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Mind the Gap: Activity Theory and Design

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ABSTRACT
This paper describes the application of the Activity Theory framework to the analysis of work practices in an organisation, to inform the design of a computer system for supporting collaborative learning in the workplace. A study involving the analysis of an organisation and using Engeström's expanded triangle model of human activity [5] is described. A methodology developed during the study for breaking down the extended triangle and applying it is given, together with practical examples. The paper concludes by highlighting strengths and weaknesses of the model, and suggests a number of refinements for its practical application.

Keywords
Activity Theory, Human-Computer Interaction, Organisational Learning, Computer Supported Cooperative Work, Computer Tool Design.

INTRODUCTION
The inspiration for this study came from the consideration of the use of theories in Human-Computer Interaction (HCI) to inform computer tool design due to the perceived 'gap' between theory and design. The paper describes an attempt to apply Activity Theory (AT) to the problem of computer tool design as a way of narrowing this gap using Engeström's expanded triangle model. The paper begins by presenting an overview of issues in HCI that led to the consideration of the use of AT ideas to guide computer tool design [15]. A brief introduction to AT is then given, followed by discussions on the method used to apply it in this study. This is followed by an outline of findings, which highlights representational and methodological difficulties in applying the expanded triangle model that would need to be addressed if it were to be incorporated as a technique for analysing socially embedded computer tools. The paper concludes by proposing a structured approach to guide the use of the triangle model by introducing a notation structure to motivate questions to be asked when analysing an organisation and aid the identification of potential contradictions.

Motivation for AT
Researchers in the field of HCI have long strived to develop computer tools that are not only usable, but more importantly useful in the sense of assisting the user to satisfy desired goals when performing tasks [7, 16]. In addition, the recognition of the complexity of human information processing, which draws from contextual issues in the environment has prompted researchers in this area to seek additional guidance from other fields [2, 9, 11]. This, together with the realisation of the importance of the context in which a computer is to be put to use, mainly due to the works of Nardi [15] has led to an increased interest in AT. The effect of this increased interest in AT has been to prompt a search for ways of applying AT in order to use it to improve computer tool design. Although, AT has already been used to study work practices [3, 6, 12] there still exist some concerns regarding its application, which needs to be addressed. Some of these concerns raise questions about how much of the theory does one need to know in order to be able to use AT effectively? Other concerns relate to the lack of a standard method or guidelines for applying AT. This study represents an attempt to address these issues through the operationalisation of AT in an organisational context using the expanded triangle model.

Brief Background of Activity Theory
Vygotsky originally introduced the idea that a human being's interactions with his or her environment are not direct but are instead mediated through the use of tools and signs [20]. This notion is usually represented using what has come to be known as the *basic mediational triangle* model of human activity or simply the *activity system* [11] as depicted in Figure 1.

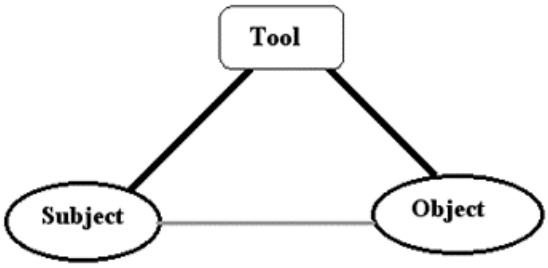

Figure 1. Basic Mediational Triangle

However, the fact that human activity tends to takes place in a social and cultural context prompted Engeström [5] to introduce an expanded version of the activity system in order to reflect the collective and collaborative nature of human activity. The *expanded triangle model* incorporates the community and other mediators of human activity, namely *tools*, *rules* and *division of labour*. The different components are shown in Figure 2 and explained below.

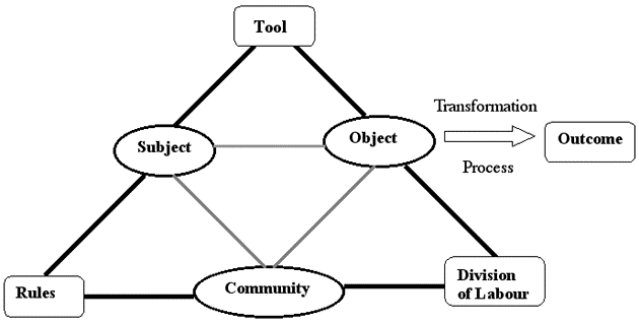

Figure 2. Expanded Triangle Model

Components of the Expanded Triangle Model

The '*Subject'* component of the model portrays both the individual and social nature of human activity through the manipulation of tools in order to satisfy desired objectives. The subjects' relationship with the object or objective of activity is mediated through the use of a tool.

The *'Tool'* component of the model reflects the mediational aspects of human activity using both physical and conceptual tools. A tool could be something as straightforward as a hammer or a spanner, or it may be something much more abstract, such as language. Physical tools are used to handle or manipulate objects whilst conceptual tools are used to influence behaviour in one way or another. The tool component of the triangle helps to address the notion that all human activity involves the use of tools.

The *'Object'* component portrays the purposeful or *objective* nature of human activity that allows individuals to control their own motives and behaviour through the manipulation of tools. The objective of an activity therefore forms the basis for distinguishing the various sub-activities that may exist within the main activity system.

The *'Community'* component of the model puts the analysis of the activity being investigated into the social and cultural context of the organisation or environment in which the subject operates. This notion reaffirms the suitability of AT to the study of work practices in an organisational context.

Other than the tool component discussed earlier, the mediational aspects of the model also incorporate the *'Rules'* and *'Division of Labour'* components. The *rules* component highlights the fact that within a community of actors, there are bound to be rules and regulations that affect in one way or another the means by which activity is carried out. These rules may either be explicit, or implicit, for example, cultural norms that are in place within a particular community. The *division of labour* component refers to the allocation of responsibilities and variations in job roles of the subjects as they carry out activity in the community.

The Activity System

The activity system incorporates all the components of the expanded triangle model. This represents a model of human activity in which activity is taken as the basic unit for analysing what people do. Kuutti [11] defines activity as a form of doing that is directed towards the fulfilment of an object. The term "*objective*" will be used in this paper instead of the original term "*object"*.

Activity Theoretical Approach to Tool Design

The ideas presented in AT enhance and extend the practical concerns of tool usage, which are traditionally addressed by the HCI discipline by linking the design solution to socio-cultural and psychological aspects of the tool user. This approach highlights the importance of the tool user's cultural behaviour revealed during tool usage. It seems to be the view that by analysing activity in context, using this framework, the computer tool developer can fully account for the complex and intertwining issues that affect the usefulness of the computer tool through its design.

OPERATIONALISING ACTIVITY THEORY

Although the ideas presented in this framework sound promising by providing a much-needed common vocabulary for describing human activity, AT does not provide a prescriptive method for putting these ideas into practice [15]. The lack of a standard method for applying AT could be attributed to the fact that the framework itself is continuously evolving. As a result, the framework has been applied in various ways in different contexts. *This flexibility has introduced difficulties in replicating, comparing and criticising the approaches taken to applying Activity Theory.*

In order to generate a workable method for investigating such a complex framework in relation to tool design two

approaches were considered. The initial idea was to select suitable concepts from AT that were deemed relevant to computer tool design. The key deciding factor here was the fact that the selected concepts should be able to guide both the data gathering and analysis processes and, transfer results into a design representation with structure and continuity. The importance of structure and continuity in the approach taken meant that this initial idea was rejected in favour of the expanded triangle model based on Engeström's conception. Engeström's expanded triangle model of activity seems to capture those concepts from AT that are relevant to the analysis of work practices and tool design, whilst giving a structured approach to the analysis. Engeström's model appeared to be an obvious candidate as it had already been applied to the study of technology and work practices [3, 6, 12], but the methodology for its application had not been clearly articulated. It was also believed that using this model to investigate human activity would put the study into the social and cultural context of the community whilst paying attention to the mediating aspects of that activity through the tool, rules and division of labour components.

In order to put AT ideas into practice using the expanded triangle model, the project employed a case study approach to examining work practices in an organisation where a computer system was to be introduced to support collaborative learning activities.

What is organisational learning?

As the organisation was being analysed to motivate the design of a computer tool to support learning while working, the concept of organisational learning is briefly introduced.

Organisational learning could be described as an activity that occurs mainly in a community of practice [13] with objects directly linked to the work activity. It tends to be informal and responsive in nature, while drawing from the social and cultural context of the community in which activity occurs [1, 17]. This kind of learning also exhibits social and cultural aspects due to the mutual bonding which takes place whilst engaging in collective and collaborative activity. The informal nature of organisational learning raises the need to address the consequences of formalising the learning activity through the introduction of a computer tool, since the introduction of such a tool usually changes the work culture. The cultural aspect of organisational learning therefore needs to be addressed in order to design tools which support it effectively.

The Organisation

The case study organisation used in this study operates in the industrial computing sector. It develops and maintains industrial computing systems for its customers all over the world. Part of this maintenance involves rendering continuous customer support on products sold using various means. The organisation was looking to promote organisational learning within the theme of rendering customer support. This was to be achieved through the sharing and re-use of knowledge about resolving customer problems amongst workers. They recognised the important role that a computer tool may play in the

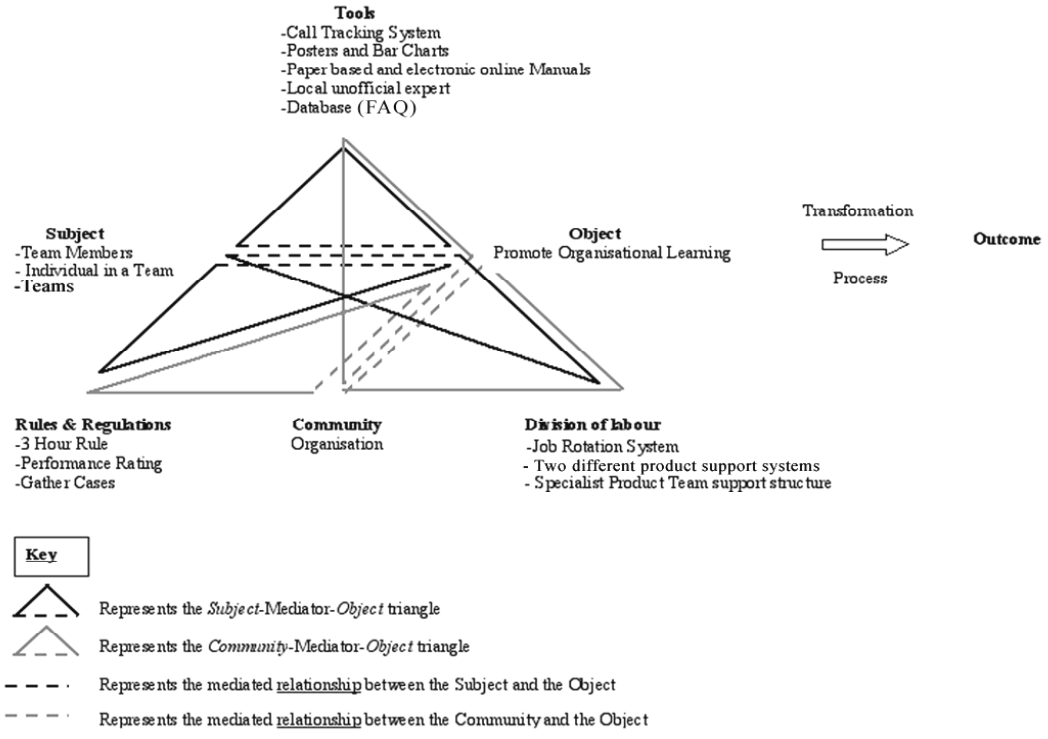

Figure 3. Organisational Triangle

management and co-ordination of knowledge sharing activities, which may eventually, result in the promotion of organisational learning.

Typically, an organisation can have many different objectives, for example organisational learning, productivity, profit making etc. This paper focuses on the organisation's objective of promoting organisational learning.

About The Study

The study began by mapping the expanded triangle model (Figure 2) onto the case study organisation to produce the activity system of the organisation as shown in Figure 3. Two key relationships were then identified crucial to the understanding of the means by which activity occurs in the case study organisation as follows:

- The relationship between the *Subject* and the *Object* or *Objective* of activity.
- The relationship between the *Community* and the *Object* or *Objective* of activity.

These two relationships were then examined in terms of current mediators, namely: *Tools*, *Rules* and *Division of Labour*. The relationship that exist between the *Subject* and the *Community* doesn't need to be considered explicitly as it reveals itself through the *Rules* and *Division of Labour* that are in place within the organisation. This process resulted into the production of a 'broken-down' triangular representation of the organisation's activity system showing sub-triangles that make up the organisation's main activity system as shown in Figure 3.

The Activity

For the purpose of the study, the main activity was identified as that of learning while working.

The Objective

The objective or purpose of this activity was identified as that of promoting organisational learning.

Subjects

The subjects involved in this activity can be classified in terms of a single individual working on their own, or a group of individuals working together in a team setting supporting a particular product, or a team working in collaboration with another team to provide support on the same product.

Mediators (Tools, Rules, Division of Labour)

The organisation already had in place several mediators to support the activity of learning so as to satisfy the objective of promoting organisational learning. These mediators included the use of a computerised Call Tracking System (CTS) *(Tool)*. The CTS was used to trace and monitor the progress of a call from the first time a case was received from a customer, right up to the time the problem was resolved. The CTS incorporated features for identifying the person dealing with the case, the status of the case, and also the predicted duration for resolving cases.

Online and paper based manuals *(Tools)* were used as an information resource for staff to refer to when resolving cases.

The organisation employed two different product support systems *(Division of Labour)* for resolving cases, a fast track system for dealing with pre-paid cases charged on a higher rate and a basic rate system charged at the usual low rate.

A '3 hour rule' *(Rules)* was introduced for dealing with fast track cases, as these had to take priority over basic rate cases. Basic rate cases had no fixed time on the duration for resolving them.

A database *(Tool)* of frequently asked questions (FAQ) together with answers was being developed as a way of encouraging workers to share experiences from previous cases. Workers were required to identify and gather suitable questions and answers from their workloads for transferring to the database, whilst carrying out normal duties.

In the meantime, the organisation had also introduced the use of a performance rating system *(Rules)* so as to monitor both individual and team performances against targets. This performance rating system used bar charts *(Tool)* as performance measures. The bar charts were published on a weekly basis and used by management to determine the productivity of an individual for the purpose of promotion. Management also used the bar chart performance measures to determine the productivity of a team for the purposes of allocating responsibilities when deciding on which team should support which product. The bar charts showed the total number of problem cases received, the number of cases resolved, the number of cases pending, the number of cases targeted, and the category of cases showing whether they were priority or basic rate cases.

Each team normally specialised in supporting a single product *(Division of Labour)*.

A job rotation system *(Division of Labour)* was in operation to allow workers to familiarise themselves with duties of other teams supporting different products from theirs.

There was also a work cultural norm of consulting a local unofficial expert *(Tool)* within the team when faced with a difficult case. This unofficial local expert would be someone recognised by fellow workers as someone willing to assist once consulted.

Data Gathering

The data gathering process used the 'broken-down' activity system of the organisation shown in Figure 3 to

guide the generation of a *notation structure* (see Figure 4 below).

The notation structure was then used to aid the formulation of suitable questions to ask during the interview process. In addition, some of the questions generated were also used as checklists or pointers to what to look for during the observational study. The introduction of the notation structure also helped to manage the sub-triangles of the main activity system of the organisation through their link and focus on the shared main objective, as shown in Figure 3.

Subject	–	Tool	–	Object
Subject	–	Rules	–	Object
Subject	–	Division of Labour	–	Object
Community	–	Tool	–	Object
Community	–	Rules	–	Object
Community	–	Division of Labour	–	Object

Figure 4. Notation Structure

In order to apply this notation effectively, rules of thumb were introduced as follows:

- Each pattern of the notation structure should consist of a doer or an actor represented by either the *Subject* or *Community* component of the triangle model.
- Each pattern in the notation structure should have a mediator represented by the *Tool*, *Rules* or *Division of Labour* components of the triangle.
- Each pattern should consist of the O*bjective* or motive for engaging in activity.

The introduction of this notation structure also helped to introduce a structure for gathering data using the organisation's activity system. This was achieved through the generation of questions that were specific to a particular notational combination, giving a complete triangular representation of a sub-triangle that could be identified within the main activity triangle system as shown in Figure 5. For example, the *Subject-Rules-Object* sub-triangle can be identified within the organisation's main activity triangle system, whose mediated relationship could be analysed in terms of the application of rules. Using this example, we could then generate and ask questions such as, "how do the rules affect the way that the subject satisfies their objective?" The notation structure shown in Figure 4 identifies six sub-triangles that together make up the complete main activity triangle shown in Figure 3. The mediator in each sub-triangle is also shown in the notation. Further examples of questions that could be generated using the notation structure at a more general level are given below. These correspond with patterns in the notation structure shown in Figure 4.

- What *Tools* does the *subject* use to satisfy the *objective* and how?
- What *Rules* affect the way the *subject* satisfies the *objective* and how?
- How does the *division of labour* affect the way the *subject* satisfies the *objective*?
- How do the *tools* in use affect the way the *community* satisfies the *objective*?
- What *rules* affect the way the *community* satisfies their *objective* and how?
- How does the *division of labour* affect the way the *community* satisfies the *objective*?

The above questions could then be translated in relation to the case study organisation as follows:

- How does the call tracking system helps the team(s) to learn from each other in order to promote organisational learning?
- How does the rule of identifying and gathering suitable cases while working affect the way the team learns so as to contribute to the promotion of organisational learning?
- How does the job rotation system affect the way the team(s) share knowledge about work in order to learn from each other as a way of promoting organisational learning?
- How does the use of a database with frequently asked questions and solutions applied help the organisation to promote organisational learning?
- Does the organisation's use of a performance rating system help to promote organisational learning?
- How does the operation of a product specialist team support structure affect the way the organisation promotes organisational learning?

Data Analysis

When analysing the organisation, as well as looking at how learning was mediated in a work context, the analysis also investigated how the learning was hindered through the use of these mediators and also other forces in the organisation.

The qualitative data gathered was then analysed in terms of AT using the notion of *contradictions*. According to Kuutti [11], contradictions come to light through problems or breakdowns *within* and *between* the activity systems. Engeström [6] emphasises the importance of contradictions in understanding how an activity system works. He presents the view that contradictions help to identify problematic areas whose investigation is necessary for the purpose of understanding what is

happening in the activity system. He also argues that contradictions are a driving force for change and constitute the basis for learning and change (see also 3).

Figure 5 shows how the case study questions helped to identify contradictions in the organisation's activity system. This was achieved by mapping notations of the sub-triangle being focused on, onto the generated case study questions. The questions in turn helped to identify areas of contradiction in the organisation's activity system. For example, by looking at the *Community-Rules-Objec*t sub-triangle questions in Figure 5, it is possible to see that by asking the question about the organisation's regulation of using a performance rating system, it is possible to identify two areas with contradictions. The first one could result from the use of 'Bar Charts' whilst the second one could be result from the team's work cultural norm of seeking help from the 'Unofficial Local Expert'. The identified contradictions are discussed in detail in the section that follows below.

Contradictions identified

Contradictions were identified *within* the internal learning systems (sub-triangles) and *between* the internal learning systems and other forces in the organisation as follows:

- Internal contradictions identified *within* the 'Rules' component as a result of the introduction of the rule 'performance rating' and rule 'gathering of FAQs'.

The organisation's monitoring of both individuals and team performance through the use of weekly bar charts seemed to have created a competitive work culture. In this competitive work culture, workers were concentrating on improving their own performance ratings which meant resolving as many cases as possible. On the other hand, the organisation's requirement that workers identify and gather frequently asked questions for the database was seen by workers as a 'side-track' which would slow down the internal activity of resolving as many cases as possible in order to improve ratings on the bar chart. This situation created internal contradictions within the internal activity of identifying and gathering cases for the database and that of resolving as many cases as possible so as to improve performance ratings on the bar chart for promotion purposes. Activity is made up of internal activities that are identified and differentiated by their internal objectives while contributing to the main activity's overall objective [11]. The internal contradictions identified in the sub-activities of this organisation affected the overall objective as it was difficult to find a suitable compromise between working quickly and efficiently to improve personal ratings, and finding time to reflect on work performance in order to gather questions for the FAQ database.

- Internal contradictions identified *between* the 'Division of Labour' and 'Subject' component as a result of the operation of a job rotation system that disturbed team culture.

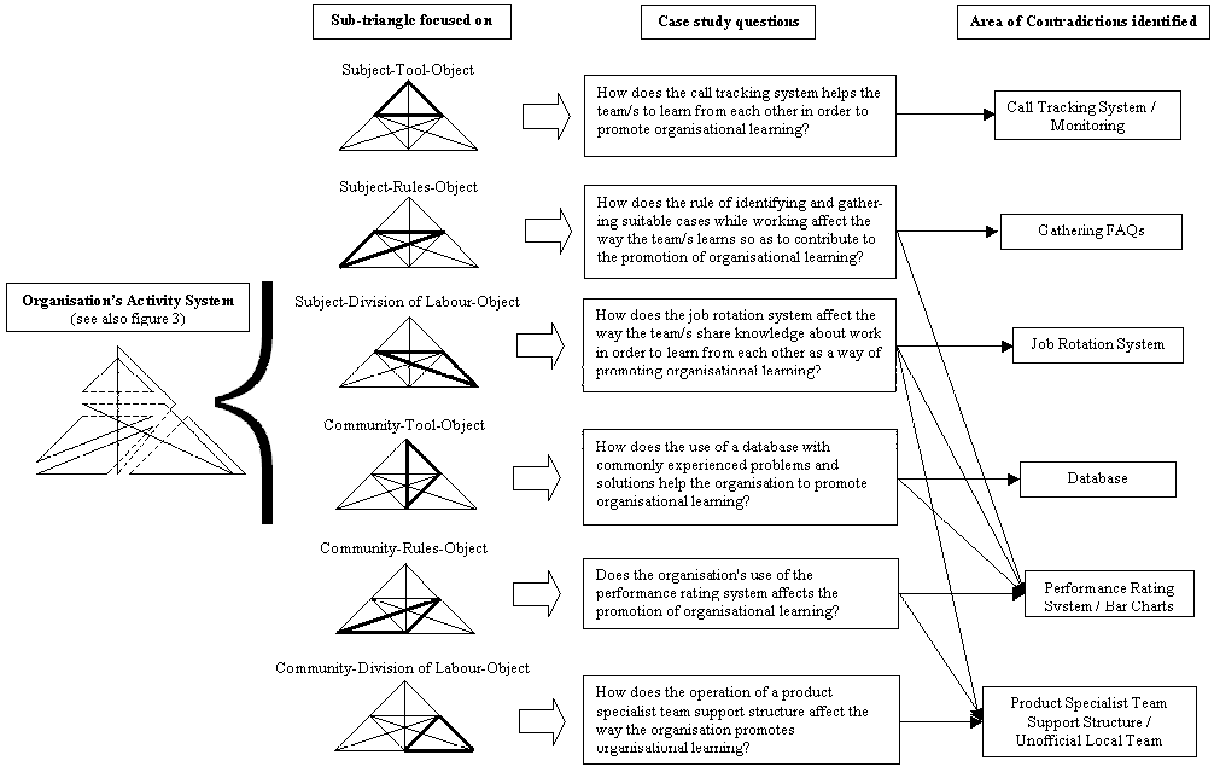

Figure 5. Mappings of case study questions onto processes in AT triangles.

More contradictions were identified as a result of the operation of a job rotation system that required workers to move around to other teams that were supporting completely different products. Different teams had different team work culture. The job rotation system was introduced in the auspices of familiarising workers with other duties as a way of sharing knowledge that presumably would lead to the promotion of organisational learning. The analysis showed that this job rotation disturbed the team social and work culture through the frequent re-organisation and re-allocation of responsibilities to accommodate the new person to join or leave the team. In situations where the unofficial local expert was suddenly moved to another team, the system introduced problems for him or her to re-establish him- or herself so as to 'fit in' with the new team. Even if the unofficial expert did fit in, there was no guarantee that he or she would command the same recognition on expertise. The competitive culture also seemed to discourage some local unofficial experts from spending too much time helping others when they could be concentrating on improving their own performance ratings by resolving as many cases as quickly as possible.

FINDINGS

The triangle model was found to be a useful starting point for interpreting and applying AT ideas in relation to technology design in an organisational context. However, weaknesses in representation and ease-of-use were identified due to the following observations.

- The first weakness was identified as a result of the difficulties experienced when attempting to represent time dimensions of temporary relations *within* and *between* the teams. While temporary relations may exist for a limited period, they tend to make important contributions to the transformation and transition of the activity. For example, the operation of a job rotation system meant that new temporary relationships and cultural norms were forged amongst team members. Those new temporary relations can affect the transformations of activity being observed. The problem experienced when dealing with this issue using the triangle model lies in the difficult in representing these temporal relations on the model in a way that is meaningful and re-usable. The layered approach to representing the transition of an activity introduced by Engeström [6] does not reflect the time span for the existence of these relations.
- The second problem was identified in representing contradictions on the model. It is difficult to represent several contradictions within a single triangle. Several researchers have invented and adopted their own methods for showing contradictions on the triangle model. For example, Engeström [6] uses a single stroke to indicate one or more contradictions. This multi-representational approach can be confusing to someone trying to re-use, compare or even criticise the method. The problem here is that it is difficult to tell whether the contradiction exists *within* a single system or *between* two systems. To get round this problem, this study has adopted a slightly different approach of showing the mapping of case study questions with arrows pointing to potential areas where a contradiction may exist (see Figure 5). This approach does not solve the entire problem but at least it gives a clear indication of how many contradictions can exist in a single area by simply looking at how many arrows are pointing to the same area from different sources.
- There seemed to be no guidelines for labelling the triangle model. This creates difficulties in determining the significance of the positioning of labels or components in relation to the transition of activity. It seems the labels have been put in similar positions by several AT researchers [6; 11] without proper explanation or rules to govern the labelling of the triangle. Differences in the labelling of the triangle usually result in variations in interpretations. Since the reasons for the fixation of the component labels in the position, where they are, are rather ambiguous, and insufficient explanation of the significance of putting them into those particular positions only increases the ambiguity, it was found difficult to work with the expanded triangle model as it is. In order to resolve this problem, the study introduced the mapping of the traditional expanded triangle model (Figure 2) on the case study, to generate a workable organisational activity system as shown in Figure 3. The idea of 'breaking down' the triangle proved to be very helpful when describing various interaction patterns occurring in the organisation's activity system.

CONCLUSION

AT has provided a useful framework for analysing human practices in context, but the lack of a standard method for applying it limits its current effectiveness. This in turn means that its full benefits may not be felt until this problem is resolved. Although the triangle model was found in this study to be a useful devise, representational and methodological weaknesses were identified that would need addressing if it were to be adopted as a tool for supporting the analysis and design of computer tools. Representationally, there are difficulties in showing temporal relations between items in the triangle. It is also difficult to identify contradictions when analysing activity without a good understanding of AT. There is need for a clear methodology on how to use the triangle to support analysis and design. This paper has introduced an approach to 'breaking down' the expanded triangle model through the use of a notation structure as a way of addressing some of the shortcomings listed above.

The study has proposed a structured approach to the operationalisation of the expanded triangle model by breaking it down using the notation structure (Figure 4). This notation structure is enhanced through the introduction of 'rules of thumb' which helps to highlight the sub-triangle being focused on during the analysis. The notation structure, can then to be used to generate questions that would assist in the identification of contradictions in the activity system being analysed.

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REFERENCES

1. Argris, C., and Schön, D.A., (1996) *"Organisational learning II: Theory, Method and Practice"*, Addison Wesley, Reading, MA, USA.
2. Bannon, L.J., (1990) *"A Pilgrim's Progress: From Cognitive Science to Cooperative Design,"* AI & Society, 4 ,4, Fall Issue, 1990, Pages 259-275.
3. Bødker, S., (1996) *"Applying Activity Theory to Video Analysis: How to Make Sense of Video Data in HCI.."* In Nardi, B.A., (1996) "Context and Consciousness: Activity Theory and Human-Computer Interaction," MIT, Massachusetts, USA.
4. Davydov, V.V., (1999) *"The content and unsolved problems of activity theory"*. In Engeström, Y., Miettinen, R., and Punamäki, R-L., (1999) *"Perspectives on Activity Theory."* Cambridge University Press, Cambridge, UK.
5. Engeström, Y., (1987) *"Learning by Expanding: An Activity-Theoretical Approach to Developmental Research."* Helsinki: Orienta-Kosultit Oy, Finland.
6. Engeström, Y., (1999) *"Activity Theory and individual and social transformation."* In Engeström, Y., Miettinen, R., and Punamäki, R-L., (1999) *"Perspectives on Activity Theory."* Cambridge University Press, Cambridge, UK.
7. Gilmore, D.J., (1995) *"Interface Design: Have we got it wrong?"* INTERACT '95: 5th IFIP International Conference on Human-Computer Interaction, Lillehammer, Norway.
8. Johnson, J.A, and Nardi, B.A., (1996) *"Creating presentation slides: a study of user preferences for task-specific versus generic application software."* ACM Transactions on Computer-Human Interaction, Volume 3, Pages 38-65.
9. Kaptelinin, V., (1996) *"Activity Theory: Implications for Human-Computer Interaction."* In Nardi, B.A., (1996) *"Context and Consciousness: Activity Theory and Human-Computer Interaction,"* MIT, Massachusetts, USA.
10. Kaptelinin, V., Nardi, B.A., and Macaulay, C., (1999) *"The Activity Checklist: A Tool for Representing the "Space" of Context."* ACM /Interactions, Methods & Tools, July 1999.
11. Kuutti, K., (1996) "Activity Theory as a Potential Framework for Human-Computer Interaction Research." In Nardi, B.A., (1996) "Context and Consciousness: Activity Theory and Human-Computer Interaction," MIT, Massachusetts, USA.
12. Kuutti, K., (1999) *"Activity theory, transformation of work, and information systems design"*. In Engeström, Y., Miettinen, R., and Punamäki, R-L., (1999) *"Perspectives on Activity Theory."* Cambridge University Press, Cambridge, UK.
13. Lave, J., and Wegner, E., (1991) "Situated Learning: Legitimate Peripheral Participation," Cambridge University Press, Cambridge, UK.
14. Lewis, C., Reiman, J., Brigham, B. (1991). *"Problem-centred design for expressiveness and facility in a graphical programming system."* Human-Computer Interaction 6:319-355
15. Nardi, B.A., (1996) *"Context and Consciousness: Activity Theory and Human-Computer Interaction,"* MIT, Massachusetts, USA.
16. Norman, D.A., (1998) *"The Invisible Computer: Why Good Products Can Fail, The Personal Computer Is So Complex, and Information Appliances Are the Solution."* MIT Press, Massachusetts, USA.
17. Nonaka, I., and Takeuchi, H., (1995) *"The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation."* Oxford University Press, Oxford, UK.
18. Orlikowski, W.J., (1992) *"Learning from notes: Organisational issues in groupware implementation,"* Toronto, Canada: Proceedings of Computer Supported Cooperative Work, Pages 362-369, ACM Press
19. Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., Carey, T., (1994) *"Human-Computer Interaction"*, UK: Addison-Wesley Publishing Company.
20. Vygotsky, LS, (1978), *"Mind in Society - The Development of Higher Psychological Processes."* Editors: Michael Cole, Vera John-Steiner, Sylvia Scribner, and Ellen Souberman, Harvard University Press, Massachusetts, USA.