EXPLORING CULTURAL-HISTORICAL ACTIVITY THEORY (CHAT) AS A TOOL FOR INVESTIGATING WORKERS' LITERACY AND NUMERACY PRACTICES

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Abstract: Public policy discourses suggest that there is a 'crisis' in the literacy and numeracy levels of the Australian workforce. In this paper, we propose a methodology for examining this 'crisis' from a critical perspective. We draw on the literature review and some preliminary findings from our current NCVER funded project, which investigates production workers' literacy and numeracy in lean manufacturing firms. We focus on how language, literacy and numeracy (LLN) practices are embedded in production work, and investigate various perspectives, including those of management, trainers and workers, on any LLN problems and issues. We adopt a critical perspective that analyses the way work, learning in work, and literacy and numeracy in the workplace are shaped and reshaped by social relations and culture, values and the histories of the industry and the local workplaces. Much of the literature on workplace literacy and numeracy research that is aligned with this perspective examines literacy and numeracy as social practices, as we will do. In this paper, we propose that cultural-historical activity theory (CHAT) offers useful theoretical concepts and tools for analysing the literacy and numeracy practices used by workers.

Introduction

The Australian Government is about to release a National Foundation Skills Strategy (NFSS) for Adults, an initiative strongly supported by industry skills councils and employers who have advocated for a policy response to what they perceive as low levels of literacy and numeracy among the adult population, and in particular the workforce (Australian Industry Group [AiG] 2010, Industry Skills Councils [ISCs] 2011, Skills Australia 2010, 2011). Their call for action emerged largely following the publication of the results of the 2006 Adult Literacy and Life Skills (ALLS) survey, which showed that approximately half of adults surveyed had literacy and numeracy levels below what was later determined by the Council of Australian Governments (COAG) to be the minimum level needed for people to be functionally literate and numerate at work and in their community (Foundation Skills Working Group Secretariat 2011, COAG Reform Council 2010). In addition to the ALLS survey results, other statistics including VET course completions, the proportion of the Australian workforce with a qualification of Certificate III or above, the availability of workers with skills in demand, and productivity levels have been added to the mix of claims fuelling a crisis discourse around literacy and numeracy.

As adult literacy and numeracy, and workplace learning researchers, we are concerned about how the contested meanings of literacy and numeracy, and indeed skills more generally, are ignored in the crisis discourse. There is an assumption that the measures of literacy and numeracy against which people are being assessed are unproblematic. We also notice that reports by influential bodies such as the Australian Industry Group (2010, 2011) and Skills Australia (2010, 2011), while documenting the employers' views on their workers' literacy and numeracy and examining results of large scale surveys such as the ALLS, provide no account of how the workers themselves experience the link between literacy and numeracy and their work practices. We regard this situation as constituting an inadequate basis for understanding the complex relationships between literacy and numeracy and the educational and economic concerns under public discussion.

That the particular theoretical model of literacy and numeracy a researcher adopts in examining workplace literacy and numeracy leads to different kinds of questions being asked, and therefore different findings being made, has been argued elsewhere by two of the authors (Black and Yasukawa 2011) and other researchers of literacy and numeracy e.g. Belfiore, Defoe, Folinsbee, Hunter and Jackson 2004, Gallo 2004, Gee, Hull and Lankshear 1996, Hull 1997). In this discussion of our research, we are interested in how literacy and numeracy practices are embedded in work practices and how workers use their skills to negotiate their work. We start from the viewpoint that literacy and numeracy are social practices that cannot be understood in isolation of the specific contexts in which they are used; that is, literacy and numeracy are what people do in different ways according to the purposes, constraints and opportunities presented to them by the historical, material and social contexts of the activities (see Barton 2007, Barton & Hamilton 1998).

In this paper, we first present an overview of Cultural Historical Activity Theory (CHAT), and explain what it offers for studying workplace literacy and numeracy from a social practices perspective. We then introduce our current research and the contexts of the sites of the research, followed by an examination of some of our preliminary data using the tools and concepts of CHAT. We discuss how CHAT can assist our understanding of literacy and numeracy in the workplace.

CHAT as an analytical tool for examining literacy and numeracy practices

The social practice theory of literacy and numeracy challenges what Street (1984) describes as an autonomous model, where literacy and numeracy are regarded as skills that can be understood without due reference and consideration to the social contexts in which they are used. The social practice model by contrast treats literacy and numeracy as being embedded in what people do in the course of some purposeful activity. Thus examining literacy and numeracy as social practices involves examining how people use literacy in their everyday lives – reading and writing, and numeracy – counting, calculating, estimating, measuring and so forth, within particular everyday social contexts. Social practice theorists maintain that literacy and numeracy practices cannot be understood independently of the social, cultural, historical and political contexts in which they are embedded. For example, a study of numeracy within the context of a school mathematics classroom would typically see students doing sums individually, using paper and pen and perhaps a calculator; however in a supermarket, the same set of numbers might be added up at the checkout counter by the shop assistant using a cash register, at the same time that the shopper might be doing an estimate of the sum in their head to make sure they are not overspending. The 'numbers' involved in the task of 'adding up' might be the same, but the social context, the people involved and their respective purposes lead to differences in the actual 'doing' of the sum. A blindness to the context can lead to inaccurate conclusions about the significance of the different ways of accomplishing the sum. For example, Joregensen (2010) found during her study of the numeracy (practices?) of young people in the workplace that the use of the cash registers by shop assistants is motivated not primarily by the ability or lack thereof the shop assistant's mental maths skills, but by the business's need to keep an accurate record of what is being sold, in what amount and what time of the day and week. The fact that in the process of punching in the purchases on the cash register, a total for the purchases is produced as well as the amount of change does not justify the kinds of popular assumptions like young people being over-reliant on calculators. Even if a mathematically confident worker wanted to demonstrate their mental maths ability to their customers, they are not at liberty to do so in this context where the good performance of the employees requires them to use the cash register.

Thus factors such as the social and cultural norms that are influenced by history and power relations are central to the study of literacy and numeracy practices. Social practice theorists of literacy and numeracy (e.g. Street 1984, Barton 2007), identify the need to research literacy and numeracy in relation to the social activity in which it is embedded, paying attention to the technological, cultural, historical and political factors that are shaping the activity.

One theoretical resource that provides useful tools and concepts for analysing literacy and numeracy practices (and other social practices) is Cultural Historical Activity Theory (CHAT). CHAT is often attributed to Yrjo Engestrom (2001) and has its roots in the work of Lev Vygotsky (1986) on the socio-cultural nature of human development. The unit of analysis of CHAT is the activity system, often represented by the nested triangles shown in Figure 1:

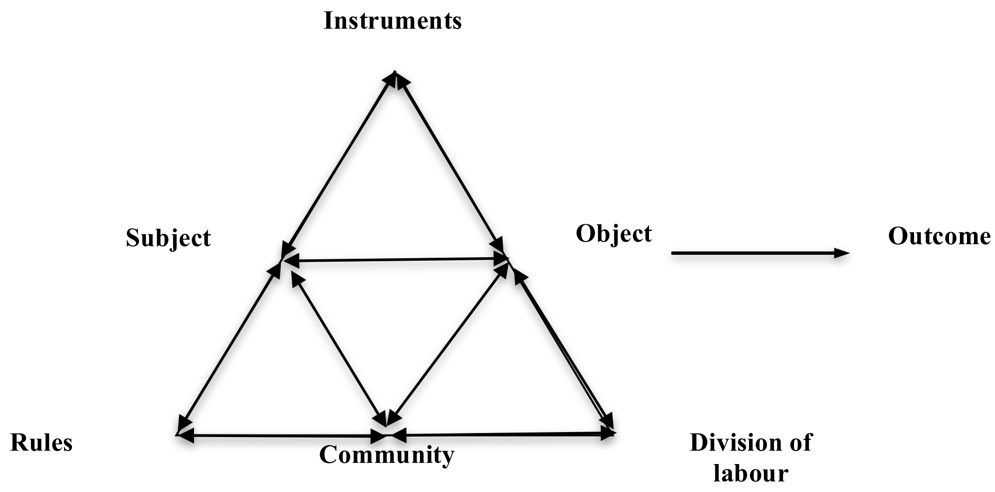

Figure 1: Elements of an activity system

The *outcome* of the activity system represents the goal of the activity, and the *object* of the activity system represents what is produced in order for the goal to be achieved. The outcome of an activity may be economic security for a worker who is the *subject* of this activity system. In order to achieve this outcome, the worker needs to produce certain objects - such as goods that their workplace manufactures and sells. The worker is a member of a *community* in the workplace that establishes, or at least subscribes to certain *rules*, or ways of working that has become formally or informally accepted in this workplace. There may also be a *division of labour* within this community that enables the work of this community to be both shared or controlled, depending on the power relations within that community. The subject would use a range of *instruments* or tools to produce the object – these may include both symbolic tools such as texts, and material artefacts such as hand tools and computers. Engestrom (2001) summarises CHAT using five principles: 1) the unit of analysis is a collective, artefact-mediated and object-oriented activity system; 2) activity systems represent multiple voices, that is, they are constituted by a community of practice; 3) attention is needed on historicity because activity systems evolve and change over time and are shaped by this history; 4) contradictions that emerge between elements of an activity system are resources for change and learning as the members of the community collectively engage in the resolution of these contradictions; and 5) activity systems can experience expansive learning, that is where the collective's taken-for-granted practices are transformed into something new and sustained.

What Engestrom's formulation of CHAT provides is a way of understanding resistance and/or impetus for change in the established practices of the community. *Contradictions* within or between, and *disturbances* to, activity systems are important foci in CHAT because they present challenges and therefore possibilities for change in the established practices of an activity system. For example, within a workplace, a disturbance might be a new piece of technology that renders certain tasks obsolete, thus introducing potential contradictions to the rules and division of labour within the community that had, until then sustained the activity system. This may lead to the new rules and new division of labour emerging that may change the mix of members in the community, or the relations within the existing community. Or, there may be industrial instruments that lock the community into working with the existing rules and division of labour so that the new technology sits in tension with the industrial agreement and cannot immediately effect workplace change.

As a theoretical framework for analysing workers' literacy and numeracy practices, CHAT guides the gaze of the researchers in the workplace. In an investigation of the current 'crisis' discourse around workplace literacy and numeracy, we would be looking at the practices in the workplace as activity systems, which would be described differently depending on who the subject is. Moreover, each worker may be a member of multiple communities, engaged in a number of activity systems that are producing different objects for different outcomes. For example, a worker may be a member of a team that performs one part of an assembly process in a factory, and the main object of that team may be the assembly of a particular part that is supplied to the next chain in the assembly line. The same worker may also be the leader in their team, and be part of the community of team leaders in the factory who meet and solve problems for the factory due to errors or problems that arise at the interface of the different teams. The literacy and numeracy practices embedded in one activity system may or may not be recognisable within or transferable to another activity system, and the individual worker may be in an activity system of her/his team or unit in the production process while simultaneously a part of the activity system of the company's overall production process.

In Engestrom's works, an increasing area of focus is on the 'constellation of two or more activity systems that have a partially shared object. Such interconnected activity systems may form a producer-client relationship, a partnership, a network, or some other pattern of multi-activity collaboration' (Engestrom & Sannino 2010: 6). In contemplating interconnections between activity systems, Engestrom and Sannino (2010: 13) find Star and Griesemer's (1989) concepts of *boundary objects* and *boundary crossing* useful for describing the development of shared objects across two or more activity systems and 'the forms, knowledge repositories, and graphic models' that facilitate this development.

The concepts of boundary objects and boundary crossing are also used by Hoyles, Noss, Kent and Bakker (2010) in their study of mathematics in the workplace. They discuss symbolic artefacts such as charts and graphs that are produced and used in many workplaces to monitor production targets, identifying them as symbolic boundary objects that facilitate communication. They have also introduced and use the term *techno-mathematical literacies*, which they define as the literacy that 'involves a language that is not mathematics but "techno-mathematics", where the mathematics is expressed through technological artefacts" (Hoyles et al 2010: 14); they argue that this term is more useful than the term numeracy or mathematics in many workplaces where computerized work is pervasive.

Gaining an understanding of workers' literacy and numeracy practices, and in the particular context of understanding the literacy and numeracy 'crisis', would entail seeking answers to questions such as –

- What are the different activities in which workers are engaged in a workplace; how can they be described in terms of activity systems within the workplace?
- What literacy and numeracy demands are embedded in the different elements of the activity systems that a worker experiences?
- How can the different tasks involved in the workplace be described as literacy and numeracy practices?
- How do the socio-culturally and historically established norms or rules of the workers, the ways in which workers identify and communicate with each other, the way jobs are distributed, and the tools and instruments of the workplace shape the literacy and numeracy practices in the workplace?
- (How) can changes to the literacy and numeracy practices of workers lead to improved productivity outputs for the workplace?

The context of contemporary production work in Australian manufacturing

The manufacturing sector in Australia, especially 'competitive manufacturing' – that involving 'lean' production, is seen to be particularly affected by the low literacy and numeracy levels of employees given the continuous skills development needed for the 'competitive edge' (Manufacturing Skills Australia [MSA] 2011: SA 38-39), and a sustainable future (MSA 2012). This sector is said to be experiencing difficulties, contracting as a source of employment, and suffering a shortage of skills, but by the same token, it is also undergoing major changes with a shift to competitive (lean) manufacturing, and accommodating significant technological innovations (MSA 2011). The manufacturing sector's workforce has a lower overall level of formal recognised skills than the Australian workforce as a whole (Industry Skills Councils 2011:39, AiG/UTS 2012: ii) and there is a sense of urgency to improve LLN skills. Manufacturing Skills Australia (MSA) (2011:58) states manufacturing employers 'still find that the language, literacy and numeracy (LLN) levels of learners are often far below standard and present a hindrance to further skills development' (MSA 2011:58).

Lean production has efficiency as its aim, and usually involves small teams of multi-skilled workers taking increased responsibility for meeting production targets. Drawing on the team members' knowledge to provide insights and suggestions for greater efficiencies is a central feature of continuous improvement, and the elimination of all forms of 'waste' which lie at the heart of lean production (see Womack, Jones and Roos 1990. Nicholas 2011). A number of manufacturing companies are shifting to lean production through the accredited course on 'competitive manufacturing', and some enterprises in the process of transitioning to 'lean' may perceive increased LLN problems in their workforce due to the increased 'textualisation' of work practices, especially involving team meetings and increased compliance documentation e.g. Gee, Hull & Lankshear 1996, Farrell 2006).

Research methods and the research site

This paper reports on some of the preliminary findings from one research site of a current NCVER funded project entitled 'Investigating the "crisis": production workers' literacy and numeracy practices.' In this project we are investigating the ways in which the workers experience and negotiate literacy and numeracy in their work practices. We are interested in understanding literacy and numeracy as social practices in the workplace.

To date, data collection has involved: on-site visits for a total of 6 full days by all members of the research team; observations and field notes of a range of the work tasks in the production areas; attendance at team meetings, and a 'lean' diploma level training session; in-depth, recorded and transcribed interviews with production managers (several interviews), human resource manager, production team leaders (7 members), team members (5). Recordings have also been undertaken of team meetings, a training session of the diploma course, and team member explanations of their work roles; and in-depth recorded and transcribed interviews with the CEO of the lean production training company and the course trainer of this company.

The company, which we will call Hearing Solutions, produces a variety of hearing aids, with its parent company and head office located in Europe. The company employs approximately 60 production workers engaged in a wide range of tasks. These tasks vary from routine manual production work to more advanced computer modelling and the service/repair/testing of hearing aids. The large majority of the production workers are born overseas and English is not their first language. The main countries of birth include: Philippines, Vietnam, Yugoslavia and China. There is little turnover of workers at the company, and many (up to 12 workers) have been at the company 15 years or more. We consider this company to be at an advanced stage of introducing lean production practices. All employees have undertaken on site lean production training (mainly competitive manufacturing courses at level cert 111 or cert IV), and lean production methods feature strongly in all aspects of the work of this company. Currently all the team leaders and the production managers are involved in a diploma of competitive manufacturing systems.

In the next section, we present and discuss one kind of literacy and numeracy 'event' that we observed at Hearing Solutions within one of the production teams. The term literacy or numeracy 'event' is used by social practice theorists to mean 'what people do with reading and writing: they are the uses of literacy, which can be observed and described' (Papen 2005: 31) and 'occasions in which a numeracy activity is integral to the nature of the participants' interactions and their interpretative processes' (Baker cited in Street, Baker and Tomlin 2008: 20). The data about the literacy and numeracy events consist of observational data that were collected by the researchers on the production floor as they watched the workers conducting their work activities, and interview data with the workers, their team leaders and managers.

Findings and discussion

All the production work of Hearing Solutions is located on the upper level of the company's two-story building. The production floor is organised so that information and various stages of the 'products' circulate through the different teams on the one floor before they are taken downstairs to the despatch team.

The literacy and numeracy event was both observed within the Modelling team that produces the outer shells of hearing aids that sit inside the ear canal. The team receives the order from the Data Entry team. The orders come on a standard Hearing Solutions order form with customer specifications recorded on it, a copy of the original order from the hearing aid clinic, and an impression of the client's ear canal. The impression is scanned by one member of the team so that a three-dimensional computer image is produced and stored on the computer system. Other members of the modelling team pick up the order details (the order forms of the company and the clinic, and the physical impression of the ear canal) and access the scan of the impression that has been stored on the system. The order number is used to identify which scanned image represents which order. When a team member picks up the order and the scanned image, they then work through the specifications of the order – determining what and how the electronic components will fit into the shell that they are modelling. The output of their effort is a three-dimensional image of the shell, and this is then sent to a laser 'printer' that 'prints' the silicon shells in batches. These shells are then cleaned, and handed over to the next team that inserts the electronic components into the shells and puts the finishing touches before they are sent to the Quality Assurance team and then the Despatch team downstairs.

The two literacy and numeracy events described and discussed below illustrate two contrasting ways in which literacy and numeracy are embedded in the work practices of the Modelling team members.

Techno-mathematical literacies at work

The workers who undertake the modelling of the hearing aid shell work in front of a large computer screen with a dual, special-purpose mouse that allows both hands to be used to manipulate the 3 dimensional image of the ear canal that appears on the screen. This image is used as the basis of the shell for the hearing aid, which fits in the ear canal. Manipulation involves pointing and zooming in and out of sections of the image, rotating the whole image, spatial awareness, and drawing contours on the surface of the image that may be trimmed to optimise the fit within the ear. The worker checks the order identification on the printed Hearing Solutions order form, and the identification on the image so that they are referring to the correct set of specifications for the modelling they are doing on the screen.

The specifications include which electronic components need to be fitted in the shell. The modeller clicks on icons of the electronic components (for example, battery, amplifier) that come up on the screen and drag them into the emerging shell on the screen. Observing the modellers work, we find that they are constantly rotating the shell and looking at it from different angles as they draw new contours and shape and reshape the shell, and insert and position and reposition the components. Then at some point they conclude the modelling, place the order forms and the ear canal impression together and put them back in the colour coded plastic container in which they came, and bring up an image of the ear canal of the next order. For us, the observers, the process of producing the computer image of the shell from the image of the ear canal to the modelled image of the shell, which can take approximately five minutes, appeared to rely on a high level of hearing aid knowledge and judgment - where to draw the contour and cut, how to position the electronic components within the shell, and when the fit was 'good enough'. It also appeared to rely on a high level of eye and hand coordination as the worker controlled the different functions of the mouse with the 'space ball' (rotation of the image, pointing, dragging and positioning components, highlighting segments, clicking icons). Even with a step-by-step narration from Bert one of the modellersI it was difficult for us as complete novices in this work to 'see' what Bert and his co-workers were 'seeing' in order to perform the various functions on the image. But Bert talked about the process as if it were very straightforward and simple:

> *As I said, the icons are down the screen; we just follow them in order. There's some that you've got to jump back and forward [in] different orders. You go down, then*

> *you've got to go back up and fix something later. But after a while it's just like playing a video game, basically.*

One of the team members who has worked in the company for twenty years, and in this Modelling team for about two years, said that the work -

> *... was easier if you knew to do the practical stuff, then later on to do the modelling on the computer. So more roughly you know how to do it on the computer. It's easier that way because if you were to start modelling without knowing how to do it with your hand, then it takes a while to learn.* (Stuart, Modelling team member)

The computer modelling software was only introduced in recent years (a *disturbance* to the existing activity system in CHAT terms) and several of the team members explained that having had prior manual moulding experience of producing the shells or having worked in the Assembly team where their job was to insert the electronic components in the shells, gave them a good feel for what was or was not a viable model when they were working on the computer. Not only did they need to exercise judgement on how small the shell should be made to accommodate all the components and be a comfortable fit in the ear, they also needed to know the interactions between the different components that influence '*where to position the modules and electronics and keep coils away from receivers so they don't cause feedback, and things like that*' (Bert, Modelling team member). They did not have a procedures manual to refer to; rather they relied on their knowledge and experience of manually producing the shells, or fitting the completed physical shells with the components in order to make judgements about how to optimise the model of the shell. They also said they sought help from others, and we observed the team members helping each other when they had an ear canal with an awkward shape, or where the specifications on the order did not seem to be suitable for the shape and size of the ear canal. Communication between the team members in these instances were verbal – a more experienced worker coming across to sit with their co-worker to problem solve the difficulty in front of the computer screen.

Although Bert, described the work of modelling the shell as being 'just like playing a video game', we saw this statement as a reflection of Bert underestimating the skill involved and also his highly developed expertise in this work, rather than as a description of anything easily learned or routine. As a literacy and numeracy event, the observable reading tasks included reading and checking the order number and specifications on the order form and on the screen to make sure they matched, and on occasions when the specifications did not seem to be able to be accommodated by the particular kind of shell that the order form indicated, going back to the original order form from the clinic, to see if there was an error in transcription from the clinic's form to the Hearing Solutions form, or if there was additional information that might give some insight into why a seemingly unsuitable shell type was being ordered. In some cases, where a solution to the problem could not be gleaned from the information available, the team member would ring the clinic.

Although three of the five interviewed computer modelling team members were overseas born and had learned English as an additional language, none of them identified having to read and write in English as a difficulty that they experienced in their work. One of the team members, Hong, described her background in the following way:

Hong: *I born in Vietnam, but when I arrive, I arrive in Perth. So I get married and then I move up here. … When I left Vietnam, I very small, about 11 or something, and then I live in a camp because I am a refugee, I live in a camp in Malaysia for like four and a half years. When I arrive here, I about 15 or 16 or something already.*
Interviewer: *Did you go to school at all in Australia?*
Hong: *Yes. Only six years only. When I come here, I was 16 or 17, they put me in year 9, you know, everyone in 12. I don't go much.*

As the interview transcript shows, Hong's spoken English is not always grammatically correct, and her pronunciation of some words required us to listen closely in order to understand what she was saying. However, there was little difficulty for us in understanding her spoken English. She explained how she negotiated the reading demands that she encounters in her modelling:

Researcher: *Is the reading difficult?*
Hong: *No, because everything, the word they using in hearing aid is easy.*
Researcher: *Because it's not your first language, is it?*
Hong: *I just pick up….Yes. If sometime too much English, if I cannot understand, I come and ask the team leader and say, what the meaning of this? Sometime they use the meaning I understand. If I don't understand, I go ask someone else.*
Researcher: *When there are mistakes, what are some of the reasons that people make mistakes?*
Hong: *The reason, the most, they don't read the paperwork properly. When you read step by step, you don't make a mistake. Or sometime you distracted by noise or something from people or something, sometimes you want to put something on the shelf and then you hear people over there talking, and you look and then you forgot this.*

Although these sources of errors were identified by Hong, the actual error rate for the team (that is recorded as part of the workplace procedure) is negligible. Hong, like the other team members that we interviewed, had an understanding of the importance of what she had to read, and that paying close attention to the specifications on the order form was a critical part of ensuring that mistakes were not made. Hong's reading practice is part of the core activity in which she and her team members engage everyday as part of their work.

Although, as the team leader and all of the team members explained, each hearing aid shell is unique because each ear canal is unique, all of the team members follow the same procedure when they receive a new order to work on. The steps in the process and the order in which they are performed are partly determined by the technology and the production stages (for example, scanning the impression, checking the scan is complete, iteratively shaping the model and fitting the components). There are other steps that have come to be agreed as 'good practice' by the team such as ways to minimise errors (checking the match between order id on the form and on the scan, checking the specifications have been reproduced accurately from the order forms to the screen). The team members helping each other both in the technical aspects (for example, 'there doesn't seem to be enough room to fit this component'), and in the literacy demands (for example, 'I can't read the clinician's handwriting', or 'what does this word mean') are practices of this community of workers that have become accepted and valued as part of the way they do things.

Examining the activity from a numeracy perspective, it is not easy to articulate exactly what numeracy is involved. There are no explicit operations with numbers (except to check whether the order number on the order forms match the order number on the screen). But much of the modelling activity is based on the three dimensional visualisation and modelling software. The contours that are drawn, and the sections that are cut away from the original image of the ear canal are not based on a set of measurements or identified positions that are provided to the worker. The worker needs to think about how the hearing aid will sit within the ear canal, because if it is too tight, or has a sharp corner, it will be uncomfortable; if it is too loose, it will fall out. But because every ear canal is different – in dimensions and shape, there is no in-built formula that tells the worker that they have the size just right or that they have cut away too much. They have to apply their knowledge of how hearing aids sit in the ear, with all the different curvatures and changes in diameter along the length of the canal. One computerised tool that Bert described, which assists them in positioning the components is the 'green colour': '*if the components are green that means they're okay. They're not squashed together, they're not going to cause feedback and things, and there's adequate room for the assemblers to put the physical in reality components inside the shell*'. In view of the kinds of resources that the workers use to complete their modelling task, it may be more appropriate to identify this modelling activity as a techno-mathematical literacy event, rather than as a numeracy or literacy event. The computer makes the mathematics that is embedded in the software to produce the three-dimensional images invisible both to the user (the worker) and to any observer of the work being undertaken to produce the image. But another aspect of mathematics or numeracy that is rendered invisible is the mental processing taking place in the worker's mind - for example, estimating how much to cut away, how closely the components can be placed, spatial awareness and the association between the three dimensional computer image and the material shells and the finished hearing aids with which they are familiar. The notion of the 'invisibility of mathematics at work' has been discussed by Hoyles et al (2010 and other authors (Coben 2001, Wedege 2010, Williams and Wake 2007), and as they point out, 'invisibility' does not equate to 'absence'.

The modelling work involves 'reading': the specifications on the standard company order forms, and the different order forms from the clinic, some of which may be handwritten by the clinicians. The workers need to be able to 'read' the computer icons to recognise which icon is for which component. The worker needs to be able to 'estimate' the fit of the shell within the client's ear canal. The worker produces a piece of digital 'text' that is the computer model of the shell, that is 'read' by the printer and printed out in the three dimensional material (silicon) form. But the computer model remains as text, which Bert explained might be referred back to by a team member trying to fit the electronic components in. If they cannot see how the components are going to fit, they can bring up the computer image of the shell with the components positioned in the way their colleague from the modelling team placed them. These images serve the function of a 'boundary object' between the Modelling team and the Assembly team, to solve some of the problems that occur in assembling the hearing aid.

A team member producing a computer model of a hearing aid shell can be represented as a subject within the activity system in Figure 2. Each of the team members allocated to doing modelling work on the day produces a number of models each day, and they are all unique. However, the way in which the modelling work is carried out by the team members follows certain 'rules' defined both by the technical necessity of undertaking certain steps in a certain order and in certain ways, and also by the cultural practices that have been established within this team, or the 'community' of workers who share the knowledge and expertise of modelling hearing aid shells. There is an established 'division of labour' in this community, for example, those who do the scanning of the impression, others who perform the computer modelling, and still others who check and sort the shells when they are printed, before they are sent to the team that will fit the electronic components into the shells. Both symbolic and material artefacts or 'instruments' including the order forms, the computer images of the ear canal, the computer modelling software and specialist mouse mediate the production of the shells from the client's specifications.

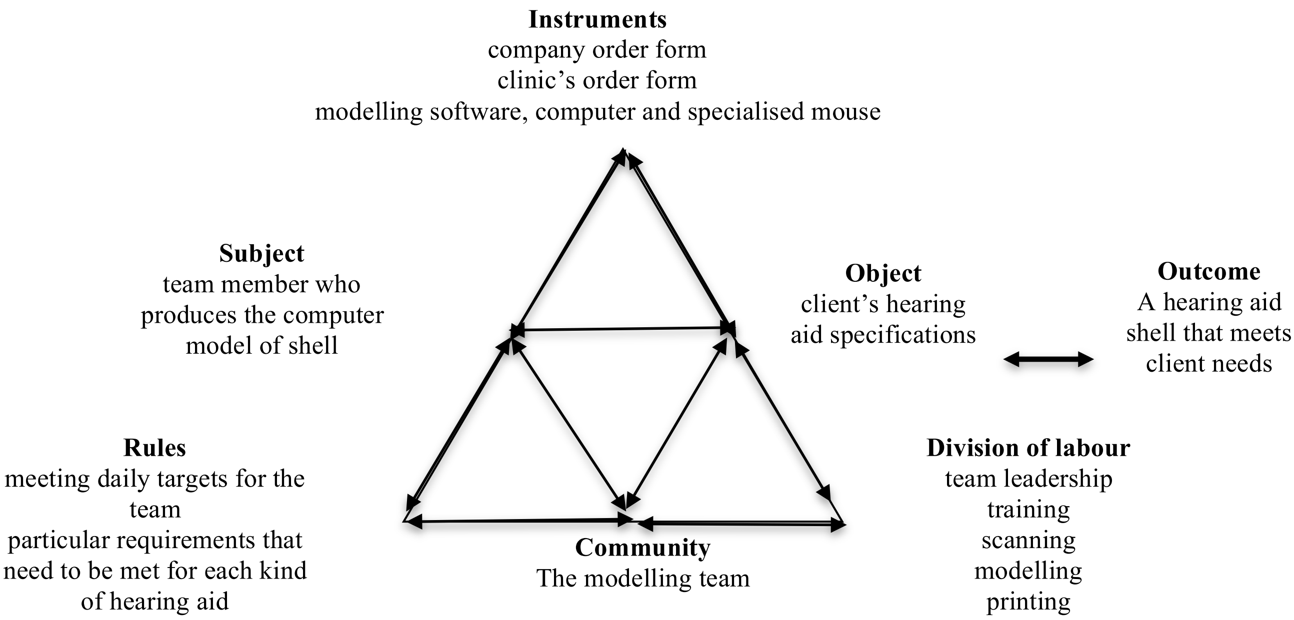

Figure 2: Modelling as an activity system

A team member producing a computer model of a hearing aid shell can be represented as a subject within the activity system in Figure 2. Each of the team members allocated to doing modelling work on the day produces a number of models each day, and they are all unique. However, the way in which the modelling work is carried out by the team members follows certain 'rules' defined both by the technical necessity of undertaking certain steps in a certain order and in certain ways, and also by the cultural practices that have been established within this team, or the 'community' of workers who share the knowledge and expertise of modelling hearing aid shells. There is an established 'division of labour' in this community, for example, those who do the scanning of the impression, others who perform the computer modelling, and still others who check and sort the shells when they are printed, before they are sent to the team that will fit the electronic components into the shells. Both symbolic and material artefacts or 'instruments' including the order forms, the computer images of the ear canal, the computer modelling software and specialist mouse mediate the production of the shells from the client's specifications.

The literacy and numeracy, or techno-mathematical literacies that are involved in the modelling work is highly specialised and embedded in the very specialised activity in which members of the team are involved. Some of the skills that are exercised by the workers in their modelling work would be difficult to recognise in the ways literacy and numeracy are described in some of the conventional, skills based frameworks of literacy and numeracy such as the *Australian Core Skills Framework* that 'has been developed to facilitate a consistent national approach to the identification and development of the core skills in diverse personal, community, work, and education and training contexts' (Commonwealth of Australia 2012: 2). Nor can the literacy and numeracy, or techno-mathematical literacies required in the modelling work be understood entirely as individual abilities or skills. Although each worker picks up a share of orders and takes responsibility for the production on the models for each of these orders, the judgement that they exercise when they perform the modelling is based on their own as well as their colleagues' experiences and knowledge of hearing aid characteristics and past and current production processes. The knowledge base is collectively developed and appropriated.

Conclusion

Based on our preliminary data, this paper has illustrated how CHAT can be used to examine and interpret literacy and numeracy as embedded practices within a workplace. The particular literacy and numeracy event that this paper examined illustrates how CHAT can help to uncover the social, cultural and historical nature of work practices, and consequently how there can only be limited understanding of the work if viewed and analysed purely from any objectified assessment of individual workers' skill levels.

Although the findings in this paper are preliminary in relation to our research project, they begin to suggest possible discord with the prevailing policy discourses about literacy and numeracy in and for work. All except one of the workers profiled in this paper have had any post-school qualifications prior to working at Hearing Solutions, and three of the workers are overseas born with varying fluency in spoken English, and yet they have shown competence and ongoing learning in a highly specialised and technological workplace. The CHAT analysis employed in this paper points to the multiple resources – tools, division of labour, rules of the community of practice of the team - that are integral and specific to the work play important roles in enabling the workers to learn and perform in their work.

Acknowledgement

Funding and support for this project was provided by the Australian Government Department of Education, Employment and Workplace Relations through the National VET Research and Evaluation Program managed by the National Centre for Vocational Education Research. The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Australian Government, State and Territory governments or NCVER

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