preference for constructed response items over 'multiple choice'.)

- Usage of calculator and other tools or objects

  (The individual chooses if and how these are used. First cycle PIAAC respondents are able to use hand held calculators as well as paper (printed) rulers that have both metric and imperial measurements.)

The crucial innovation in the fieldwork methods of PIAAC is the introduction of adaptive computer testing run in tandem with pencil and paper testing. The PIAAC approach to assessment is outlined in Figure 1.



The conceptualisation of numeracy in PIAAC was captured in the following item development profile.

- **Item Pool Developed Included Items that are:**
- Paper and Pencil Only
- Computer Only
- Linking Items (60% of Literacy and Numeracy Items come from item pools of ALL and IALS)
- Some items available in both computer and paper and pencil format, and results from both assessment formats will be compared.
- **Item Distribution – Mathematical Content**
- Quantity and Number 30%
- Dimension and Space 25%
- Patterns, Relationship and Change 20%
- Data and Chance 25%
- **Item Distribution - Level of 'Difficulty'**
- Level 1 5%
- Level 2 25%
- Level 3 40%
- Level 4 25%
- Level 5 5%

- **Item Distribution – Response Type**
- Identify, Locate or Access 10%
- Act upon, use, order, count, estimate compute, measure or model 50%
- Interpret, evaluate, analyse or communicate 40%

Designing items for computer-based presentation provided a number of challenges for the development team, such as:

– Coding free text responses of number ranges or estimates which have multiple mathematically equivalent representations e.g. 'a quarter', ¼, 0.25, 1 in four.

– Providing explanations of how a certain result was reached

– Describing the interpretation of given information such as in a simulated media statement

– Writing justifications for answers given.

A number of innovative approaches were developed to meet some of these challenges. For example, with respect to the respondent's providing an *explanation* for his/her answer, in the Pencil and Paper version of a particular task a respondent is given a graph as a stimulus and asked 'Does the graph support the claim that .....? Explain your answer.'

In the computer-based version, the respondent is presented with the graph on Screen 1 with the question 'Does the graph support the claim that ..... ?' The following possible responses are offered:

– 'Yes I think it does.'

– 'No I think it doesn't.'

– 'I don't know.'

Depending on the response selected on Screen 1, Screen 2 offers the choice of several rationales. For example, if the response on Screen 1 is 'Yes, I think it does', then Screen 2 offers the following responses:

'Yes I think the graph does support the manager's claim because:'

– [Reason 1 given]

– [Reason 2 given]

– [Reason 3 given]

– 'I have another reason for my answer.'

In this way the computer based assessment allowed some assessment of why the individual chose to respond in a particular way to the given task. This is virtually the only type of situation where multiple choice questions are used in PIAAC.[4]

In order to understand what is measured in the numeracy domain in PIAAC it is important to examine the similarities and differences of the numeracy conceptualisation and assessment frameworks used in other International Surveys. Since PIAAC retains close affinities with IALS and especially ALL, in terms of overlapping use of items as explained above, the next section considers comparisons with PISA.

Comparison with PISA

Though the PIAAC adult numeracy survey and the PISA mathematical literacy survey address different target populations, 18 to 65 year-olds in PIAAC and 15 year-olds in PISA, the assessment frameworks of both surveys have many similarities. In fact part of the original brief for PIAAC numeracy from its governing body was a recommendation to establish a conceptual link with the PISA mathematics study, if not an operational one in terms of linking items. This section briefly compares the two frameworks.

PISA (2006) defines mathematical literacy as follows:

> 'Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen'.

This definition shows considerable overlap and consistency with the definition of numeracy given in the preceding section. They both focus on how well individuals can use their mathematical knowledge and skill to solve problems and to make sense of the world around them, rather than on their knowledge of the more formal and decontextualised mathematics that is the main focus in school mathematics curricula in many countries.

As mentioned earlier, the PIAAC numeracy framework has four main dimensions: Contexts; Mathematical Content areas; Response processes; and Representations. In addition to the response processes, there are also enabling factors and processes.

The PISA framework has three dimensions:

i. mathematical situations and contexts;

ii. mathematical content areas described as 'Big Ideas' that arise through interaction with day to day phenomena; and,

iii. clusters of cognitive processes / competencies involved in solving problems.

When we place these dimensions opposite one another (Table 1) we can more readily see the similarities and differences between them. The first two dimensions of each framework, the context dimension and mathematical content area dimension, are very similar although at the item level categorisation within these dimensions may differ. The third dimension of the PISA framework is based on a set of key competencies which are

[4] For further details of the fieldwork procedures planned to be used in the UK countries as an illustration, see DCSF (2009).

involved as clusters of competencies, at different levels of complexity (reproduction, connections, reflections), that come into play in responding to mathematical tasks, usually embedded in a practical or 'applied' context. The PIAAC framework has two further dimensions – a set of response processes (access, use, interpret, evaluate) - invoked by the tasks, and the modes of representation (text, symbols, graphics, etc.) involved in task presentation, (as well as a set of enabling factors and processes described in previous section). Although there are similarities between some of the PISA competencies and some of the PIAAC response processes, differences also emerge, in part due to the different environments for which these frameworks have been developed. The PISA framework assumes a level of mathematical knowledge and skill and reading ability on the part of 15 year-olds, acquired through the early secondary school curriculum, which PIAAC does not assume since for adults much of this knowledge will have decayed unless brought into play in later schooling or training. This would be particularly true of tasks involving algebraic manipulation and rules.

Table 1 Comparison of PIAAC and PISA Dimensions

PIAAC Contexts	**PISA Contexts**
Everyday life	Personal
Work	Educational/occupational
Societal	Public
Further learning	Scientific
PIAAC Content Areas	**PISA Content areas**
Quantity and Number	Quantity
Dimension and Shape	Space and Shape
Pattern, Relationship and Change	Change and Relationships
Data and Chance	Uncertainty
PIAAC Type of Response	**PISA Competencies**
Access of maths information and ideas	Reasoning
Use maths information and ideas	Argumentation;
Interpret maths information and ideas	Communication;
Communicate maths information and ideas	Modelling;
Evaluate/solve maths problems	Problem posing and solving;
PIAAC Representations	Representation; using symbolic,
Objects/pictures, diagrams, maps, graphs, tables	Formal/technical language & operations
Texts, mathematical symbols, Formulae	Use of aids and tools
Technology-based displays	

Appendix 1 gives some examples of items based on, and classified according to, the PIAAC numeracy framework, itself closely related to the earlier ALL framework (Gal et al., 2005).

The Future of Educational Policy-making

The development of projects like PIAAC, and of PISA before it, takes place in a context of increasing globalisation. One of the effects of this is to decrease the ability of national governments to control outcomes in the competitive economic environment. Thus the competitive advantage of nations is "frequently defined in terms of the quality of national education and training systems judged according to international standards" (Brown et al., 1997, pp7-8). One could say there has been a 'comparative turn' in educational policy-making – and international studies like PISA and PIAAC can be seen to form part of what has been called a scientific approach to political decision-making (Martens, 2007, quoted in Grek, 2009a, p25).

In this setting, international organisations like OECD and the EU can be seen as 'actors' on the international research / policy scene (Grek, 2009a). This means that as institutions, they take decisions that enhance their positions and interests within a system formed by nations, international organisations, multi-national corporations, and others that jostle for influence. Grek argues that the OECD and EU have come to share broadly similar policy agendas (*ibid*.).

Conclusion: 'Handle with Care!'

We have discussed a number of the issues for people wanting to understand the relevance and meaning of international survey results in the context of their own country's political goals and the particularities of the national education system. Many reports of the results include constant 'acknowledgements' of the need to interpret them 'in context' – but this is challenging to do! Meanwhile, such educational indicators tend to be 'taken-for-granted' as valid, and as dependable for making international comparisons – but great care is needed in interpreting them (see e.g. Brown, 1996; Goldstein, 2004).

References

Brown, M. (1996). FIMS and SIMS: the first two IEA International Mathematics Surveys, *Assessment in Education: Principles, Policy & Practice*, *3*, 2, 193-212.

Brown, P., Halsey, A. H., Lauder, H. and Wells, A. S. (1997) The Transformation of Education and Society: An Introduction. In A. Halsey, H. Lauder, P. Brown & A. S. Wells (Eds), *Education Culture Economy Society.* Oxford: Oxford University Press.

Department for Children Schools and Families (DCSF) (2009). *Programme of research: 2009009 BIS: National Project Manager For The Programme For International Assessment Of Adult Competences (PIAAC)*. Online:

http://www.dcsf.gov.uk/research/programmeofresearch/projectinformation.cfm?projectId=15685&type=1&resultspage=1 [15 March 2010].

Gal, I., van Groenestijn, M., Manly, M., Schmitt, M. J., & Tout, D. (2005). Adult numeracy and its assessment in the ALL survey: A conceptual framework and pilot results. In S. Murray, Y. Clermont and M. Binkley (Eds), *Measuring adult literacy and life skills: New frameworks for assessment* (pp. 137-191). Ottawa: Statistics Canada.

Goldstein, H. (2004) International comparisons of student attainment: some issues arising from the PISA study, *Assessment in Education: Principles, Policy & Practice*, *11,* 319-330.

Grek, S. (2009a) Governing by numbers: the PISA 'effect' in Europe, *Journal of Education Policy, 24*, 1, January, 23-37.

Grek, S. (2009b) The role of the OECD as an agent of Europeanization: problematisation and change in education governance in Europe; paper presented to University of Edinburgh's Europa Institute seminar: Practicing EU Government: Problematisation, 6 May 2009. Online: http://www.ces.ed.ac.uk/presentations/Sotiria/SG_Europa.pdf

Lingard, B. & Grek, S. (n.d.) The OECD, Indicators and PISA: an Exploration of Events and Theoretical Perspectives, Working Paper 2, ESRC / ESF Research Project on Fabricating Quality in Education, unpublished paper.

National Council of Teachers of Mathematics (NCTM) (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

OECD (2009) *The OECD Programme for the International Assessment of Adult Competencies (PIAAC)*. Online: http://www.oecd.org/dataoecd/13/45/41690983.pdf [accessed 30 April 2009].

PIAAC Numeracy Expert Group (2009) [Gal, I. (Chair), Alatorre, S., Close, S., Evans. J.,

Johansen, L., Maguire, T., Manly, M., Tout, D.], *PIAAC Numeracy Framework*, OECD Education Working Paper no. 35 (24-nov-2009), OECD Publishing . Online: http://www.olis.oecd.org/olis/2009doc.nsf/linkto/edu-wkp(2009)14

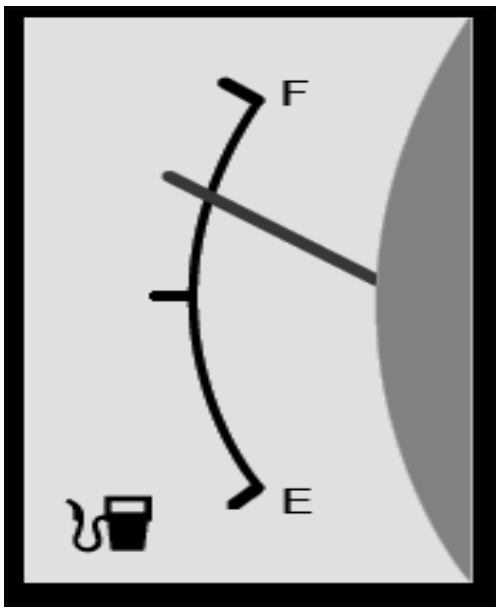
Schleicher, A. (2008) PIAAC: A New Strategy for Assessing Adult Competencies, *International Review of Education*. Online: http://www.oecd.org/dataoecd/48/5/41529787.pdf

Steen, L. A. (Ed)(1990). *On the shoulders of giants: New approaches to numeracy*. Washington, D.C.: National Research Council.

Young, M. (2007) *Bringing Knowledge Back In: From social constructivism to social realism in the sociology of education*. London: Routledge

Appendix 1. Examples of Items Classified according to the PIAAC Numeracy Framework

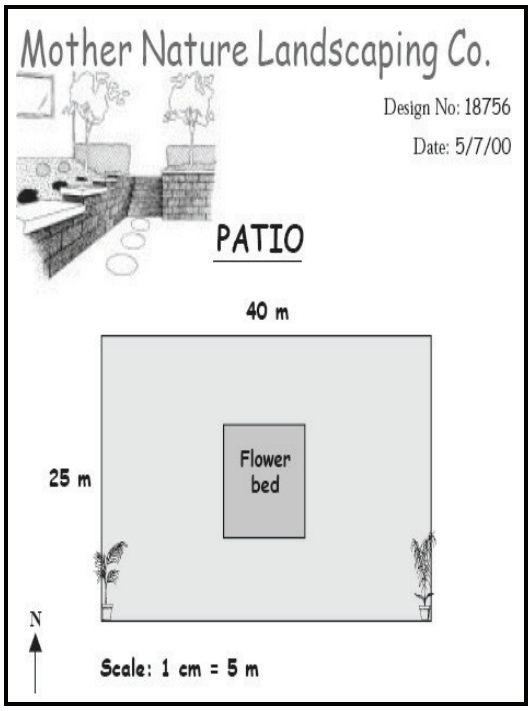
Sample Item 1: Gas Tank



The gas tank in this truck holds 48 gallons. About how many gallons of gas remain in the tank? (Assume gauge is accurate)

Framework Classification:
Everyday life
Interpret/Estimate/measure/compute
Quantity and number
Diagram and text

Sample Item 2: Patio



Assume that you work for Mother Nature Landscaping Co. You are given the sketch showing a patio that is to be landscaped by your company. The centre square is to be planted with blooming flowers and the rest of the patio will contain a variety of potted plants arranged on its concrete surface.

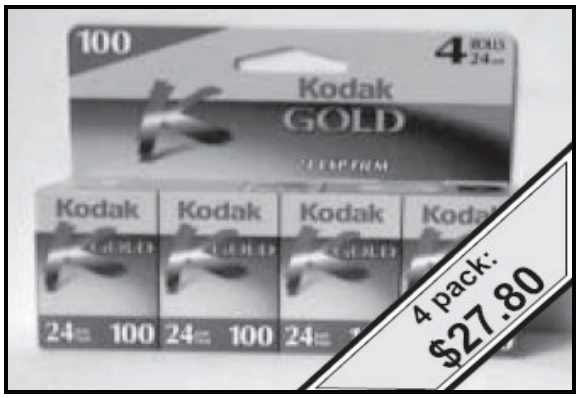
a) The design calls for 5 large potted plants to be placed along the south edge of the patio, one in each corner (as shown) and 3 in between. How far apart should the centres of the pots be if you want them to be equally spaced?

b) What is the area of the actual square flower bed in the middle of the patio? (Note: you can use the scale on the bottom).

Framework Classification

- Work
- Evaluate/Solve
- Dimension and shape
- Diagram and text

Sample 3: Kodak Packs

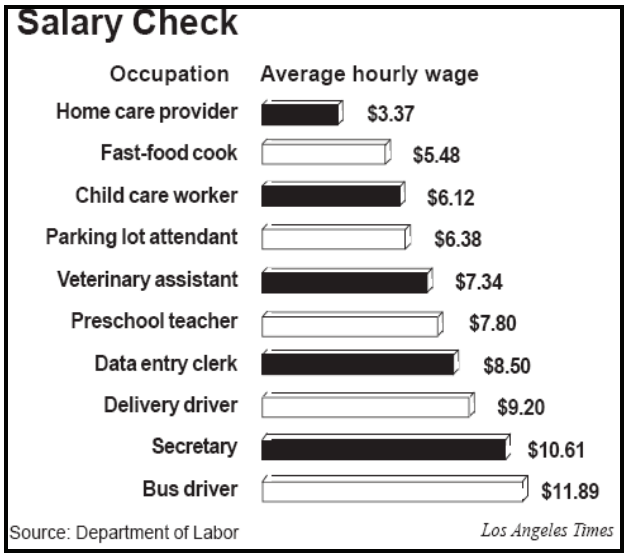


Which pack of film gives you more for your money?
Explain how you decided.

Framework Classification:

- Everyday life
- Interpret/identify/compute
- dimension and shape
- Picture and numbers

Sample Item 4: Salary Check



a) What is the difference between the average hourly wage for a secretary and that of a home care provider?

'I am a veterinary assistant and make only $5.20 an hour. I think your chart must be wrong.'

b) How would you explain to the veterinary assistant that the average
wage for veterinary assistants given in the chart can be correct?

Framework Classification

- Work
- Locate/Interpret, compute, communicate
- Data and Chance
- Picture and text