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A MODEL FOR USING ACTIVITY THEORY IN EDUCATION DESIGN: A GAMIFICAITON EXAMPLE

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Abstract

This paper argues that the emergence of design thinking and design-research provide a renewed opportunity for expansive learning, and proposes a model for educational design using concepts drawn from Activity Theory, Ecological Cognition, and other systems-based understandings of learning. The model is argued in the context of a design project involving the 'gamification' of workplace learning. The use of games and game mechanics has become a popular approach to workplace learning due to the apparent capacity of the approach to increase collaborative problem solving and 'user' buy-in. This paper, however, discusses a workplace learning game that, in prototype, has lead to significant transformation or workplace practice, particularly in relation to information and knowledge sharing within the company. Through a design-research process, we use the proposed model to examine the game and identify its successful features. The paper concludes with a discussion of how the model can inform understandings of the value created through learning in workplaces and other settings.

Introduction

> *Organisations are placing increasing importance on workplace learning as a way to remain competitive in the face of globalisation, technological change, privatisation and deregulation (Gustavvson, 2009).*

> *Individuals and organisations are continually learning knowledge and skills that are not stable and defined, rather that are evolving and changing. In fact, the knowledge, skill and activity is being learned as it is being created (Engeström 2010).*

This paper argues that educational design can be improved by approaches that take into account entire learning systems, and offers a tool for doing so. While still in early development, it is our contention that the tool can support and improve design thinking and design-research approaches to educational design. It is introduced with reference to an educational design project that 'gamifies' learning the workplace, the game *ThinkTopia*.

The paper will begin with a discussion of 'gamification' as an educational design. Gamification is becoming a popular approach to workplace learning design, and is also increasingly common in higher and secondary education. At its simplest, gamification is about the use of points, badges and leaderboards to incentivise particular performances or behaviours and, in current workplace implementations, the approach is often supported by an online platform allowing it to be implemented at scale. While in its infancy as an approach to workplace learning, gamification is a good place to think through a variety of educational designs as many of the design elements can be seen elsewhere in education, from 'merit awards' to 'credit points'. As such, while the discussion in this paper will focus on improving gamification designs in workplace setting, the approaches taken, and the design principles identified, promise to have application in the context of other educational designs.

Having introduced gamification, we will outline our tool for improving gamification and other educational designs by taking the wider learning system into account. The tool draws heavily on Engeström's Activity Theory (Engeström, 2001) and its ability to connect learning theory and practice in a coherent way, and is also informed by work in ecological psychology (Hutchins, 2010), and the psychology of creativity (Gruber & Wallace, 1989).

The use of the description 'tool' rather than, say, 'model' here is deliberate and points to the framing of this paper and related projects within the nascent design-research tradition (Abrahamson, 2009). Design-research is an approach that takes an active role in approaching educational problems, and the tool proposed in this paper is intended to contribute to both research understandings and to the work of educational designers. With this intent, the paper will conclude with a consideration of the educational design work of one of us in developing the game *ThinkTopia* and the design principles that emerge through an application of the tool to this case.

Gamification

Gamification is an emergent approach to educational design that is receiving much attention due to its potential to significantly change student and worker engagement and learning (Buckley and Doyle, 2014). Gamification is defined as the application of game theory and game mechanics to non-game contexts, namely enterprises and institutions, to reward and incentivise the behaviour of consumers, employees and student (Kim, 2013). It is about creating game-like experiences, and is often applied through technology and can therefore be easily applied on a large scale.

Gamification is in its infancy. It is beginning to be applied by both private and public organisations, though the majority of the current focus is on marketing and consumer engagement (Hamari, 2013). As more companies see and realise the value of gamification, its application is continuing to grow to new industries and different types of engagement challenges. It is estimated that more than fifty per cent of organisations will have at least one gamified process and that the gamification market will reach $5.5 billion by 2018 (MarketsandMarkets, 2013).

In its most basic form, gamification is the use of points, badges and leaderboards to reward performance. It uses social status and team spirit to incentivise and reward desired behaviours. There are copious examples of basic gamification application of to increase brand loyalty, including large companies such as Nike, Samsung, and McDonalds ("Nike+ Fuel", 2015; "Samsung S Drive, 2014; "McDonalds Monopoly", 2011). However, gamification has the potential to be applied in other spheres and is also being used in healthcare, environmental sustainability, public services and formal education settings. Classdojo.com is an example of gamification in the classroom. It allows teachers to define behaviours and award points, as well as connecting with parents through messages and pictures. Teachers, students and parents interact through a browser-based application and mobile device. Superbetter.com is gamification applied to health, and allows individuals to set goals, tasks and daily actions to progress towards their health goal. It uses points, badges, leaderboards and social connection to encourage progress.

Used in workplace education, gamification challenges the pervasive paradigm in which the learner acquires small, identifiable and concrete components of knowledge or skill from a teacher who imparts them. This standard one-way transaction model is becoming redundant with the ever-increasing speed of change in organisational contexts and practices. Gamification, in contrast, seeks to promote learning by promoting new activity including new interactions with the (social) context.

A major theoretical basis for games and gamification stems from behavioural psychology's Self-Determination Theory (SDT) (Conway, 2014). SDT describes three core needs and incentives, namely autonomy, competence, and relatedness. Autonomy is the player's level of choice and free will; competence is the skills required and gained; and relatedness it the feeling of connectedness to others. These needs are more likely to be met when the goals created in a game are intrinsic, or sought for their own sake, rather than extrinsic, or sought as a means to an end (Songer and Miyata, 2014). The importance of the intrinsic merit of a goal plays out in other research. Piaget's (DeVries, 2000) notion of the value of play in learning, and that intrinsic motivation and playfulness are critical to the successful learning of new knowledge and skill is a well-known example. Csikszentmihalyi's concept of autotelic flow is another (Hektner & Csikszentmihalyi, 1996). Through this work it is known that individuals achieve a 'flow' state when there is a matching between the player's competence and the challenge of the activity. In this state, users are completely immersed in the activity to the point where

they can lose track of time and physical needs such as food and even sleep. This principle is well utilised in games, where players are guided or on-boarded into the game when they begin, and gradually gain competence as they aim for levels within the game. Each level becomes increasingly more difficult, and provides a new challenge for the player as they become more skilled and competent at the game. Users do not achieve the flow state if there is a mismatch in their skills and the challenge of the activity. If the challenge is not great enough, the user will become bored and disinterested, and if the challenge is too great, the player will become frustrated and disengaged.

Different players achieve this state of flow under different conditions and for different intrinsic motivations. This is the notion of player types, or classifications of how players tend to interact with their real or virtual world. The most well-known classification is the Bartle Test, which classifies players into four main types based on their motivation and predilections (Kim, 2013). Killers are players that enjoy competition with others, such as fighting and direct competition where they can beat another player or team; achievers enjoy attaining challenging goals and receiving concrete rewards such as points and status; explorers prefer to discover the virtual world and the game itself, seeking to understand the intricacies of the game, hidden areas or unknown glitches; and socialisers are those that care about the relationship with others more than the game itself, enjoying the community aspect of the game. While there is some debate about the generalisation of Bartle's four player types to different games and gamification (Dixon, 2011), the concept of understanding and designing for different player types is critical to all game and gamification design.

Criticisms of gamification as an educational design model

Despite the current attention, gamification is not yet well understood and its application is typically focussed on behavioural modification rather than creating activities of intrinsic value (Conway, 2014). As such, it is not overly surprising that gamification has received a lot of criticism as an educational design. The most important of these criticisms of is the over-application of extrinsic motivators, such as points, badges, levels and game currency, because these can have a crowding-out effect of intrinsic motivators, leaving players without internal motivation to pursue the target behaviour and activity (Hamari, 2013). The danger this creates is that the player focuses on the achievement and consumption of signs, such as more points or a new level, instead of the transformation of learning. This results in the cessation of the behaviour if the extrinsic motivator is removed. Conway (2014) has recently dubbed this process to 'zombification', although the basic phenomena has been well understood by social psychologists for years with Campbell arguing forty years ago that:

> [t]he more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor (Campbell, 1976, p.49).

Such 'corruptions' seem to be amplified in the application of gamification to workplace settings where the focus has often been on increasing sales and other 'hard' metrics, which can actually lead to disengagement because of the additional feelings of pressure from the quantification and visibility of individual performance (Conway, 2014). In such applications, the quest to improve on the chosen measure may lead to activity that is quite different to activity that is in the best interests of the player or the workplace. We may see, for example, the adoption of strategies that improve sales in the short term, while sullying the reputation of the business in the longer term.

Given such criticisms, there is quite reasonably some scepticism about whether or not gamification can 'live up to the hype' (Hamari, 2013). In practice, gamification designs have been applied to a quite limited number of activity types, and there is little empirical evidence of genuinely transformative learning occurring as a result. While we broadly agree with such criticisms, our contention is that this lack of evidence does not show an inherent flaw in gamification as a valid education design, but rather it shows a need for developing better models using games for workplace learning. There is a need, we suggest, to learn from Campbell's arguments about the use of quantitative social indicators in social planning, and to develop gamification models that move beyond basic quantitative indicators such as badges, statues and leaderboards (Songer and Miyata, 2014), and instead begin to design entire

systems that are solidly based on the unique and local needs of the players. In the next section of this paper we will argue that an application of Activity Theory through a design thinking process provides a pathway for achieving this type of comprehensive gamified educational design.

Theories for Expansive Design

Our purpose here is to develop educational design tools that will assist in the development of more expansive game designs that move beyond the simple application of extrinsic motivators. We do so taking a design-research approach. Design-research, also referred to as design-based research (DBR), is an approach that is used to observe and evaluate, and also to iteratively test, implement, analyse and modify theories and interventions in natural settings (Leonard and Fitzgerald, 2015). It is not so much a research method, as an approach to research that makes use of mixed research methods in a pragmatic way. Design-research is typically committed to understanding and engaging the complexity of a local context rather than 'controlling' it, and does so by engaging with it through iterative design. Design-research is conducted in real world settings to take in the plethora of variables, it embraces the complexity of interactions and perspectives, and it focuses on characterising the design in practice (Barab and Squire, 2004).

Hoadley (2010) defines four ways in which design-research differentiates from traditional experimental research. First, the researcher works closely with the participants, which blurs the lines of objectivity but allows for intimate understanding of contextual factors. Second, design-research uses generalisations and themes to draw conclusions and build designs, without the expectation that they will necessarily hold true in other contexts. Third, the process is explorative and researchers follow new revelations as they occur, adjusting the intervention and measurement iteratively as needed. And lastly, it treats enacted interventions as outcomes and leads to a broad documentation of the intervention, its rationale and all consequences of the design on the enactment.
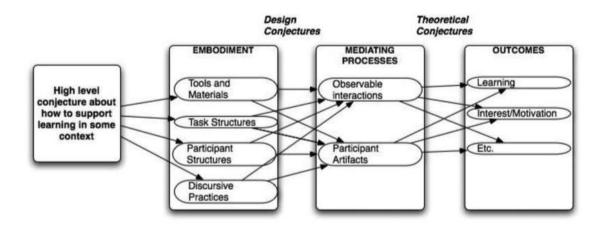

Figure 1. Conjecture Mapping (Sandoval, 2014)

Design-research contributes to theory, but is also theory led. Interventions within a context are made with clear conjecture about what activity will be created, and what learning or other value will be created through that activity. Sandoval (2014) has recently argued that design-research can be improved by the explicit mapping of design conjecture, his model is shown in Figure 1 and adopts an approach similar to a results-chain or logic-model methodology (W.K. Kellog Foundation, 1998). Sandoval argues that educational designers can be explicit about the design and theoretical conjectures held with their designs. Design conjectures, he suggests, are the activities the design intended to create, while the theoretical conjectures are about how the designers believe the activity will lead to

learning.

This paper aims to extend this model by introducing a body of educational theory to that mapping process. We begin this extension by calling upon Engeström's (2000) vision of expansive learning. Expansive learning concerns itself with the simultaneous learning and creation of new forms of activity, through the interaction between the learner and her or his context. It argues against the limited view of learning to be about the acquisition of skills and knowledge that have already been mastered and codified (Engeström & Sannino, 2010). This expansive understanding of learning brings focus to the collective transformation of the entire system, as opposed to individual learners only. In this way, expansive learning activity produces new patterns and forms of activity (Engeström, 2001).

Engeström's expansive view of learning is increasingly supported by other fields of research such as the nascent field of cognitive ecology. Researchers in cognitive ecology are showing that human cognitive processing and learning are *embodied and enacted*; developing through goal-orientated action and interactions between the human organism and its environment (Hutchins, 2010; Rueschemeyer et al., 2009). It follows, they argue, that individual learning happens as part of the environment, not in isolation from it. That learning depends on the structure of the cognitive ecosystem that extends beyond the individual mind or body, and on the dynamic formation of particular practices within the ecosystem (Hutchins, 2010).

Engeström's own Activity Theory provides a good place to begin design work within educational ecosystems. Engeström's theory builds on the Cultural-Historical Activity Theory (CHAT) of the Soviet psychologists that he has described as 'the best held secret of academia' (Avis, 2009) due to its ability to connect learning theory and practice in an integrated and meaningful way. Vygotsky pioneered CHAT in the 1930's, emphasising that human consciousness is culturally mediated through artefacts, tools, and language. The theory was further developed by Luria (1971) and Leont'ev (1978) to include social, cultural and historical dimensions through elements such as community, rules, and division of labour. Led primarily by Engeström, the theoretical construction is now in its third generation of development, which includes the consideration of multiple activity systems and application to many different contexts (Roth and Lee, 2007).

CHAT considers learning to be an interconnected part of a complex system of human actions, interactions and relationships with their environment (Gustavsson, 2009). It states that consciousness and learning are mediated through the use of artefacts and are oriented towards goals or objects, as well as being strongly situated in the local cultural, social and historical context. Cognition is therefore embedded in and inextricable from activity and local practice. Key elements of an activity system include the object, an entity or a goal which is continually evolving; the activity, a form of doing that is directed to an object, is goal-orientated and targeted to a need; mediating artefacts such as tools, signs and language; subjects, the human actors or participants in the system; community which consists of subjects that share an interest and involvement with the same object; division of labour, the roles within the community, including division of power and resources; and rules, which regulate the subject's actions and interactions within the system.

Engeström (2001) provides five key principles for using Activity Theory. The first is that the prime unit of analysis is the activity system itself, being the collective, artefact-mediated, object-orientated system understood in relation to other activity systems. All actions are to be comprehended in this setting. The second principle is that of multi-voicedness of the system, meaning the diversity of individual and community perspectives that exist within the system. Due to the division of labour within the system, each individual and the system as a whole has their own unique point of view and history, which manifests in their artefacts, rules and norms. This multiplicity of viewpoints can result in tension but also provides opportunity for innovation. Principle three is historicity, the transformation of the system over time. The local history of activity and objects within the activity systems needs to be understood in order to understand the system itself. The fourth principle is about the fundamental role that tensions and contradictions play in change and development. When a new element is added into the system it creates friction and disorder, typically around structural tensions

that have accumulated in the system over time. These contradictions can occur between each of the six elements of activity system: subject, artefact, object, rules, community and division of labour (Foot, 2001). Primary contradictions also lead to secondary contradictions, which are opportunities to change and innovate the activity. The final principle is expansive transformation, the cycle of qualitative development undergone by activity systems over time. The cycle is begun when a few individuals question and diverge from current norms. This questioning can lead to a collective change through the development, modelling, implementation and consolidation of new norms and solutions. The cycle is complete when the object and intent of the activity are transformed, and the collective envisage a significantly different world of possibilities.

These principles indicate the richness and multi-factored nature of activity systems, and the various complexities, which need to be identified and understood when applying CHAT. This richness of understanding is the key differentiator and value of using CHAT in the understanding, evaluation and design of educational and workplace systems.

The tool we propose in Figure 2 draws together aspects of both Sandoval's conjecture mapping with the analytical approach developed in Activity Theory to provide a practical tool for educational designers to use in building a picture of the complex educational ecosystems they are working with. The model essentially suggest that activity systems, as understood through Activity Theory, create 'detours' in the conjecture maps educational designers might develop. In doing so, the model extends Sandoval's position that there is a need to analyse our designs for 'embodied conjecture' and how such conjecture might interact with the learners as participants, to suggest that there is a further need to analyse the way learning designs will interact with activity systems.

By including an emphasis on the social milieu, the tool in Figure 2 also draws on critical theory as a way to tease out the historical context of activity systems; and on personality psychology and work in creativity to acknowledge that an individual within an activity system might themselves be understood as a complex set of subsystems such as knowledge, motivation and affect (Gruber & Wallace, 1989).

Applying the Model: ThinkTopia

ThinkTopia, currently completing an extended prototype phase, is an interactive gamified experience that engages and rewards employees for desired business behaviours. The lead author of this paper is also the lead designer of the game, making this section of the paper a very real design application of the model proposed above. This discussion provides a sketch of how the design of the game can be better understood using the proposed tool for thinking through some prominent aspects of the game. It is brief, with a more complete exploration to come in a future publication.

ThinkTopia engages at an individual, team and organisational level through a series of activities and rewards. These activities are based on business needs and strategic priorities (the institutional milieu), but cascade from the strategic level to the team and individual levels to demonstrate how individual effort directly contributes to both the greater organisational purpose and to individual concerns. The game has been prototyped at ThinkPlace, a mid-sized management consultancy specialising in innovation and design thinking.

In the prototype phase, ThinkTopia has been used to offer incentive and reward to employees for certain activities ranging from simple administrative tasks that are burdensome to the employee yet critical to the operation of the business, to higher order tasks such as creating and engaging with intellectual property and the intellectual work of other employees. Notably the activities rewarded in the game while being broadly quantifiable, are not the headline or 'hard' metrics of the business. Rather the game has focussed on incentivising a set of contributing behaviours that are advantageous to employer and employee alike. They include:

- Timely submission of timesheets
- Tidying of work areas

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- Engagement with the company's online knowledge sharing platform
- Writing of case studies, internal newsletter pieces, and blogs to be published on the company's websites
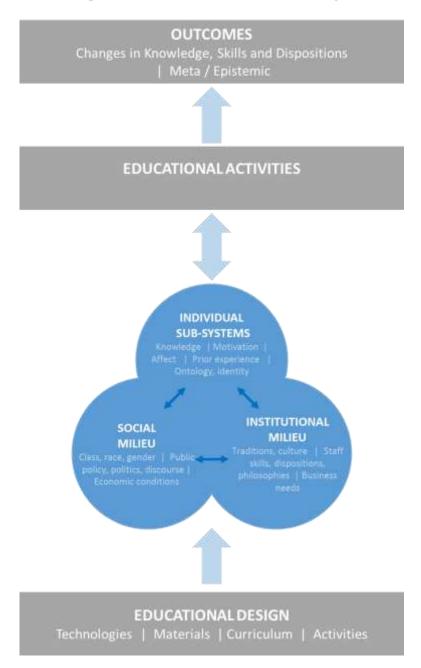
Design Based Research Context Analysis

Figure 2. A model for contextual design

The first two of three activities are relatively low order activities, but were widely agreed by all to be affecting both individual and whole-of-company performance. Poor attention to timesheets, for example, was seen not simply as a poor business process, but as leading to tense interactions between the anxious operations team and the time poor consultants and therefore an important issue to address in a relatively small organisation. In terms of the proposed design tool, the intention of changing this activity was intended to both respond to a business need (institutional milieu) and change a work

culture (institutional milieu. The value, however, was seen primarily in improving affective relationships between staff (individual sub-systems) with staff across the primary divisions of labour (operations and consultancy) sharing the extrinsic rewards offered through the game.

The tidying of work areas had similar benefits. Due to the creative nature of the work and the time-driven nature of consulting work, employees tended to use areas and leave them once the work had been complete. Through ThinkTopia, individuals were provided with a way to signal messy areas and give authority for others to tidy them, rather than feel disallowed because the mess 'belonged' to another employee. There was a marked improvement in the tidiness of the workspace. Interestingly, it can be seen that there was a noticeable drop in cleanliness when ThinkTopia is not in use, suggesting that unlike with the time sheet submission, the benefits of the change achieved through the game may not be intrinsically rewarding enough to lead to a sustained outcome rather than simply gamified activity.

One of the most significant changes in behaviour and culture is the active use of the company's online knowledge sharing platform, Bloomfire. From the organisation's perspective, it is important to document and share the client products and intellectual property, such as refinements or creation of new cognitive models, techniques and methodologies, produced by employees during their day-to-day work (business need). It is equally important for employees to access and leverage this knowledge to better perform in their role (individual sub-system of knowledge, and possibly affect). Prior to ThinkTopia, employees were slow to take up the use of this new platform, and finding IP and previous examples of work was difficult and relied heavily on verbal corporate knowledge. With benefits for multiple parts of the workplace system evident, ThinkTopia rewards were introduced both for contributing to Bloomfire, and for making use of contributions of others through this system. In the process, use of this platform is now part of the daily activity of employees, it is now used through the company's offices in several countries, and it is a key resource for new employees as part of the induction process. It is used to showcase outstanding client products, new methodologies, knowledge and inspiration from the industry, as well as administration and operations items, such as policies and procedures. Quantitatively, the number of weekly uploads and the percentage of overall engagement (includes reading, commenting, downloading) is significantly improved from less than 20% to 58%. Qualitatively, it can be observed to be part of the discourse between employees. The name of the platform is used as a verb. For example, if an employee speaks about a useful product or article, another employee will often ask 'Have you "bloomfired" it? or 'Can you please "bloomfire" it'?

Using the proposed tool, our interpretation from the prototyping phase is that by targeting an activity that has significance for different members of the activity system, the 'educational activity' of sharing information across the company has led to demonstrable changes at a knowledge, skill and epistemic level. The benefits of participation in this system were not initially evident to many in the company, and might easily have been seen as a distraction from core business, but the value was created through enacting the activity. Indeed it could be argued that the activity was not useful until it was enacted, as it is only through widespread participation that value moved from potential to realised value (Wenger, Trayner, & Laat, 2011).

Participation in publication activity was also chosen as key activity to be encouraged by the game that does not directly contribute to the core activity of the company, but has diverse value within the activity system including connecting to the wider social milieu, and allowing staff to develop their own identity within the context of the company's work. In addition, the types of individuals taking part in this activity has changed. Prior to the introduction to ThinkTopia, the writing of website blogs and case studies was largely performed by the senior and Executive members of the team. While publications from these individuals have increased moderately, the change is more notable from individuals in the middle and lower levels of the organisational hierarchy. Writing of articles was always open to all team members, but ThinkTopia seems to have changed a social norm that prevented junior members from this activity and has legitimised their contribution to the organisation in this way.

Drawing on our proposed design thinking tool once again, the design targeting changes in individual activity appears to have had an effect on the local culture or institutional milieu, leading to a

fundamental change in the division of labour within the company.

Design Principles, and further research

Clearly this is a work in progress, but we conclude by offering some design principles to further work on the gamification of educational activity.

1. Consider the entire system in game design

Overlaying extrinsic rewards onto current activities is not sufficient. The gamified system needs to be whole and fully functioning, integrating individuals, teams, activities and objects. In regards to motivators, the design should employ a mix of extrinsic rewards but, as can be seen in the prototyping phase of ThinkTopia, to be successful there must be intrinsic value in the activity for a variety of participants in the activity system as appropriate to the unique context.

The challenge in workplace learning settings may be to convince managers of the value of creating activity with intrinsic value only, or devoting time to activity which improves the activity system without directly contributing to quantifiable targets. Further research on measurement and evaluation systems that can support expansive learning activities is required.

2. Gamification must be user-centred and located in the unique socio-cultural context

An organisation or educational institution will typically drive the mandate for gamification. Where ThinkTopia has had success, however, is where there has been clear intrinsic value for the participants in the game beyond the needs of the company. This value may be that it makes it easier to do their job, but it is more than simply making things easier for the boss. The multi-voicedness of the system must be recognised, in that each player has his or her own unique perspective, goals and way of interacting with the rest of the system. The gamified system must cater for not only the four main player types – achiever, killer, socialiser and explorer – but also more meaningfully for the expression of these player types within the unique context that is being gamified. Historicity is another important element. The implementation of the gamification will be in the setting of the current history of the context. It is important to understand what attempts and structures to reward behaviour exist currently and have been used in the past. This will provide a basis from which to introduce the gamified system.

User-centeredness is an important goal for design-research as gaining a deep understanding of the context and the underlying needs and motives of the various users is difficult. Our discussion of ThinkTopia is a discussion of educational designers and lacks the rigorous methodology. There remains an urgent need to develop methodologies that have both rigour and are also agile and rapid enough for use in workplace game design. Recent advances in computer-assisted research do hold promise in this area (Leonard & Fitzgerald, 2015).

3. The gamified system must evolve with its context

Engeström has noted that the 'object of activity is a moving target, not reducible to conscious short-term goals' (2001, page 136). Games and their educational or occupational context will mutually transform each other over time. The gamified system must account and design for this and designers must not assume they are working with an unchanging, or even stable, system. A flexible, evolving design will ensure the mechanics continue to be relevant and meaningful for both players and the organisation. Effective game designs will always be in developmental mode.

This principle again suggests a need for the development of agile and rapid evaluation methodologies that show the nature of change occurring. More significantly though, it challenges the dominant paradigm for measurement and evaluation (M&E) of learning activities. Current workplace learning, like learning in most formal settings, is currently evaluated in terms of the achievement of various pre-known and typically short-term goals. The measures focus on items such as how many employees pass a multiple-choice test, or were the participants satisfied with the trainer's presentation. Designs that

evolve are, by definition, leading to unknown outcomes. Games such as ThinkTopia ought instead be evaluated against their capacity to create value with the system as a whole.

We conclude with the contention that the tool proposed in this paper might form the basis for such a changed M&E system. By providing a framework for a broad investigation into the system being designed, it can allow for an account of the value it is creating to be developed as it evolves, rather than simply creating an accounting process against pre-determined quantitative measures.

Of course, having accused quantitative indicators of being potentially distorting and corrupting, we must acknowledge that a flexible M&E system can certainly be corrupted. The development of common but flexible tools and frameworks, however should reduce this risk. In the end better educational designs that are responsive to contextual and user needs are in the interests of all involved, and tools such as the one proposed here must be able to support comparison of design options, identify weaknesses in designs, and not simply allow designers to point to their successes.

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