Numeracy down the drain: Adult Education explores House Water Expert*

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House Water Expert is educational software developed by the Commonwealth Scientific and Industrial Organisation (CSIRO) to increase community awareness of domestic water use. It engages the adult learner with a numeracy model and invites the user to experiment with changes to household water use. This paper explores the theoretical basis of HWE and offers both a critical perspective for its implementation in Adult Basic Education as well as a framework for extension activities.

Earlier this year I attended a conference on domestic water use where numeracy curricula and theories of pedagogy were never mentioned. It was an Alternative Technology Association conference focussing on the need to educate consumers about environmental issues, new water saving technologies and, in particular, water use in and around the home. I was there for the new products and technologies. The new technology that intrigued me was House Water Expert, educational software developed by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) that allowed Australian consumers to access a wealth of information about water saving strategies and experiment with their own water usage.

The most intriguing aspect to the teacher in me was the way the program allowed the user to interact in a mathematical environment, achieve desired outcomes and yet not face a single calculation. That started the process of reflection in which I pondered the efficacy, if any, of such a program in the Adult Basic Education environment.

House Water Expert - HWE

This software was developed for community education on the harvesting, use and disposal of water in the domestic arena. It requires simple computer skills and comes with a tutorial. Data within the program is for Australia and the user must choose the town or city nearest them. The program models a household by allowing the user to choose a house or an apartment then populate the household by selecting and naming members (personal icons). Users can elect to have members 'join' or if desired 'evicted'.

The exterior of the house is represented in plan so that users can drag the roof perimeter to expand or contract the size. The program automatically gives a house area calculation. The exterior icons are dragged up from the bottom of the screen, placed and size-adjusted as desired. Icons represent garden, lawn, paved area, water tanks, sheds and pools etc. The user must make choices about how often the garden is watered, and for how long during different seasons. In addition, choices are made about the use and disposal of stormwater.

The interior of the house is similarly represented in plan with icons for washing machines, taps etc dragged up from the bottom of the screen. However this section requires choices representing each household member's use of water e.g. how long they each spend in the shower and whether or not the tap leaks.

After the household is entered the results screen gives readings for how much water is harvested/used externally, internally and by each household member. The user can then go back and make changes, for example shorter showers, and see what water savings can be achieved. Outside the house greywater diversions and rainwater tanks may be added, or paved areas reduced, to achieve water savings. In addition, the program includes three games: Choose a Rose, Back to Nature and Save the Town. The games are generally considered to have less integrity than the main focus of the program.

House Water Expert engages learners with modelling on two levels. Firstly the program itself models household water use, and secondly, embedded within that is a model of numeracy.

Modelling in adult numeracy

The significance of modelling permeates current debate on numeracy education.

Yasukawa (1998) argues that mathematics based models are increasingly complex in the way they explain and control our world. Further she asserts that modelling bridges the gap between the 'expert' and 'lay' knowledge and as such should have its concepts and processes scrutinised. The adult basic education practitioner can have an important role in building that bridge.

This paper is a contribution to that process. Using the four components of Baker's (1998) ideological model and Drago-Severson's (2004) work on constructive-developmental theory, I will attempt to situate HWE in current theory and present a way of thinking about our practice in enriching and extending the model for our students. Baker focuses on the numeracy practice while Drago-Severson has researched the individual's changing attitudes to making meaning.

Baker's (1998) ideological model views numeracy practice as having four components – content, context, culture and ideology. The first 'content' he describes as 'the activities, techniques and kinds of numeracy that individuals engage in'. The context also includes the purpose for the activity and is therefore highly individualised. The 'culture' component examines beliefs, values and ways of knowing that underpin practice. The ideological component includes the relationships, status and roles of the people and the numeracy knowledge, concepts and practices they employ.

Content 1: Numeracy model

House Water Expert does not require the user to engage in any calculation. This challenges the traditional notion of numeracy/mathematics where discrete skills are treated as independent of context or culture. Indeed for far too long the ability to work out the sum and achieve the right answer formed the basis of what many valued unquestionably as numeracy. Instead the program embraces the notion of numeracy as social practice which allows a wider context where the user operates as part of a society.

The program does require that the user engage with numeracy concepts. The 'house' is represented in plan by a basic rectangular roof shape. As the perimeter of this shape is dragged in or out so the area calculated increases or decreases. Most people either know or have some rough idea about the size of their house. Significantly the lack of exactly accurate ('right') information does not preclude use of the program. In another section users must estimate how their water will be used. This is achieved through three sliding scales (number lines expressed in percentages) representing different choices eg municipal drainage, greywater or rainwater tank. On the same screen these scales are represented graphically in a pie chart showing the identical information as proportions of a whole.

As the user decides and then refines their choice the program recalculates and the proportions change accordingly. Since this is fast and in bright colour students generally perceive it as a fun activity. The concept of percentage is illustrated on screen and the student can then make changes as desired. This was probably not the feedback that Kolb (1993) envisaged for his experiential learning theory but it does constitute testing for the validity of ideas, for example, the student who tried to put 20% of rain water onto the lawn and 40% into municipal drainage and 60% into the rainwater tank soon found that percentages had to add up to 100 to make the pie chart 'work'. The program automatically adjusts previous choices to formulate the pie chart.

Estimation of the detailed water use practices of each household member is an integral part of 'Inside' the house. In addition the selection of a rainwater tank and decisions on the extent and nature of paved areas involve measurement of time, capacity, area etc but do not require 'specialist' knowledge in any particular field. For any required element a range of choices is always available on screen. Working with the concept is preferenced over making a 'right' choice first time. The program encourages the user to return and change the choices to achieve better outcomes for water use and water saving.

The results button accesses information about water use inside and outside the house as well as data and graphs on items such as rainfall in your area and individual water use. The display of this information conforms to dominant practices and illustrates the abstractions that characterise formal numeracy. The results screen contains so much information that students could easily be overwhelmed unless specific strategies like those used in literacy, such as skimming, scanning, reading for detail, are employed to help students extract meaning from the data. Students may confidently navigate the program's representation of their multiple numeracy practices and yet still miss vital meaning if they are not competent in the formal numeracy curriculum.

Content 2: Household water use model

Any model is but a representation of the reality. HWE simplifies and categorises our domestic dwellings and matches them with data from major capital and regional centres across Australia. The available dwellings are a house and yard or an apartment or flat without a yard. Adult educators who are engaging learners with the hidden processes of constructing models need to contrast the model with the student's reality. Students may know the floor area of their house but be unable to model it accurately as the model makes no provision for two storeys. Double storey houses generally harvest less rainfall than a single storey house of similar floor area. The model forces a choice between accurate floor area or accurate rainfall harvest data. These choices must always be related back to the purpose of the program and its intended audience. When students understand these relationships and see the choices that have been made then the validity of the model is put in clearer perspective.

It is worth noting here that in our limited experience in using HWE with inmates we have found that the graphics in the program can also frustrate students. Once dragged onto the 'Outside' screen, icons are placed and size adjusted but the constraints of the design process mean elements are simplified and must not overlap. Some students demand the level of control only found in sophisticated drawing programs. This is another aspect of the modelling process that students must experience, comprehend and learn to manipulate in order to make their choices legitimate.

Context

HWE is a purposeful response to Australia's experience of drought and resultant water shortages. It could never be conceived as context free. Habermas (Hyslop-Marginson, 2004) argued the ideological neutrality of technology but this ignores the social, economic and political context of its introduction. In particular his theory of neutrality detaches the technology from any political agenda driving its introduction.

The program offers domestic water users a research tool for investigating water use and savings. Water restrictions are widespread and prices are rising. Interest in water saving strategies and devices has never been higher. Currently the public debate includes all States and has moved from primarily a rural concern to an urban priority as the existence of some cities is threatened.

Media reports broadcast details of how much water is used, by whom and how much is paid for it. This is opening new spaces and fuelling debate as previously hidden facts are exposed for public discussion. Water use has never before in Australia been subject to such widespread scrutiny and investigation across government, commercial and domestic arenas. The campaign is pervasive and presented as a prerogative for which all residents must take responsibility.

HWE is therefore infused with values from the culture which teachers should appreciate if they are 'to understand how a particular mathematical representation 'models' a context, and what the model ignores or assumes about the context' (Lukin, 1998, p. 78). It is also situated as relevant and timely and presents one way for students to enter the public debate.

Culture

Australians have been accustomed to thinking of their country as one of abundant natural resources - especially clean air and water. While these perceptions may be changing with greater public knowledge of pollution, its multiple forms and effects, the water use habits of generations are proving harder to redress. Education is a first step. Experience also plays a part. The gardeners of Australia are moving to drought resistant species but HWE is able to present alternative water use/saving strategies that can be tested in model form first. Testing by using a model represents a cultural change in behaviour and contributes to wider societal cultural change.

HWE fits within the culture of Australia in another important way. Designers have capitalised on the popularity of 'Big Brother' – a reality television program – by using the work 'evict'. When using the program with inmates they recognised the similarity immediately and their ensuing enthusiasm was palpable. The icons for household members are not quite androgenous but neither are they easily categorised, making them far more inclusive. Even setting up a 'house' and a 'household' is more inclusive than 'family' and friendlier than 'residents.'

The HWE model is substantially different from the dominant culture's perceptions of school mathematics. The program is in CD format, not paper-based and is interactive, involving colour and movement. This sets it apart in a physical sense from the common experience of school mathematics. The absence of a quest for the 'right' answer and preference for student-generated alternatives challenges expectations and common views that 'numerate' is synonymous with the 'ability to calculate'. Its timeliness and cultural context give HWE a legitimacy that would not be afforded such material in a traditional paper-based school curriculum. Paradoxically the elements that set HWE apart from perceptions of school mathematics also are hallmarks of contemporary technology in learning and are therefore strong motivators.

Ideology

The power relationships evident within HWE are another significant departure from traditional views of the role of the learner in the learning environment and even the role of pedagogy. Democratic values in education can be realised in diverse ways. In HWE the 'authority' is the program itself and the student always controls their own learning. For some critics of educational technology, though, this view is problematical. They argue that if the predetermined strategic objective is 'x', then instrumental rationality plans the various steps to realise 'x' (Hyslop-Marginson, 2004, p. 138). In their view instrumental rationality is more likely to be tied to commercial interests but HWE welds individual benefit and common good.

HWE could be assessed as of little value in the numeracy classroom because of the lack of direct calculation. However similar arguments were mounted when calculators were first introduced. Forrester (2005) reports that research now supports the view that 'calculators can be used to improve numeracy skills rather than replace them.' Further, the instant feedback and freedom from any fear of criticism, mean that motivation is improved. Within HWE the program does the calculations and students become the evaluators of their choices.

Students can engage with the program at many levels. For some the only results they will use are those on the main screen – townwater used, wastewater and stormwater generated. They may not even understand the term 'kilolitre'. Other students will seek out and absorb any extra information available in the program, for instance water saving tips, and talk it over with friends in the effort to achieve greater independence. Again some will be interested only in water saving strategies while still others will utilise the capacity of the program to give measured calculation to inform their decision making. An insistence on pure, formal skills would withhold legitimate knowledge, marginalise many students and hinder participation in public debate. 'Contemporary educators concerned with the political implications of classroom technology should not repeat their [Luddites] mistakes by rejecting technology outrig … rather they should consider ways ... to achieve objectives that respect the principles of democratic learning' (Hyslop-Marginson, 2004, p. 146).

Learning that transforms behaviour

The diversity of such responses prompted Drago-Severson's (2004) interest in the concept of a 'new pluralism' involving developmental diversity along with the gender, age, race, class religion and ethnicity. Her research looked at developmental levels and the meaning-making systems or 'ways of knowing' that adult learners bring with them to the classroom. The study identified three different categories of learner: instrumental, socialising and self-authoring. The focus of these learner categories moves from concrete needs and goals, with the 'right' steps to achieve them, to realising abstract goals and the best way to achieve them, through to identifying one's own independently conceived goals. Further the study's core findings included the variety of importantly different ways of knowing that adults bring to the ABE/ESOL classroom, the importance of the 'cohort' or 'community of connection' and the possibility for and variety of significant change for adults in these settings.

Drago-Severson's (2004) research findings are pertinent in understanding how our students respond to new technology that is explicitly aimed at changing behaviour and gives a framework for identifying where a particular student's understanding may be situated. The study emphasises too the importance of peer learners and the legitimate learning that transpires through public debate. Her constructive-developmental perspective attends to both the structure and process of learning. Constructivism asserts that people are actively engaged in making meaning through experience while the developmental aspect assumes that constructions of reality will progress throughout life, gradually and constantly being discarded as greater complexity is accommodated. Drago-Severson (2004, p. 35) contends that 'taking into account the way a person makes sense of the world creates an opportunity to offer support and challenge in a way that is developmentally appropriate. Learning is enhanced and transformational learning is possible.'

Chadwick (2004, p. 49) however takes issue with the view that sees constructivism as active and behaviourism as passive. He argues that pedagogical strategies, for example problem solving, critical thinking and creativity are not 'owned by constructivism' and that it tends toward the idea that there is no solid truth and no right answers…' Further he warns that if perceptions and personal constructions are the goals of learning then evaluation is complicated. Lukin (1998, p. 77) reached similar conclusions in her study of a coal mining disaster. 'The kind of numeracy required in this context is not one that can be developed by progressivist pedagogies in which the learner is seen as the source of derived meanings/abstractions…….The worker is not free in this context to draw their own models or interpretations.'

In HWE these opposing views are accommodated. The student is free to experiment with different water saving strategies but the manipulation of the abstract symbols of mathematics is isolated within the program. Its everyday context will always be vulnerable to scrutiny and, as students discuss its application in their experience, found to be inadequate to represent ‘real life’. The abstractions inherent in HWE should be seen as Lukin suggests, as a point of departure. It is to these further activities that we now turn our attention mindful of developmentally appropriate challenges.

Extension activities

As students discuss their water use practices many opportunities will develop for extending their numeracy experience and for testing the validity of the model. In this paper I offer only four activities for lower and higher level students.

Lower level

1. Using a bucket under a shower or tap collect the cold water that runs out ahead of the hot water. This can be measured either as a rough fraction (□ or ½) or in litre jugs depending on student interest, development or need.
2. Investigate different ways of watering the garden e.g. hose, bucket, drip bottles. Measure how much water is used and evaluate which way is more effective.
3. Research household appliances such as washing machines and dishwashers. Find out how much water different styles of machine use and which cycles are most water efficient.
4. Practice cleaning your teeth using 100ml of water. Measure how much water you would usually use cleaning your teeth at the bathroom tap. Do the calculations on the water saved over a year. A similar activity could be designed for car washing using a bucket or a hose.

Higher level

1. Find the difference between the area of the roof in a plan and the actual surface area. (Teacher provides dimensions.) How does this affect rainfall harvest?
2. If you double the roof area what happens to the perimeter (gutter) length?
3. What’s the difference in stormwater runoff between the same size block and the same size house where (a) all the yard is lawn and (b) half the yard is concrete?
4. Investigate the validity of rainfall data. HWE uses one data set for a city. Find out what the rainfall is for a ‘dry’ and ‘wet’ part of that city. For example in Sydney, Turramurra has a higher rainfall than Richmond. How would this affect the model’s results?

Language/computer skills

HWE utilises language that is simple and clear and in places betrays its roots in the scientific community. Most students will not be familiar with ‘harvest’ in relation to rainfall but the meaning is easily transferred and the word itself not difficult to read or spell. The word ‘pervious’ is more of a challenge as it is unfamiliar to a much wider section of the community. It is best viewed as ‘an opportunity for learning’! I worked with a low level student who stumbled on ‘municipal drainage’. However she understood ‘council pipes’ and went on to complete the remainder of the house set-up mode independently. I believe the unfamiliar aspects of HWE were so readily accommodated because she was so thoroughly familiar with the context and to her it was legitimate knowledge.

The initial screens are extremely simple and easy to follow both in terms of labelling and instructional language used and in the pre-requisite computer skills. Simple mouse clicking and dragging is sufficient to operate most of the program. However changing the properties of elements requires a facility with the right-click function. The most confusing aspect we have found with students is the Save function which operates automatically when moving from ‘Tell Us About Your House’ mode to ‘Make Home Water Use Improvements’ mode but subsequently each ‘improvement’ style must be named and saved manually.

Conclusion

Australian society is obsessed with measurement. Daily our news is crammed with sporting results, race times, financial markets, weather data, dam levels and especially the abundance or lack of rainfall. Widespread water restrictions are but one part of the cultural context surrounding the introduction of HWE – an interactive, modelling tool designed by government scientists to endeavour to change our water use habits.

Adult educators have a responsibility to help scrutinise and situate such models. The numeracy model inherent in HWE takes a constructivist approach by encouraging users to experiment with their own solutions but constrains the experience of calculation. I have argued that this should be viewed as enhancing accessibility and part of the bridge building that models can achieve between specialists and generalists. The pedagogical approach I have taken involves using the model as a point of departure where enrichment activities can address student needs at an appropriate developmental level and where elements of formal numeracy curriculum can be introduced in situated contexts. This approach will facilitate a critical understanding of the representational nature of models and encourage students to move beyond the model in making meaning of their experience.

> Technology is always designed and applied within some historical context, but its potential application is never completely dictated either by this context or its intended application. (Hyslop-Marginson, 2004, p. 142)

And in the words of an inmate:

> 'I'm building a house! It's like Big Brother!!!'

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