

Implementing problem based learning in a science faculty

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Problem based learning is a successful teaching and learning strategy used to engage students in deep rather than surface learning and where the learning is student focused rather than teacher focused (Biggs, 1999; 2003). The strategy is also successful in aligning university courses with the real-life professional work which students are expected to undertake on graduation. At this university, plans to introduce PBL into a number of units taught in the Science Faculty were initiated in 2006, to improve student engagement and enrich the student learning experience at the first year level. This paper reports on the implementation of PBL into a core first year unit in 2007. Data for the research were gathered through student surveys and semi-structured interviews. While the implementation is perceived as a successful strategy, to achieve both aims there are still challenges, linked to group processes, to overcome.

Introduction

This paper documents an initiative beginning in Semester 1, 2007, to implement problem based learning (PBL) into a research intensive Science Faculty at The University of Western Australia. Following a brief overview of PBL, I outline the scope of the implementation at the Faculty entry level then focus on a specific unit. The preliminary data presented relates to participants' perception of the implementation of PBL into the *Resource Economics* unit. Rather than seek to explain or control events for this research I sought to articulate people's experience and understanding of the phenomena. This is achieved by interpreting student feedback and developing narratives after completing semi-structured interviews with participants.

Problem based learning represents a major and widespread change in educational practice within higher education (Dolmans et al., 2005). The relevance of PBL is reflected in its spread through professional education from the 1960s in medical schools, across disciplines to the current situation, where PBL is practiced in such areas as education and science. While abundant research exists about PBL, there is an absence of material describing the Western Australian setting.

This paper provides a richly descriptive account of the first steps towards implementing PBL into this internationally recognised Science Faculty. To complete the research I sought the answers to several questions.

1. How was the implementation of PBL into the *Resource Economics* unit perceived by the unit coordinator?
2. How was the implementation of PBL into the *Resource Economics* unit perceived by the students completing the unit?
3. Did the implementation of PBL enhance the student learning experience?

Background

To emphasise fundamental sciences training in the context of real world problems in undergraduate degrees, plans to introduce PBL into the Faculty were initiated during 2006.

Funds from a federal government competitive funding program were allocated to support implementing and embedding PBL across the Faculty schools. Explicit within the Teaching and Learning section of the Faculty Operational Priorities Plan, developed in 2006, are the objectives 'to improve the student experience' and 'to enrich the student experience in the first year of study'. The implementation of PBL into the tutorial, laboratory based and field work component of first year units was one strategy identified to assist in achieving these objectives. During January 2007, I joined the Faculty as Problem Based Learning (PBL) Lecturer.

Problem based learning was popularised during the 1960s as a result of research by Barrows (Barrows & Tamblyn, 1980). Initially PBL was introduced into McMaster University and Case Western Reserve Medical Schools, and during the 1970s into medical schools, for example, at Newcastle (Australia), Maastricht and New Mexico Universities. As an approach to learning, PBL has spread across the world since the 1970s (Savin-Baden, 2000) and is currently practiced in the United States, Canada, Europe, Singapore and in Australia (Dolmans et al., 2005; Savin-Baden, 2000; Schwartz et al., 2001). Problem based learning has been introduced into all of the health sciences, engineering, business, science, agriculture and education (Boud & Feletti, 1991; Schwartz et al., 2001).

Modern insights on learning emphasise four elements of learning: that learning should be constructive, self-directed, collaborative and contextual (Dolmans et al., 2005). Problem based learning is 'problem first learning' (Spencer & Jordan, 1999). It is the problem which defines what is to be learned. Instructors design problem scenarios to represent authentic, real world situations or issues likely to be addressed in the work place after student graduation. Typically, students in small groups work through the problem to decide on the information and skills they will need to investigate the issues evident, and perhaps resolve the situation. Often the problem involves collaboration between disciplines so that students are required to build on current knowledge to synthesise then integrate new information. Instructors monitor group processes and attend sessions to facilitate student learning. However, students themselves are responsible for the learning that occurs within their group. When students engage with PBL there is a greater likelihood of deep rather than surface learning due to the alignment of teaching and learning activities, curriculum objectives and assessment tasks (Biggs, 1999, 2003).

Approaches to PBL are varied with institutions, adopting both 'pure' and 'hybrid' models and a variety of forms in between (Dahlgren & Oberg, 2001; Pawson et al., 2006). According to Savin-Baden (2001, p.4) PBL is 'an approach to learning that is characterised by flexibility and diversity in the sense that it can be implemented in a variety of ways in different subjects and disciplines in diverse contexts'. The hybrid model adopted in the university Faculty of Medicine was used as a guide to implement PBL into the Science

Faculty. Nevertheless, from the outset it was clear this model would require adaptation to accommodate the large number of students in Science Faculty units. No attempt was made to use PBL to define or map the entire curriculum. Instead, the strategy was used as a teaching and learning methodology for part of the curriculum within a selection of Faculty units. Such use of a single problem over several weeks is reported as effective by Hans (2001).

Initiation is the first phase of the change process and involves preparing people for change (Huberman & Miles, 1984). Discussion about initiating PBL occurred prior to my arrival. Implementing an innovation, the second phase of the change process, is usually challenging and always time consuming (Huberman & Miles, 1984). Research also indicates that a strategy for implementation is essential (Boud & Feletti, 1991; Huberman & Miles, 1984; Savin-Baden, 2000; Schwartz, et al., 2001). In the early weeks of my appointment, meetings were arranged with first year unit coordinators to hear their views on, and gauge their understanding of, PBL. The next step was to target unit coordinators interested in experiencing the advantages which PBL could bring to their students' learning and to their own teaching. Staff training and development, problem design and construction, group facilitation, assistance with assessment, attendance in tutorials and workshops and the presentation of guest lectures are examples of the support I offered to unit coordinators.

From the outset it was critical that unit coordinators viewed the likelihood of success as a strong possibility. Rather than unsuccessfully champion a total conversion to PBL at this early stage, opportunities to re-organise laboratory sessions, re-structure field trips and develop PBL tutorials were welcomed. This approach ensured assistance could be offered to one unit coordinator within each School in the Faculty. Due to the strong collaboration experienced in all aspects of PBL implementation and the perceived success of the *Resource Economics* unit, I chose to elaborate on it in this paper.

Methodology

In educational research the implementation of an initiative is frequently documented as a case study (Patton, 2002; White, 1996). Case studies are described on the one hand as a specific way of collecting, organising and analysing data and so represents an analysis process. On the other hand the analysis process results in a product, a case study (Patton, 2002). For these reasons the case study methodology was deemed a suitable approach to report on this PBL implementation.

Early in Semester 1, the *Resource Economics* unit coordinator and I began PBL discussions. We agreed that one section of the unit, to be taught over four weeks later in Semester 1, would be restructured and presented as a PBL task. Regular meetings over the next two months enabled us to develop a resource economics problem suitable for the diverse cohort of 75 students enrolled in the unit. We devised a problem which was authentic, interdisciplinary, open ended, required knowledge that students didn't already have, promoted discussion, required self direction and met the unit objectives (Biggs, 2003). In achieving this we crafted a problem focusing on the potential impact of an Avian

influenza pandemic on the Australian economy. We considered this an appropriate PBL task because the students had completed an introduction to economics, markets, money and investment. The PBL exercise was introduced as students prepared for the final module on trade and policy issues. We wrote the problem as a consultancy brief with the state Department of Agriculture and Food (see Appendix). To ensure continuing interest and provide some support for the students, we wrote two further triggers for progressive disclosure at weekly intervals and gathered resource materials. Because the unit assessment details had been published at the beginning of the semester, and prior to developing the PBL task, this component was incorporated into an attendance mark allocated to tutorial sessions rather than introduce an additional assessment item.

Students received an introduction to PBL during a lecture session the week before we introduced the problem. Group processes, PBL roles, tutorial responsibilities and assessment details were all provided during this session. On receiving the Avian influenza problem during the first PBL tutorial students self selected their groups of six to eight people. They were reminded to consider group protocols and allocate PBL roles before engaging with the problem. In exploring the problem student groups identified the learning issues and the level of related knowledge within their group. Students identified the information and skills they lacked to address the problem then collaborated to obtain and share the missing information and skills. Both lecturers attended all tutorials during the PBL exercise to facilitate student learning and ensure all learning issues were identified. The first few minutes of each subsequent tutorial session were spent reminding students of the importance of group protocols and of our assistance if any issues had arisen. Reminders regarding the group assessment (an oral presentation) and the significance of self reflection were also provided at the beginning of each tutorial.

At the completion of the task, students provided written feedback on their impressions of the PBL exercise. In addition, I conducted semi-structured interviews with the unit coordinator and six randomly selected students after the Semester 1 exams. Consistent with the phenomenological approach in such interviews I explored background information about the participants and sought their understanding of the benefits and challenges of participating in the PBL exercise. I allocated pseudonyms to each participant to ensure anonymity and using writing strategies with which I was familiar, generated short narrative accounts from the interview data (Clarke, Wildy & Pepper, 2007; Clandinin & Connelly, 2000; Pepper & Wildy, (2008); Wildy & Pepper, 2005). Narratives permit participants' stories and descriptions of experience to be honoured and given status (Conle, 2003). They permit life-like accounts which focus on experience and are aligned with qualitatively-oriented educational research. Each narrative was returned to the participant for feedback and approval of its use in the research prior to analysis (Strauss & Corbin, 1990).

Data and analysis

In this section I present a summary of the general student feedback and three narratives developed from semi-structured interviews. The first narrative was developed from interviews with the unit coordinator and the next two from interviews with two students.

General student feedback

All students were invited to complete a PBL feedback sheet after their oral presentation during their final Semester 1 tutorial. Students are frequently required to complete feedback forms on teaching and unit structure so the questions were few and brief. Of the 75 students enrolled, thirty six provided written feedback.

The first question asked “What was the most important thing you learned in today’s session?” While the majority of students answered the question from an economics perspective, six students provided answers with direct reference to PBL. Four of these comments addressed the positive aspects of group work in facilitating learning. Another referred to a dislike of public speaking and the final comment linked the level of effort with the quality of work produced.

The second question asked “What questions do you have from today’s session that remain unanswered?” Many students did not answer this question. Those who answered responded from an economics perspective, suggesting gaps in their knowledge of monetary policy. Five responses raised further questions about Avian influenza.

Question 3 asked “What are two aspects you enjoyed about the PBL process?” All students who returned the feedback sheet answered this question with one or two examples. As responses were varied, the information was categorised into themes (Ryan & Bernard, 2003). The seven themes identified appear in Table 1.

Table 1: Thematic response to PBL feedback question 3

Theme identified in response	Number of responses
Working in groups	21
Making new friends	10
Locating own information	5
Applying interesting/relevant economic concepts	5
Hearing different perspectives within group	5
Listening to presentations	3
Having flexibility in time	3

Clearly students in these tutorials enjoyed *working in groups* and appreciated the opportunity to *make new friends*. Of course, while both elements are beneficial to students in their first semester at university such opportunities are not exclusive to PBL. That some students recognise the scope for *different perspectives within their group* and the *relevance of applying economic concepts* to an authentic situation is largely attributable to the PBL nature of the exercise.

Question 4 asked “What are two aspects you didn’t enjoy about the PBL process?” Many students did not answer this question. Nevertheless the responses were diverse and were

also categorised into themes (Ryan & Bernard, 2003). The eight themes identified appear in Table 2.

Table 2: Thematic responses to PBL feedback question 4

Theme identified in response	Number of responses
Presenting research for no marks	7
Listening to presentations	5
Locating own information	4
Meeting out of class time	4
Speaking in public	3
Receiving information in stages	1
Working in groups	1
Accommodating uneven contribution from group members	1

Interestingly, some of the themes identified as positive elements, for example, *working in groups*, *locating own information* and *listening to presentations*, were also identified as negative elements. Perhaps this simply reinforces our knowledge that students gain understanding through a variety of learning styles. Similarly, where some students liked the flexibility of meeting in or out of class time, others were unhappy about the need to meet out of class time. At first glance the theme *presenting research for no marks* is of concern. However, students possibly overlooked the information that rather than redistribute marks so that the PBL task became an extra assessment the marks already allocated to tutorial attendance were assigned to the Avian influenza problem. It is surprising that just one person identified the uneven contribution from group members as an issue. This issue is highlighted in the discussion.

Narratives

In the Science Faculty the *Resource Economics* unit is considered an important core component of all applied science degrees. Jane has coordinated the unit for the past seven years and she is responsible for delivering all lectures and conducting all tutorials. Jane also has an interest in pedagogy. The purpose of using narratives to present this data is to illustrate the every day, ordinary actions and beliefs of participants. It is not to portray the exotic or bizarre.

Jane - First steps

Several years ago a colleague introduced a form of problem based learning into a course we lectured together in. While I viewed the strategy as worthwhile and of benefit to our students, not everyone shared my enthusiasm. Funding for additional tutors to support PBL became another issue so the strategy was discontinued. I liked PBL because my students were working in groups to problem solve, become creative and had the opportunity to think about their own learning. I welcomed the appointment of a PBL academic to the Faculty at the beginning of this year.

Early in the semester I met with the PBL lecturer to discuss implementing PBL into my first year economics unit. I viewed PBL as one vehicle to assist students accept responsibility for their own learning, take on challenging material and move on from rote learning alone. While I was enthusiastic about the potential of PBL I did have some reservations. These centred on my concerns for the level of support I know first year students require and how I could assess group work fairly and effectively.

I searched for a real life multi-disciplined example with strong economics links, to develop with the PBL lecturer, into a suitable problem. When I located an article about Avian influenza I recognised this as perfect for the exercise. Together we crafted the problem, some guiding questions and session plans for the four weeks that PBL tutorials were scheduled. I knew it was important for the first year students to be clear about the aims of the task so provided them with learning outcomes as a guide and several references. Groups identified their own learning issues within the problem.

The week before the PBL exercise was introduced I invited the PBL lecturer to address my students to inform them about the process, their group responsibilities and how the task would be facilitated and assessed. Assessing the students fairly was my greatest challenge. I wanted them to address the problem seriously and work in functional groups. I also knew how motivated they were by marks yet couldn't risk allocating more to PBL because tutorial attendance marks were already published. I asked each group to discuss each individual's contribution then noted in written feedback whether anyone should receive less than the full group mark. I felt relieved that the groups shared their marks equally but I knew one dysfunctional group existed.

I found the PBL exercise beneficial to help my students engage in believable and 'real world' economic issues. During tutorial sessions student conversations focused predominantly on the problem and I know several groups met out of class time to share information and prepare for their assessment. After refining the problem I plan to repeat the PBL exercise with my next group of students. Nevertheless my concerns about fair group assessments, though reduced, linger.

Jane welcomed the PBL exercise as an opportunity for her students to accept responsibility for their own learning, while working in small teams, and to shift from the 'normalised' rote learning model. She identified an authentic issue likely to face her students in their early careers as resource economists while encouraging them to think beyond the immediate problem. As an experienced lecturer, Jane viewed the PBL task as successful learning experience for her students and despite her lingering concerns about fair group assessment intends to strengthen her own engagement with PBL in her future classes.

Six students were randomly selected for semi-structured interview and the narratives developed from two are presented here. Chris completed an Arts degree eight years ago and is now preparing for a career change. Lee entered university straight from secondary school and will turn 18 later this year.

Chris – 'Acoqalypse Now'

Since completing my first degree I've developed a passion for Viticulture so I enrolled in a Bachelor of Science at the beginning of this year. Prior to this course I had no experience of problem based learning, but plenty of experience of working in groups. The economics unit was the second one I completed with a PBL component. Perhaps for this reason I enjoyed the process more than during the first time.

Before beginning the PBL exercise we received information about the process and the responsibilities we were expected to adopt. I appreciated receiving this information at the beginning. Our group of 5 (four girls and me) was formed because we sat together in the small lecture theatre although we didn't know each other beforehand. As the oldest member in my group the others encouraged me to step forward as the leader. Two girls rarely spoke and contributed little during our meetings. One of them didn't join us for either of our meetings out of class time or offer any explanation for her absence. I think she 'free loaded' but I wasn't willing to discuss her poor contribution. Afterwards I learnt her attitude irritated the others too although we shared our group mark evenly with her. We resolved to speak up if it happened again in a future PBL exercise.

Overall, I enjoyed and felt comfortable with the PBL exercise and think it suited this economics module well. The content was challenging and I liked the scope for us to investigate the economic impact of an Avian influenza pandemic as deeply as we wished. After hearing the diverse presentations from other groups I saw that they too had engaged with the problem.

As a mature student, Chris enjoyed the PBL exercise and appreciated the opportunity to delve as deeply as his group wished into the problem. As the oldest member and only male in his group Chris accepted the leaders' role by default. While he saw some group members 'free loading', he made no comment about this, nor invited comment from others in the group. Chris does, however, acknowledge that the group would not allow this to happen again.

As an aside, his sense of humour and enjoyment of the task were evident in selecting the title for the group presentation, which focused on the chicken industry, and is re-used by me for this narrative title.

Lee - Sharing the workload

The Avian influenza problem was the fourth PBL exercise I was given to work on in four separate units this semester. Initially PBL was very new to me as it was not practised at my secondary school. Each time the process was slightly different. I felt better prepared for the economics task after hearing how it was to be conducted and assessed at the beginning. The economic problem was also studied for longer than the earlier problems we were given.

Six people formed our group with only two of us school leavers. An older student worked well as our leader and the scribe was serious about her role too. Our facilitator was just like another group member but it was no problem because we all knew each other at least a little. Sometimes our meetings were a little difficult and we had some awkward moments when people expressed different opinions. Although not everyone attended all our out of class meetings there weren't any hassles or major disagreements. Sometimes it meant that we made the decisions on their behalf.

I think PBL was a good process for making new friends from other classes and for sharing the workload. By sharing with others we could separate out the trivial things and concentrate on the important information. It was harder to become involved early in the semester because we were still settling into university life so I think it worked better for me in this unit later in the semester. Even though I didn't like PBL I know that it helped my learning.

Lee states clearly that she did not enjoy the PBL exercise although she indicates she became more comfortable with the process during this unit held late in Semester 1 than with earlier tasks. As a school leaver she focuses on the benefits of group work, rather than PBL, to meet new friends and share the workload. She also acknowledges her group worked to dispense with trivial matters and concentrate on the important ones. Lee states that she knows PBL helped her learning though her narrative suggests she was not comfortable with the process.

Jane, Chris and Lee refer to the benefit of improved learning as a result of the PBL exercise. While Jane initiated the PBL strategy purposefully as a means to encourage her students to think differently about their own learning and responsibilities, Chris and Lee acknowledge greater engagement and improved learning for themselves. Similarly, each respondent identifies the challenges involved in group work.

Discussion

According to Savin-Baden (2001), one of the keys to successful PBL implementation is effective staff development. Collaboration between two people simplified implementing PBL into the *Resource Economics* unit and enabled the best practices in PBL, as synthesised by Pawson and his colleagues (2006), to be adopted. The unit coordinator and I viewed the Avian influenza problem an authentic and real world problem for students to engage with. Reassuringly, the student feedback suggests they too viewed the task as contextual. Research indicates that difficulties may arise when problems are too well structured, as they are not challenging or are viewed as unrealistic (Dolmans et al., 2005). As the students were relatively new to university and PBL, we provided support to address the unstructured problem as we felt appropriate. Examples of such support include the staggered release of relevant resources and two facilitators available during all timetabled sessions. Student feedback also indicates they understood that several approaches were appropriate to address the problem, there was no simple solution and that the problem required more than rote learning from them.

When PBL is new to most students it is vital that they receive guidance about how they will be working, what is expected of them, why they are working this way and how they will be assessed (Pawson et al., 2006; Tan, 2003). Students were reassured to hear in advance that they may find working on the 'messy' 'unstructured' problem frustrating in the early stages, though less enamoured with the expectation of self direction within their group. They also acknowledged the benefit of receiving background information about the process before embarking on the problem. Student comments from both survey and interview data indicates that they appreciated sharing different perspectives and information within their groups. This in turn implies students were working collaboratively and constructing new knowledge.

The majority of students indicated that they enjoyed working in groups as a means of making new friends and sharing the workload. According to Allen et al., (n.d.) the power of working cooperatively fosters valuable communication and interpersonal skills in

addition to harnessing the power of different thinking and learning styles. Nevertheless, both facilitators shared concerns about the existence of a dysfunctional group and suspected the presence of another. Despite frequent reminders about the importance of revisiting group protocols and our willingness to assist should any difficulties arise neither facilitator was approached for assistance. Consistent with research (Dolmans et al, 2005; Schwartz et al., 2001) the feedback through interviews and surveys indicates that some students found the group work problematic. Some students report being discouraged by group members who did not attend meetings or contribute to the group presentation yet were happy to share the group assessment. Perhaps group members while sympathetic of others' circumstances at the time were resentful later. Perhaps they felt uncomfortable about confronting underperforming group members. Moreover, providing self and peer feedback opportunities for the students did not prevent these issues arising and require further reflection.

Another issue arising from the data relates to assessment. As indicated previously, the assessment details were published prior to developing the PBL task, resulting in little scope for adjustment. In future, assessment for a PBL task in the unit will be assessed separately from tutorial attendance and after in depth discussion as encouraged by Savin-Baden (2001) and Pawson et al., (2006). Of course, not all students welcomed assessment via an oral presentation and groups chose who, and how many from within their group, would speak. However, a variety of assessment tools, including self and peer assessments will be embedded into future PBL activities. For example, the WebPA project facilitated through Loughborough University (UK) will be further investigated for its relevance (<http://webpaproject.lboro.ac.uk/>). In addition both individual and group components of assessment will be included to determine final results. Further refining the PBL process in this unit should facilitate a richer learning experience for the students. It will be interesting to 'track' developments and student perceptions of the PBL activities in the unit as a longitudinal study. Such a study also offers the opportunity to observe the third phase of the change process, termed institutionalisation, should this transpire. Institutionalisation occurs when an initiative is embedded into the routines of an organisation so that it becomes routinised and is considered normal in that setting.

Conclusion

PBL is 'problem first learning' where the problem defines what is to be learned. Students in the first year unit *Resource Economics* worked in groups, to build on current knowledge and synthesise then integrate new knowledge, while taking responsibility for the learning which occurred in their group. The implementation occurred over four weeks late in Semester 1 2007. Data were gathered from written student feedback at the completion of the PBL task and through narratives developed from semi-structured interviews with students chosen at random, and the unit coordinator, after the Semester 1 exam period. Such use of narrative accounts permits the ordinary, every day experience of participants to be revealed, rather than the bizarre or exotic, and honours that experience.

Based on the data and analysis, the close collaboration between Jane (the unit coordinator) and I to develop the PBL task, the resource materials provided to students, the facilitation

of the weekly tutorials and student assessment, Jane perceived this implementation as successful. Jane implemented the PBL strategy purposefully as a means to encourage her students to think differently about their own learning and responsibilities. She sought to shift her students away from the 'normalised' rote learning of old to encourage them to think more deeply and beyond the immediate task at hand. Both her lingering concerns, related to fairer group assessment and remediation of dysfunctional groups will be addressed in future PBL applications.

Student feedback data was mixed. While students appreciated the background information and training provided before embarking on the PBL task not all of them welcomed taking responsibility for their own learning. Positive comments from the majority of students indicated they enjoyed working in PBL groups to share the workload and their new knowledge. While we can be certain some students believe their university learning experience was enhanced through PBL other students disagree. Data gathered from both student interviews refer to the challenges of group work while acknowledging the PBL task enhanced their own learning.

Two issues requiring attention prior to continuing the PBL implementation in this unit emerged from the data analysis. These are, firstly, ensuring students refrain from under-estimating the importance of group processes and, secondly, ensuring that students view the assessment model as fair. To address the first issue, group process and team work skills will be strengthened, prior to student groups forming in future PBL tasks. To address the second issue, assessment will be clarified so students recognise clearly the alignment between the learning activity, the learning outcomes and the assessment form. Future assessment will be designed for the unit from the outset and prior to unit information becoming public. It is anticipated that by refining the PBL activity in this unit the first year student learning experience will be further enhanced.

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Appendix

Resource Economics

Avian influenza 1

There is continuing concern and interest in the possible emergence of an avian influenza pandemic in many countries across the world, including Australia. How a pandemic might affect Australia is an important policy issue, as is formulating appropriate responses to such a pandemic. You are a consultant team contracted with the Department of Agriculture and Food to report on the potential short term economic impacts on Australia, its states and territories and the key sectors likely to be affected by a pandemic.

Avian influenza 2

You have considered the role of the Australian Government in managing an avian influenza pandemic and its strong focus on maintaining a stable economy. What are the ramifications of an avian influenza pandemic on Australia's monetary policy?

Avian influenza 3

You have determined the ramifications of an avian influenza pandemic on Australia's monetary policy. Determine the policy implications for Australia's international trade.