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Visualization in Analysis: Developing ANT Analysis Diagrams (AADs)

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Abstract

This paper presents a novel diagramming approach which employs aspects of Actor-Network Theory (ANT) in the creation of ANT Analysis Diagrams (AADs). ANT is a socio-material approach which allows for the consideration of both human and inanimate entities in a social context. AADs provide a novel method for the analytical investigation of social situations, thereby both operationalizing elements of ANT and generating a visualization of a domain. It is the process of creating an AAD which is

crucial, focussing attention on the characteristics of the entities involved and the nature of the relationships between them, thereby supporting the analysis of qualitative social data. As this paper illustrates, AADs can be usefully applied to a wide range of social contexts and across scales, from the individual person, to groups through to broad social concepts.

KEYWORDS: actor-network theory, ANT analysis diagrams, data analysis, conceptual model, diagram, objects, relationships, visual, visualization

Introduction

This paper presents a novel method for the analysis of qualitative data, through visualization, using Actor-Network Theory (ANT) (Callon, 1986; Callon and Latour, 1981; Law and Singleton, 2005; Mol and Law, 1994). ANT is often used to support the investigation of the stages of development of a particular context (Fenwick, 2010). Here some concepts from ANT are applied in a diagramming approach called ANT Analysis Diagrams (AADs). These diagrams can be used to explore and develop an understanding of the interactions between, and influences of, elements in a social situation, supporting the careful consideration of relationships between them. By employing AADs an analysis of a context can be explored, and the diagrams can be considered to be an analytical device or tool. The creation of this tool can be seen as a way of operationalizing aspects of ANT but, more significantly, it provides a

visualization which could be useful to many qualitative researchers. As will be shown this method can be used to explore a wide range of social or socio-material contexts and can be employed to investigate issues of any scale: individuals, groups or concepts.

Whilst the AAD method is generic the examples presented are taken from a single research project: 'Why Computing?' and this paper commences by providing a brief summary of that project. Since the method is based on some parts ANT, its salient aspects are then described. Most particularly this will present the fundamental principle of ANT, object symmetry, and introduce three types of object. Having covered the relevant background the paper then moves to explain the notation and semantics of the novel AADs, presenting a number of illustrative examples. Aspects of AADs which could be perceived as weaknesses are considered and the paper concludes with some comments about the application of AADs.

The 'Why Computing?' project

The AAD approach to analyzing data was derived whilst undertaking an interpretive project entitled 'Why Computing?' and the examples presented here are drawn from it. This project was established to investigate the social processes which led students to study computing at university. It looked at the sources of influence on potential students and their perceptions. Most data was narrative in nature, arising

from one-to-one interviews and focus groups, held with existing students, school pupils considering their Higher Education options and university academics. Other forms of data were also collected, such as questionnaires and participant profiles (Payne, 2013), but the bulk was discussion transcripts.

The early stages of the data analysis were based on thematic analysis (Braun and Clarke, 2006). Data were coded and then categories and themes were derived, emerging from the coding. The AAD method which is the subject of this paper was used in parallel with those typical analytical processes, guiding them and being guided by them. It provided an analytical thinking aid.

This project originated from a desire to understand why a sizeable minority of HE computing students are surprised or dissatisfied by, or disengaged from, substantial elements of their degree course (Livesay et al*.,* 2003; Lovegrove and Round, 2005; McGettrick et al*.,* 2005). The project sought to gain an understanding of how they arrived in university. The main themes which emerged covered a broad range of concerns.

The image of computing as a subject and career option proved to be a very significant matter: its associated 'geeky' stereotype forming an overt deterrent. The process of choosing computing is understandably affected by whether pupils know what it is but it is common for them to believe it would follow-on from the computer-based work they do at school. In the UK, at the time of the project, this was called Information and Communication Technologies (ICT) and focused largely on the use of

computer applications. This project looked at sources of influence on how youngsters had gained their understanding, particularly how those who had an accurate perception had acquired it. The project also considered aspects of student engagement and relationships between students and their responses.

The project thus encompassed a significant range of issues, exhibiting a number of types of effect and influence. As will be shown the analytical method described here should be useful in a wide range of contexts in qualitative research, particularly where the aim is to explore the relationships between diverse elements. AADs are diagrams based on aspects of ANT, so before explaining the diagramming method it is necessary to summarize the salient aspects of ANT, primarily: symmetry, networks and the relevant object types.

Actor-Network Theory (ANT)

ANT is a socio-material approach which emerged from science and technology studies in the 1980's. It is generally attributed to Bruno Latour (Callon and Latour, 1981; Latour, 1993, 1999, 2005a, 2010), a sociologist and anthropologist, but was developed with fellow sociologists, particularly John Law (Law, 1999; Law and Hassard, 1999; Law and Singleton, 2005; Mol and Law, 1994) and Michael Callon (1986). It has evolved, various elements being used in various ways by authors, changing to such an extent that versions are sometimes referred to as post-ANT or

after-ANT. ANT has *'translated itself into something new, indeed into many things that are new and different from one another'* (Law, 1999:10).

ANT considers human agency, providing a way to view interactions between people. However it also allows for the power of objects (Latour, 1993) and the way in which the inanimate can influence social processes. ANT is thus *'concerned with the dynamic and simultaneous mutual influence of both the social and the technical'* (Díaz Andrade and Urquhart, 2010:353), allowing the investigation of the power which things can exert, affecting relationships.

The core principle of ANT is that all entities (or objects) in a context are potentially relevant to understanding it and they can, indeed should, be brought into its analysis. It is an object-oriented approach (Law and Singleton, 2005), considering all entities in the situation to be objects. It is a 'non-modern' philosophy, in that humans and non-humans are treated equally and the human elements are not privileged (Latour, 1993). This is an approach first used by Callon (1986): social, natural and inanimate objects are all treated in the same way, *i.e.* symmetrically. In a 'modern' philosophy entities would be categorized, grouped, into sets of like objects through a 'process of purification' (Larval Subjects, 2009:unpaginated). However ANT denies such distinctions and humans are not seen as being privileged. Humans just form some of the objects present in the problem domain.

However ANT is not quite as symmetrical as this suggests. Whilst ANT is generally regarded as a flat ontology, with all objects considered on an 'equal footing'

(Larval Subjects, 2009:unpaginated), of course some do have a greater impact than others. However this object symmetry caused difficulty with the acceptance of ANT, most particularly with the view that human entities must not be privileged. Additionally, the adoption of the term 'agency' in the context of inanimate entities led to critique based on the intentionality of human action (Fenwick and Edwards, 2010). Latour clarified his position:

> *'ANT is not, I repeat is not, the establishment of some absurd: "*symmetry between humans and non-humans*". To be symmetric, for us, simply means not to impose* a priori *spurious asymmetry among human intentional action and a material world of causal relations'* (Latour, 2005a:76).

Connections between the objects in a domain bring them together as a network. These connections are often termed associations (or relations or relationships) and represent any form of interaction or effect between the objects. The objects in a network are often referred to as actors, hence the name 'Actor-Network Theory', coined by Callon (1986).

Whilst objects are actors and act achieving effects, so too is the network itself. The network influences its wider context and, at that level, can be considered to be a single, composite actor. Also, actors can themselves also be considered to be a network and decomposed into a number of interacting 'sub-actors'. Thus whilst networks are actors, actors are also networks (Fenwick and Edwards, 2010; Latour,

2010): *'actor and network […] designate two faces of the same phenomenon'* (Latour, 1999:19). The more you want to understand an actor the more you have to look at its constituent network (Latour et al., 2012). In this way objects and their interactions can often be seen to be nested or hierarchical, with objects encompassing networks of others and the analyst having a choice of scale for consideration (Latour, 1996). In this way elements which may be considered to be object attributes at one level may be seen as interacting sub-actors at a lower level.[1]

The name Actor-Network Theory has been extensively critiqued (for example Latour, 1999). Here, there are two points which need to be made. Firstly, ANT is not a theory in any of the ways in which the term is usually employed (Hammersley, 2012). Rather ANT is a framework or approach which provides a way of viewing a problem domain: a sensibility (Fenwick, 2010). Secondly, the actors within a network influence each other and can change one another. Together they form a dynamic system of interacting objects which evolves over time, maybe reaching stability or maybe decaying and disintegrating.

Object symmetry and interaction are central tenets of ANT. Beyond this various authors have employed a range of concepts, expanding ANT in a number of directions. The account presented here is selective, focussing on aspects of ANT relevant to the creation of AADs. For much ANT research the processes involved in the development and maintenance of object networks, termed 'translations', are central (for example Callon, 1986; Latour, 2005a; Law, 1992, 1999), with ANT sometimes being referred to

as the '*sociology of translation*' (Callon, 1986). However these issues are not relevant here and will not be fully elaborated.[2]

The derivation of AADs adopts a categorization of objects as being immutable mobile, fluid or fire. Networks (and therefore objects) can reach a stable state termed, by Latour, immutable mobile (Law, 1992): *'something which moves around but holds its shape'* (Law and Singleton, 2005:335). They are objects which are stable, but not necessarily fixed and static. They can change their location or scope, as 'mobile' is intended to convey.

Some studies (such as Mol, 1999) found that an object can be very different in different contexts, the '*problem of difference*' (Law and Singleton, 2005:341). Specifically, something such as a medical condition can be enacted so very differently in diverse contexts such as medical departments, doctor's surgeries, laboratories, the community and so forth, that they exhibit '*ontological multiplicity*' (Mol, 1999:79). Sometimes these are most usefully treated as different, multiple objects, which co-exist (Dugdale, 1999; Law and Singleton, 2005). This multiplicity was sometimes considered to be epistemological, and the result of differences in perspective, with a single underlying reality (Law and Singleton, 2005; Mol, 1999). But these recent ANT studies pointed to the perhaps deeper understanding which may be gained by viewing them as separate objects.

In addition to apparently 'single' objects being multiple, not all objects are immutable and mobile. Some are 'fluid' in nature. They slowly change and, despite

having a permanence, are mutable.[3] 'Oxymoronically*, [a fluid object] is something that both changes and stays the same'* (Law and Singleton, 2005:338). These authors' example concerned initially-identical water pumps installed in Zimbabwe, which were subsequently subject to unique improvized repairs and gradually diverged in their design. In the social world very many objects have this fluid character. People and their unique relationships are subject to constant flux and change, even where there is apparent permanence.

The other type of object identified is the 'fire' object which has a randomness and unpredictability, such as is exhibited by an uncontrolled bush-fire. Different instantiations of an object may have different qualities present and absent, so called absent presences: *'absence, otherness, is integral to objects'* (Law and Singleton, 2005:349). The absence of fuel will extinguish or prevent fire but its presence does not guarantee fire: that depends on the introduction of a source of intense heat. Thus in different contexts a quality may, or may not, be present in a way which can seem to be random and unpredictable. However such messy situations are frequent in 'real world' contexts. Fire objects can be considered to be 'optional': they may occur in a specific example of a situation but they may not. Absent presences, fire objects, facilitate the investigation of such phenomena, allowing the exploration of meaning behind commonalities and differences. *'If the world is messy we cannot know it by insisting that it is clear'* (Law and Singleton, 2005:350). Thus objects can be considered to be fluid, immutable mobile or fire.[4]

ANT Analysis Diagrams (AADs)

ANT is not associated with any particular form of diagrammatic modelling, which seems curious for a framework which, in its very naming, calls on a visual metaphor. The nature of relationships in networks, 'bringing together' actors in pairings or other groupings, seemed to demand some diagrammatic representation. AADs, which are the subject of this paper, have been presented at internal seminars and to external experts and have been found to be accessible, being understood with little explanation.

Throughout research, including qualitative studies, there have been many diverse, and sometimes very creative, approaches to the visual presentation of empirical data or its analyses (for numerous examples see McCandless, 2009; Spence, 2001). Qualitative data analysis software often provides a range of visualization formats (for example ATLAS.ti, MAXQDA). Of course some ANT scholars have previously employed diagramming. Callon (1986) employed simple schematics. Venturini et al. (2014) created diagrams showing the issues raised at annual climate change talks and the scale of each country's involvement. Latour et al. (2012) created visualizations which showed the interconnections between authors, keywords and references in articles, allowing clusters of issues, stabilities and other relationships to be identified. Of course some of these presentation forms were created with, and supported by, specialist software drawing directly on the research data corpus. This

can allow, say, zooming in to reveal more detail or changing the central focus of a presentation (for example Venturini, 2012). Much of this work, whilst supporting the processes of analysis and interpretation (to varying degrees), is designed primarily for the presentation and exploration of data. Such visualization approaches may lead the researcher to new understandings but they are not designed to facilitate the representation of analyses or interpretations, nor do they mostly engage with the core ideas of Actor-Network Theory.

Silvis and Alexander (2014) have developed diagrams based on ANT, which they refer to as ANT Graphical Syntax (ANT-gs). ANT-gs, unlike AADs, focuses on the development of networks of objects and provides a notation which represents their changes and cross-influences. It employs aspects of ANT which relate to the translation stages of a network. Ponti (2012) combined ANT with ESA (Event Structure Analysis), also focussed on network translations, specifically considering event causalities. Events which were potentially causal during network development are identified by the analyst and a diagram of their sequence and relationships is created, supported by specialist software. Little attention is paid to the actors and their networks. The 'controversy-website' (Venturini, 2012) however, amongst its many social cartography facilities, provides actor-networks diagrams. These show actors, issues and the connections between them and, like AADs, consider objects in a network, at a point in time. However the AAD notation allows the analyst to focus in on the character, the nature, of objects and their relationships.

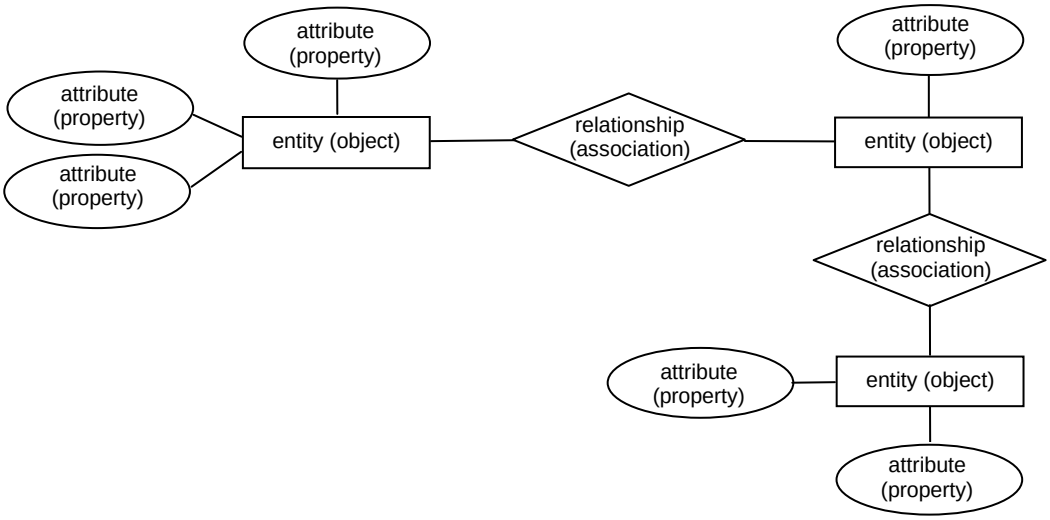


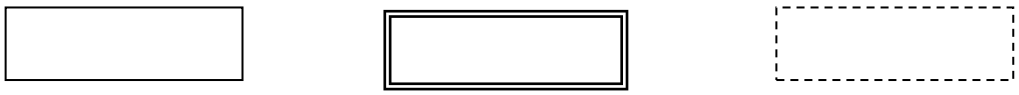
Figure 1: A vacuous ERD (or AAD)

The Notation

The description of an actor-network is redolent of an entity-relationship, which evoked connections to entity-relationship diagrams (ERDs): a standard database design technique in computing. Hence AADs were developed by the author as a variant of ERDs for use with ANT concepts. There are several styles of ERD diagram but the one which seemed most helpful here was the earliest, that defined by Chen in 1976 (Elmasri and Navathe, 2007), which permits the clear representation of the characteristics of entities. A vacuous example is shown in Figure 1. This shows three entities (objects, actors), with their associated attributes (properties), and the relationships (associations) between them. This arrangement can be seen as representing a small ANT network, in a novel, visual way.

Objects

The notation created by the author employed a different box style for each of the three types of object (fluid, immutable mobile and fire) which a network might contain (Figure 2). Solid lines are used for fluid objects; double lines immutable mobiles, which are fixed, and dashed lines for fire, absent-presence objects, which do not always exist and can be seen as being optional.[5] In addition to including associations between objects, as indicated in Figure 1, object properties can be represented as and when useful.



a fluid object | an immutable mobile | a fire object

Figure 2: ANT object notation

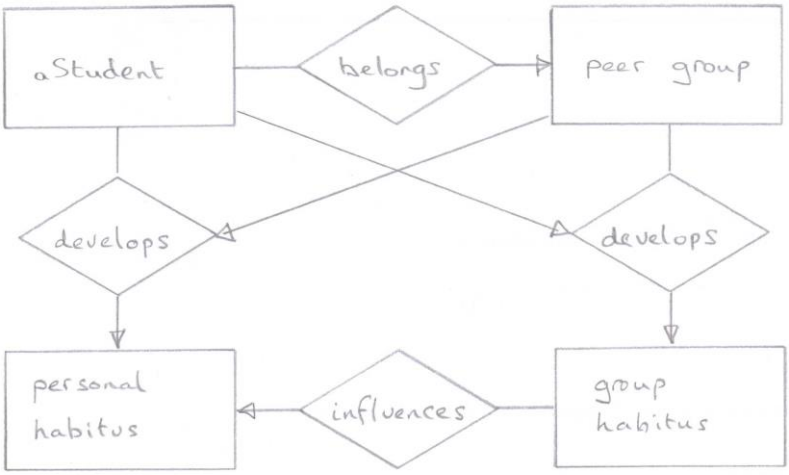


Figure 3: The development of habitus

[Insert figure 3]

The example AAD presented as Figure 3 shows the relationships between four of the objects involved in students developing their habitus (Bourdieu, 1993) in an academic context. (Since AADs are intended to be used as a device to support analysis, they have been left in a hand-drawn format to emphasize their working nature.) As the 'Why Computing?' project identified, a student develops a personal habitus but they are also involved in the development of a group habitus with their peer group. The process of creating this AAD required and supported the careful consideration of how these objects interrelated. This work was done alongside the derivation of categories and themes from the coded text, with these tasks informing

each other. An extract of the codes related to the peer-groups-and-habitus category is presented as Table 1. All four of the objects in this AAD will change and hence are represented as fluid objects. Most objects were found to be best presented as being fluid, as would tend to be the case when considering human or social elements.

theme: engagement **sub-theme:** disengagement – causes and manifestations	
category	**codes from text and ideas from sources**
peer groups and habitus	attendance, attitude to university peer group structure influences individual's agency (including attendance, effort); absenteeism may become a habit students are still developing, working out their norms and values; peer group norms influence the individual; group habitus guides the group's behaviours; an individual's social capital will affect how they influence their peer group peer pressure can affect an individual's attendance; peer 'gossip' can misinform

Table 1: Themes, categories and codes related to the development of habitus

[insert table 1]

The AAD in Figure 4 shows the seven objects revealed as being involved in the potential development of the appeal of computing. A student has a personal identity which affects how they perceive many things, including the cognate area of computing. Both this personal identity and their perception of computing, of course, directly affect

the appeal of studying computing. All these objects are fluid: they will change over time. The elements identity, perception and knowledge could alternatively have been represented as properties of the student object. However by presenting them as separate objects focus can be paid to their inter-relationships and influences.

[Insert figure 4]

The geeky stereotype often associated with computing in the UK is based, at least to some extent, on the reality of the profession and influences how potential students perceive it. That stereotype appears to be relatively resistant to change and has been represented as an immutable mobile to reflect its fixedness. The student also has knowledge of computing which influences objects in this network. This is informed by the reality of the profession but in turn affects how the individual perceives it. However the 'Why Computing?' project found that some students (who are either engaged in the process of deciding whether to choose to study computing or who have already enrolled on it) know very little, if anything, about the reality of the subject. Rather their choice-making was often based on mis-perceptions. This sometimes absence of knowledge is shown by presenting the knowledge object with a dashed box, as a fire object. Knowledge is sometimes present and sometimes not.

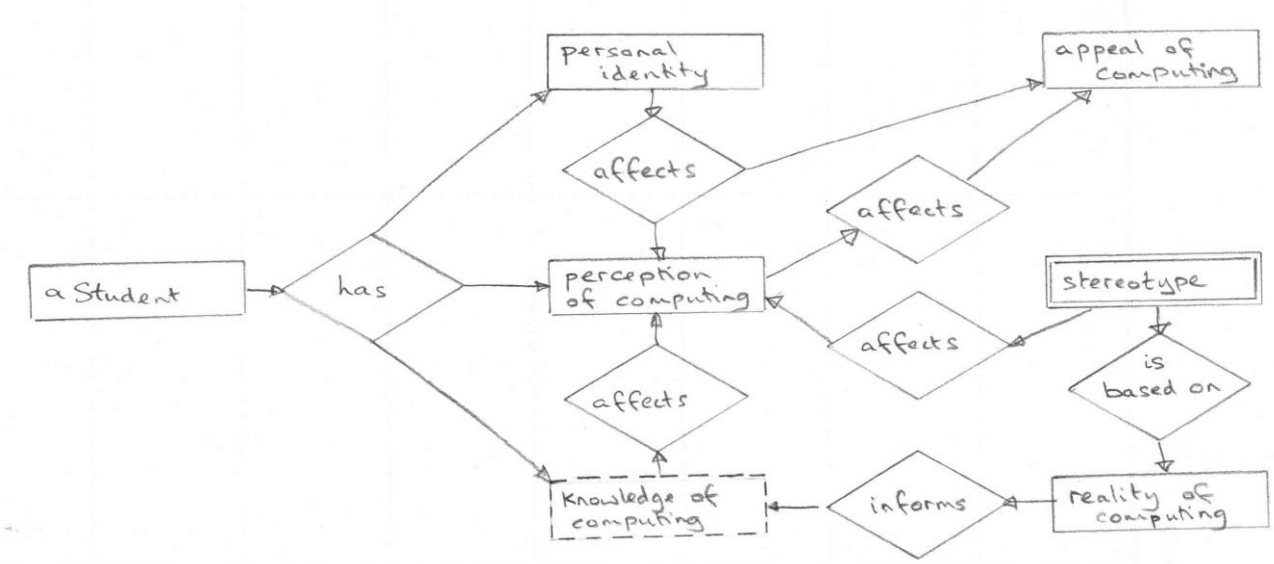


Figure 4: The formation of the perception of computing

Relationships

For some diagrams the nature of the relationships themselves was important. To present these, similar notations were developed for the lozenge-boxes using solid lines for most, reflecting the fluid ability of the relationship to change; double lines for those which are fixed and dashed lines for relationships which do not always exist and can be seen as being optional. Also, where it is useful to clarify the direction of influence, arrowheads can be added to the lines connecting objects to their relationships. As indicated earlier, AADs can also include a representation of object properties, where these are germane, and hierarchies of networks. Figure 5, which

considers how universities affect students' course choice, includes examples of many of these elements.

[Insert figure 5]

A pupil has properties which are significant in the context of the influence of universities' influence on their choices and therefore can be represented. These include their interests, the subject of their course choice and their developing university choices.

The content of a university course influences what is presented on the university website, in its prospectus and so forth. These can be seen as a sub-network, all collectively considered to be interacting elements of a 'university' network object. Salient properties of this complex object can be included, such as location and reputation. This sub-network object, of course, affects a pupil's choices through a number of mechanisms, such as their website and prospectus, which are designed to inform and advise on course choice. Some of these university-based features, such as Taster Sessions and Open Days, are designed to enthuse and inspire. The 'Why Computing?' project found that none of these features are always present in the influences on a particular pupil. Therefore both the 'inform and advise' and the 'enthuse and inspire' relationships are indicated as being fire and optional. They are

only sometimes present. Likewise, the Key Information Sets and university league tables, both of which can inform students, do not always do so and hence this association is also one of fire.

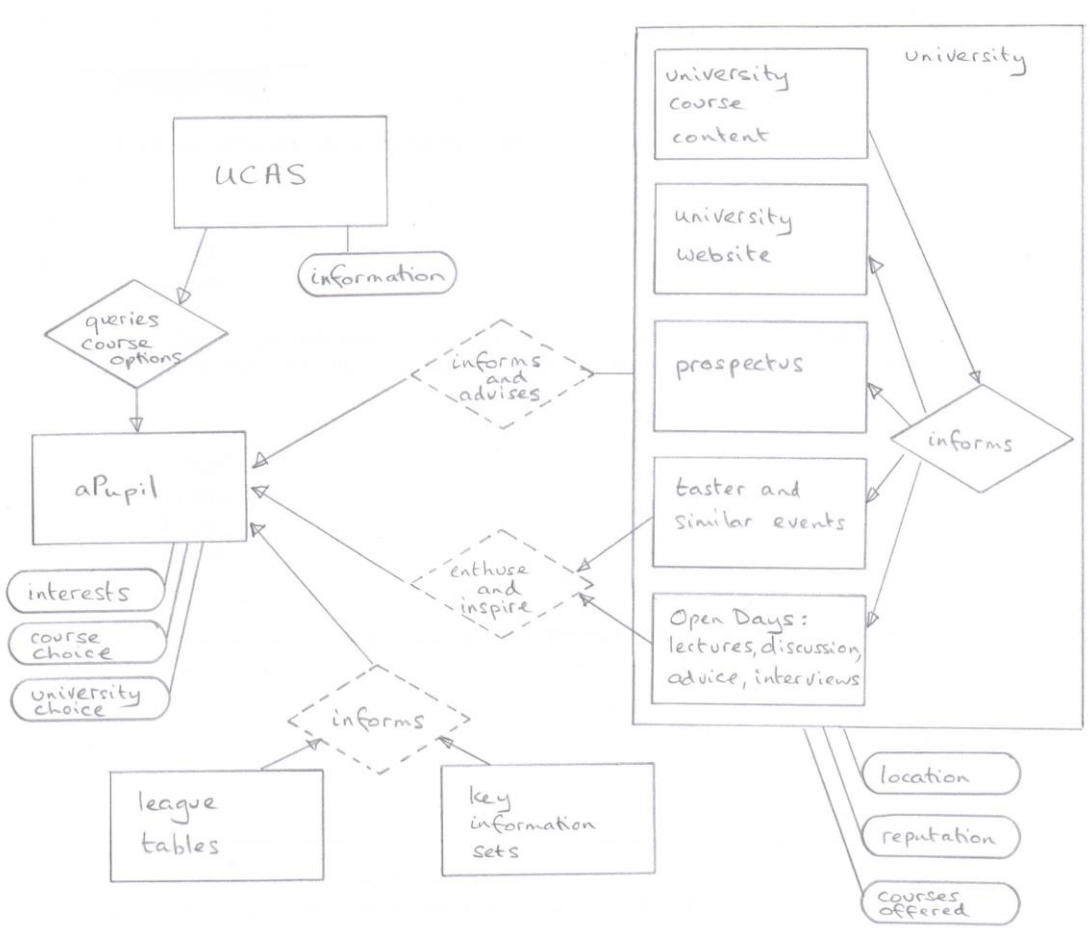


Figure 5: Role of universities in students' course choice[6]

Connectors

Sometimes the clearest representation of a situation can be created by indicating optionality on the connecting arrows, perhaps in addition to optionality indicated on the objects or their relationships. Figure 6 considers the factors which were found to influence student engagement. A student's engagement is often reflected in their attendance levels. However this is not always the case and that optionality has been indicated through the dashed notation of both the relationship lozenge and the arrow connector.

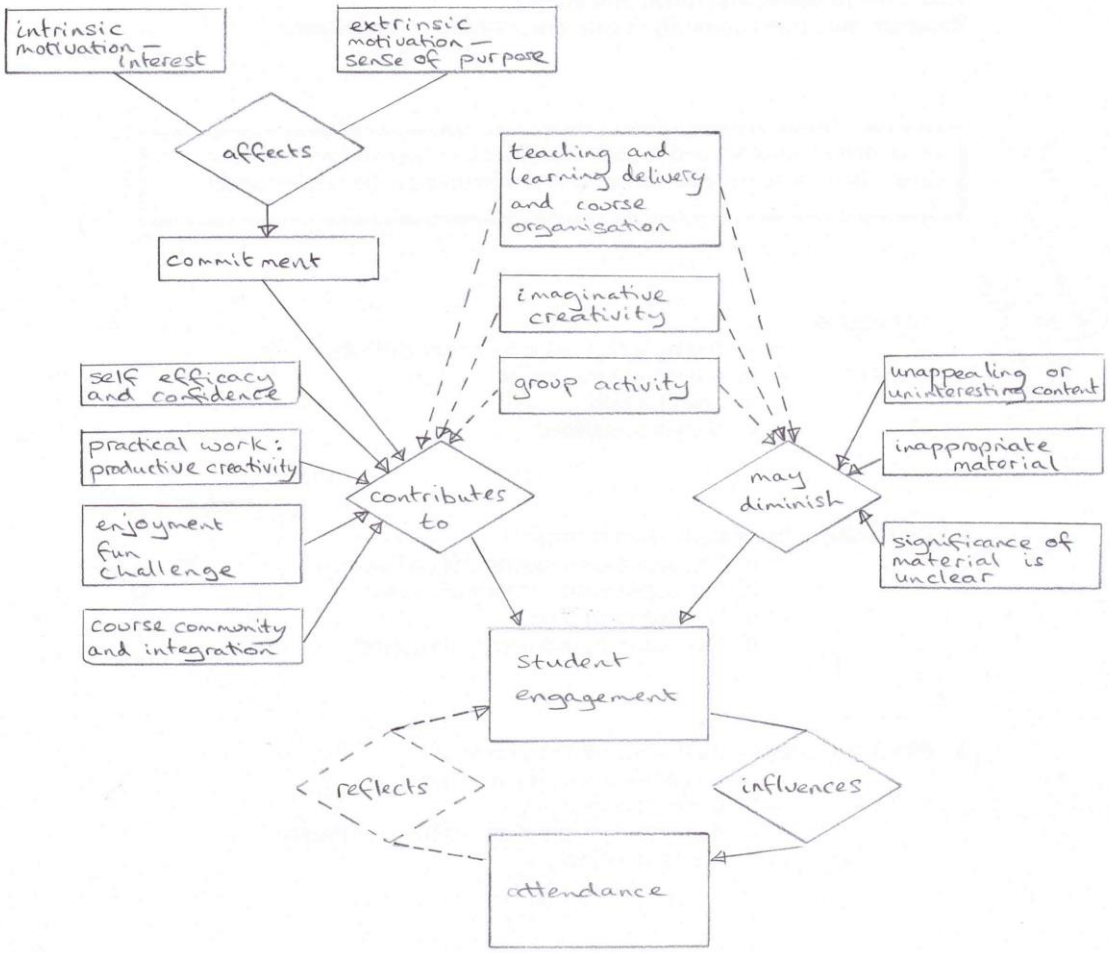


Figure 6: The engaged computing student

[Insert figure 6]

More interestingly, very many factors were found which either contribute to or diminish student engagement. Many factors appear to have one of these roles for all students – so these relationships are presented as being fluid: always present although

changeable. However three objects (teaching and learning delivery, imaginative creativity and group activity) were found to sometimes contribute to the positive relationship but sometimes to the negative one, the impact varying between individuals. The clearest way of representing this was to indicate the optionality of these relationships on the connector arrows.

Thus the AAD method described here consists of notations for object boxes to represent immutable mobile, fluid and fire objects, which can be nested, and which can be decorated with ovals indicating any salient properties; association lozenges in the same three categories and connectors which can have directional arrows if this assists clarity and which can be dashed to indicate optionality.

Application of AADs

A number of reasonably-diverse examples of AADs have been presented which should serve to indicate that AADs can be created to explore diverse contexts. However a number of comments and observations are necessary.

When using the AAD notation for analysis or interpretation there are choices to be made in what is included in a diagram and how it is presented. The analyst would select which items are of interest, whilst ensuring the diagram is coherent. Not all relationships or properties have been included in the diagrams presented but attention has been paid to those of salience. The analyst would present elements in the manner

which seemed clearest and most informative in the context of their analysis. For example, in Figure 4 the ‘stereotype’ object was drawn as being immutable. However viewed over a long timeframe, the computing stereotype does change. Several decades ago computing in the UK had a very positive image: its geeky, negative stereotype has developed in the interim period. However against the timescale of a pupil considering their career options it is essentially fixed and hence represented as such. In the same manner an element which is 'always' present may very occasionally be absent. The analyst needs to judge if this is significant and how best to represent it but it may be that seeing the pattern is in itself a useful analysis. Nesting can be included when the simplification which this can bring aids clarity.

In some places the analyst may detect objects which are in reality multiple, with separate objects operating in different contexts. Where detected, AADs could represent these multiplicities. For example, the analyst might find that the 'reality of computing' (Figure 4) was multiple (perhaps reflecting different areas or aspects of computing) and it might be more informative to the analysis if it had multiple representations, each with relevant associations in the AAD.

There is no single valid AAD, since each reflects its author's interpretation. This contrasts with ERDs which must fully and accurately reflect the relationships within data for them to serve their purpose of guiding the design of a database. There is no fixed heuristic for the creation of an AAD. It is recognized that this may be seen by some as a weakness. However in an interpretive analysis this flexibility is both useful

and appropriate. AADs do not provide any indication of the significance or power of individual elements. This reflects the principles of ANT. However in a particular context the analyst will identify which elements are of particular significance. Indeed it is the opportunity to explore ideas graphically which is the key benefit of AADs. They provide a tool for investigating the messiness of real-world situations. However this does mean that an analyst might choose not to include some elements which could have proved illuminating. Nonetheless, the creation of an AAD could be considered as making analysis more explicit than some other approaches, by clearly identifying objects and their associations, thereby enhancing transparency (Finlay, 2002).

The word 'visualize' refers to the cognitive activity which generates a mental model (Spence, 2001), although the term 'visualization' often refers to some form of diagram or image. As with all visualizations, the very act of creating the AAD reifies the content embodied within it, giving it a reality, almost giving it life. However there is a danger. Both the analyst, and particularly the reader, risk treating the diagram as though it were the one-and-only truth and blinkering to other options. Ideas which are presented in an AAD, intended as tentative, could be 'read' as being more certain. However Amann and Knorr-Cetina consider that "*images… provide infinite opportunities for visual exegesis, thereby functioning to keep the discussion open, not closed*" (Amann and Knorr-Cetina, 1988:163). Whilst AADs can be used in an interpretive narrative, providing visual support to text, the process of creation, considering options, possibilities and alternatives can help the analyst clarify their thinking. They can sketch out their rough, tentative ideas and gradually develop their

representation as they unfold the complexity, supporting their development of their understanding (Venturini, 2012). However AADs may be particularly useful in groups, where a team is exploring the interpretation of their results. AADs provide a notation or lexicon for sharing ideas. By providing a language through which ideas can be seen and explored (Amann and Knorr-Cetina, 1988) it may allow the identification of concepts or issues, creating new understandings. Of course many visualization approaches can provide a mechanism for exploring ideas but adopting the lexicon of AADs may reduce potential misunderstandings.

The examples presented contain few immutable mobile objects. This reflects the context of the 'Why Computing?' project. That project was located firmly in the social world, with few inanimate actors. Whilst social factors can sometimes be immutable, this is relatively unusual, but inanimate entities often are. A study located in a more socio-material context, for instance, is likely to identify more immutables. It might appear that there could be a conflict in the notation between reflecting durability (immutability) and optionality. An immutable object would have a double-lined box whilst an optional, fire object would be represented by dashed lines. Whilst no examples have been encountered of an object which is both immutable and optional they could be readily represented with double-dashed lines.

Conclusion

This paper has presented a novel form of diagram, an ANT Analysis Diagram, a device which can support the analysis of qualitative data. AADs are based on selected aspects of Actor-Network Theory, exploiting them in a way which might develop fresh insights. AADs were developed for use primarily as an analytical tool, creating diagrams which can be refined and modified as new understandings and interpretations are reached. They are seen as working documents and for this reason the examples provided have been left hand-drawn. However the notation could be readily employed to support an interpretive narrative.

The author's background is largely in computer science, working across disciplines for this project. It was the similarity between designing a database and aspects of ANT which led to the idea of re-purposing ERD notation as AADs. There were concerns about how accessible AADs would be to other data analysts. However experience suggests that they are accessible, with little guidance required for their interpretation.

Whilst the example AADs provided here all emanate from a single project they do illustrate that the approach can be applied in a range of social contexts. They can be used to consider issues at a range of scales or granularities. They can be used to consider issues related to a single student. This could be a generic student or pupil, as in the examples provided here (Figures 4 and 5), or a specific individual if the desire was to consider issues from their personal viewpoint. A group of people or organization, such as a university, could form the focus. Alternatively a specific

phenomena or concept can be interrogated, as in the examples of student engagement (Figure 6) and the development of habitus (Figure 3). However AADs are also eminently useable beyond the purely social but particularly in socio-material contexts too. That is where ANT had its origins and, as has been explained, since ANT does not privilege the animate over the inanimate, AADs can be used to explore interactions and effects in situations involving any entities. Thus AADs can be usefully employed to explore and develop understandings in a very wide range of contexts.

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Notes

1. Latour suggested that because of these interactions and layers we should consider the world as comprising the totality of 'things' (Turnbull, 2010). Early uses of the German word 'Ding' (*i.e.* thing) embraced broad issues such as the concepts of assemblage, matter and concern, as well as the inanimate object itself, like actors and their actor-networks (Latour, 2005b). "*There are no objects but only things and disputed assemblages*" (Latour, 2008:6). 'Thing' terminology has not been adopted here.

2. Some ANT studies focus on the role particular objects play as their network develops, stabilizes (if it does), is maintained and eventually disintegrates (Brown and Capdevila, 1999). Objects can create transformation or modification, working as a mediator (Latour 1996), or they can transport a force without changing it, being an intermediary (Fenwick and Edwards, 2010; Latour, 2005a). Some studies consider the degree to which various objects work together during their networks' translations to create stability: their convergence (for example Díaz Andrade and Urquhart, 2010). None of these significant ANT ideas are reflected in AADs however since AADs present a static view of object networks.

3. A fluid object is sometimes referred to as a mutable mobile (Law and Singleton, 2005). Indeed Law and Mol (2001) considered an object ontology comprising the four combinations of mutable/immutable and mobile/immobile.

4. Mol and Law (1994) described objects as being a region, network or fluid, with Law and Mol (2001) later introducing fire objects. Region (or volume) objects were,

there, seen as being separate from network objects. However, since objects can be decomposed into a network of interacting sub-objects, the distinction between region and network objects essentially disappears. As Law and Singleton (2005) put it: an immutable mobile holds its shape both in physical space and as a stable network of associations, and yet is able to move. Thus the two categories of object, region and network, merge as 'immutable mobiles', giving the three types of object used in AADs: immutable mobiles, fluid and fire.

5. The semantics given to the double line here differs from that used by Chen in his ERDs (Elmasri and Navathe, 2007). He used it to indicate optionality.

6. UCAS (The Universities and Colleges Admissions Service) is the body which supports the university application process in the UK.

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