Time and the Meta-Compositional Elements of Business Simulations

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ABSTRACT

Instead of exploring how real-world time is replicated in a business simulation this paper explores how time impacts meta-compositional design where meta-composition is the structural elements of the simulation that are independent of the real-world situation modelled. The paper explores business simulation as a time-based systems dynamics process and the temporal aspects of meta-composition structural design.
The concepts explored by the paper are illustrated using a business simulation designed for company training use where there is a the need for relevant and necessary cognitive processing (learning) and a short duration (time) that limits cognitive load. The paper focuses on the temporal aspects of the learning process, learning effectiveness and learning efficiency.

INTRODUCTION

Bellman et al (1957) suggested that *"Making models, mathematical or otherwise, of complex systems is an art with a small amount of science to guide one"* and the artistic aspects of business simulations has be reiterated since (Thavikulwat, 2004; Bott & Daalen, 2007). A key aspect of art is composition - *"the structural arrangement of elements distinct from the subject of the work of art"* (Dow, 1913). This leads to two questions "What are the meta-composition aspects of business simulations?" and "What role does time play in meta-composition?".

Commonly, a business simulation involves participants running a simulated business for several time periods. Each period participants make decisions that are entered into a model that simulates their impact producing results that are analysed by the participants and used by them to plan the next decisions. This leads to two meta-compositional aspects - the meta-composition of the simulation as a whole and the meta-composition of each period. The simulation as a whole is an evolving time-based system dynamics feedback process (Hall & Cox, 1993; Hall, 1996) with each period's decision-making cycle analogous to the servomechanism's feedback process and for each period there is a temporal decision-making cycle that maps to Kolb's Experiential Learning Cycle (1984).

A COMPANY TRAINING EXAMPLE

The business simulation used to illustrate the temporal aspects meta-composition was used on a half-day workshop designed to help leaders of small and medium sized enterprises (SMEs) improve the way they priced their products and services. It is suggested that a company training simulation like this is particularly relevant to exploring temporality because of learning purpose, how learning is assessed, the manner of use and time pressure.

The pricing simulation's purpose was to provide participants with the skills and tool to enable them to review and improve their pricing and thus focussed on Psychological Fidelity where the "*training environment [simulation] prompts the essential underlying psychological processes relevant to key performance in the real-world setting"* (Kozlowski & DeShon, 2004) rather than External Validity (Cook and Campbell, 1979) where the simulation's purpose is to replicating reality (Decker & Adler, 1987; Chiesel, 1979; Miller & Leroux-Demers 1992)). Psychological fidelity requires a design focus that is on (temporal) process rather than theoretical content. That is to say psychological fidelity requires an emphasis on temporal meta-composition (Hall, 2015).

It is usual practice for any company training to be assessed by the learners. An evaluation that may be extended to include actual company benefits and outcomes (Kirkpatrick, 1998) and perhaps extending to learning ROI (Phillips and Phillips, 2011). Bennington and Laffoley (2012) quote a report that the evaluation of learning was a top priority for learning and development professionals (Personnel Today, 2012). The importance of learning assessment by the adult learners is not surprising since adult learners require learning that is relevance and benefit the individual learner and his or her company (Knowles et al, 1998). This assessment by the learners focuses on how the simulation improved their business skills and made good use of their time (learning effectiveness and efficiency).

Commonly business simulation are used on company training in a single session and this means that cognitive processing and cognitive load is restricted to a set time period. This contrasts with the situation where a business simulation is used in an academic setting where it may be spread over a semester and cognitive processing is likely to continue consciously and sub-consciously beyond the time-tabled sessions meaning that it is not possible to define the amount of time spent working on the simulation. Restricting to a set time period increases the need for good meta-cognitive temporal design and balancing cognitive processing with cognitive load.

Finally, company training is costly and this means that there is pressure to reduce course durations and improve learning efficiency while not reducing learning effectiveness. For the pricing simulation a short duration was crucial as courses for SMEs are rarely longer than half a day. As a consequence the simulation's duration needed to be about two hours and the temporal meta-compositional design was a key enabler of this short duration.

SYSTEMS DYNAMICS PROCESS MODEL

Hall and Cox (1993) proposed a two dimensional time-based conceptual systems dynamics model of the simulation process and Hall (1996) extended this from learning (cognition) and engagement (affection) to include work-load (cognitive load). The learning dynamic (Figure 1a) and the workload dynamic (Figure 1b) are especially pertinent to temporal meta-compositional design.

The learning dynamic (Figure 1a) leads from initial confusion (negative cognition) to learning. Peach & Platt (2000) explore this process in terms of initially learning *how to play* *the game* (initial confusion) with learning occurring during the later periods. Peach & Platt cited Rollier's study (1992) of a number of simulations where the learning to play lasted up to the forth decision period and uncertainty (confusion) disappeared by the sixth period and Peach & Platt suggested that ten to twelve periods needed to be simulated. For the pricing simulation to have a two hour duration, it could only have six decision periods and initial confusion needed to be limited to the first period.

For learning to take place and for the simulation to be engaging, cognitive load is bounded with upper and lower limits (Grey zone figure 1b) (Hall, 1996). If the workload strays above the grey zone then cognitive load will be excessive and participants will be overwhelmed, have insufficient time to reflect and conceptualise and become disengaged. Equally, if the workload strays below the grey zone then business learners will see feel that their time is being wasted and become disengaged.

Each of these dynamics has three components - basic response, natural response and managed response. The Basic Response is caused by the basic simulation model where temporal aspects of the simulation are largely ignored as the environment is static, the number of decisions made each period and the results (reports) produced each period remain the same throughout the simulation. As illustrated in figure 1b, the Basic Response's workload is usually the highest at the start of the simulation and reduces over time as familiarity improves. If the initial Basic Response workload is set so that it does not cause role overload, cognitive load may fall to a level where learners feel their time is being wasted.

The Natural Response is caused by the meta-compositional temporal progression (see the Temporal-Topical System) built into the simulation during design. The Natural Response increases the amount of learning in a given time by increasing workload as new decisions, results, tasks and issues are introduced purposely as the simulation progresses and learning evolves. For example, in the pricing simulation participants initially made four price decisions but the number of decisions made increased as the simulation progressed until by the sixth period they could make 24 different decisions.

The Managed Response is caused by the proactive actions taken by the trainer during simulation use to adjust cognition and cognitive workload to take into account learners' knowledge, skills, competencies, learning needs and opportunities.

Figure 1a
Learning (cognition) Dynamic

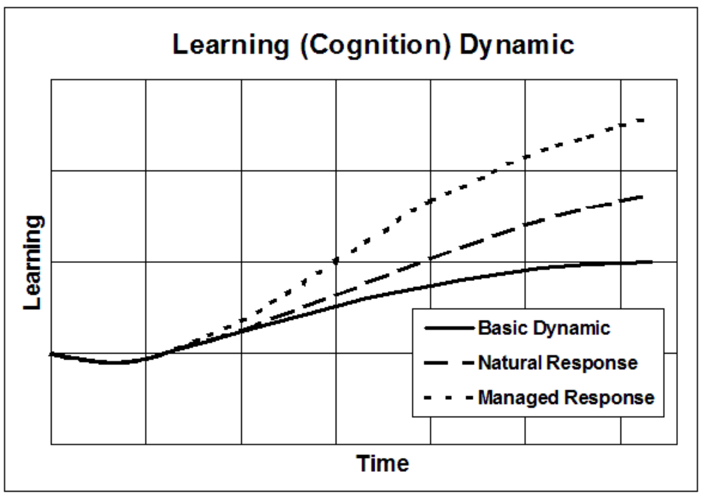
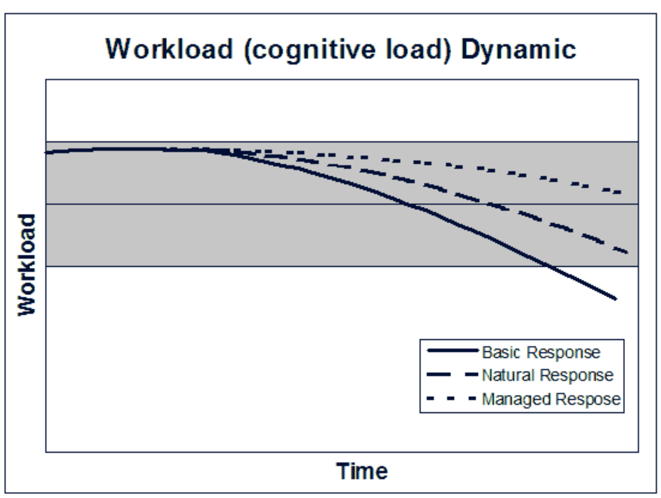


Figure 1b
Workload (cognitive load) Dynamic



META-COMPOSITION

The temporal-topical system is the meta-compositional element that address the needs of the systems dynamics process model for the simulation as a whole and there are additional meta-compositional elements that impact the in-period experiential learning cycle. Figure 2 shows meta-composition elements positioned relative to the decision-making/experiential learning cycle.

The Temporal-Topical System

The Temporal-Topical System (Hall, 2009) involves deciding how the experience is taken forward, previous learning is built on and new business issues and topics are introduced to create a *learning journey* that forms the *natural response* of the simulation's systems dynamics process model. The Temporal-Topical Progress for the pricing simulation is shown in figure 3.

There are several meta-composition ways a simulation can progress in a planned way over time (Hall, 2009).

TEMPORAL-TOPICAL PROGRESSIONS

Economic Progression
Task Progression
Issue Progression
Business Progression
Viewpoint Progression
Ad Hoc Progression

Economic Progression is the way the economic situation changes over time - for example how market demand and costs change period-by-period. The pricing simulation did not have any economic progressions as it was deterministic without any seasonality or stochastic fluctuations. This was deliberate to reduce cognitive load and as it was felt that omitting these would have little or no effect on learning but cut duration substantially.

Task Progression involves introducing different tasks as the simulation progresses. The pricing simulation started with assessing price sensitivity and moved on in period 4 to adding value and demand forecasting in period 6.

FIGURE 2
META-COMPOSITION RELATIVE TO THE EXPERIENTIAL LEARNING CYCLE

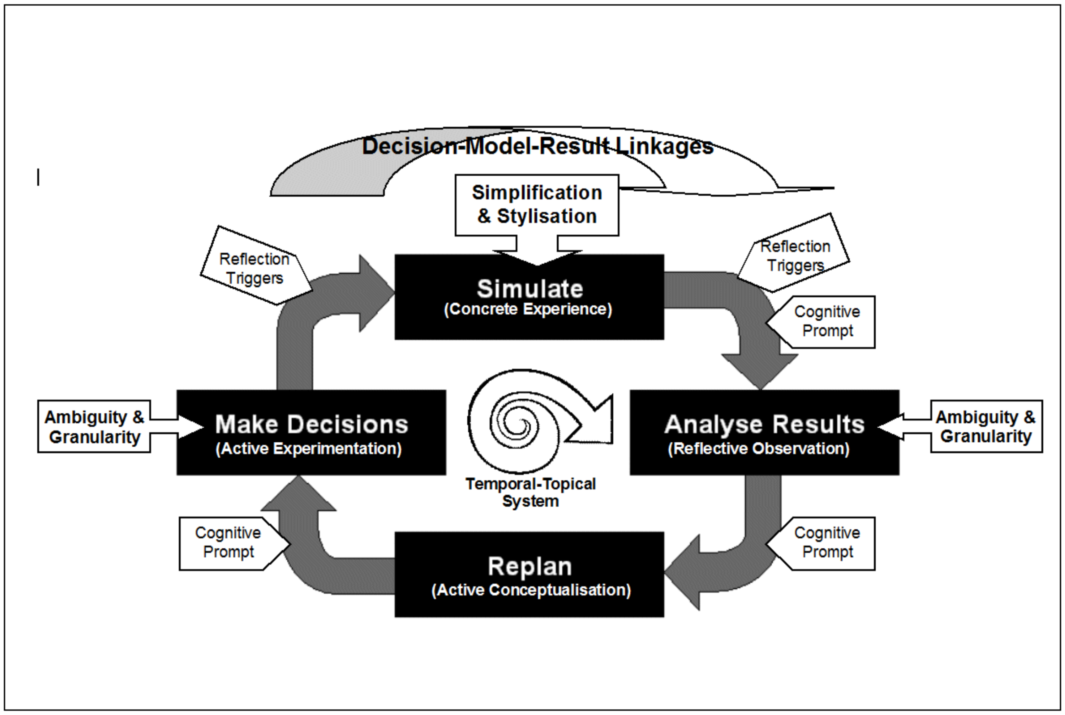


FIGURE 3
TEMPORAL-TOPICAL PROGRESS FOR THE PRICING SIMULATION

Period	Decision	Results
1	Set prices based on sector descriptions	Sector profit statement
2	Set prices based on prices sensitivity rubric	Sector & overall profit statement
3	Set prices to ensure full capacity utilisation	Sector & overall profit statement
4	Set prices and change values	As above & value research
5	Set prices and change more values	As above & value research
6	Set prices and forecast sales	As above, value research & forecast

Issue Progression involves changes to the issues faced by the participants as the simulation progresses. For the pricing simulation the issue of capacity use was introduced in the second period to be dealt with in subsequent periods.

Business Progression involves the way the business changes as the simulation progresses. For example, for a simulation where participants launch a new product as they grow sales they would need to increase capacity and possibly face cash flow problems. Business Progression elements were omitted from the pricing simulation as it was felt that these would add to duration (cognitive load) without adding useful learning (cognition).

Viewpoint Progression involves deciding when reports are produced as the simulation progresses. For the pricing simulation a report showing the impact of capacity use on staff utilisation and costs was introduced in the second period. This was to stimulated discussion on capacity use, pricing and the trade-off between margin reduction and idle staff cost reduction. After the value change decisions were introduced, market research reports were produced to provide feedback on how the value changes were viewed.

Economic, Task, Issue, Business and Viewpoint Progressions are build into the simulation during design and collectively result in its Natural Response. In contrast, **Ad Hoc Progression** involves the tutor deciding new, unexpected or disruptive events such as a tax change impacting market demand and is part of the simulation's Managed Response.

Decision-Model-Result Linkages

Key to learning from simulations is the way participants think through and tease out the causal links between decisions (actions) and results (outcomes) and this is impacted by how the simulation model defines the *linkages* between the decisions and results. Hall (2009) listed and explored structural relationships between decisions, the model and results:

DECISION-MODEL-RESULTS LINKAGES

Independent decisions and results
Interdependent decisions and results
Model Specific decisions and results
Parallel decisions and results
Duo specific decisions and results
Montage

Initially, the pricing simulation used the independent decisions and result relationship where a single result (sales demand) was caused by a single decision (price). This contrasts with the demand relationship common for Total Enterprise Simulations where demand is impacted by several marketing mix decisions (price, promotion, product offering etc.). This meant that the relationship used by the pricing simulation was much less complex than the demand relationship of Total Enterprise simulations and this reduced cognitive load but still focussed on learning purpose. Later, the pricing simulation introduced other (value change) decisions that impacted demand. This made the relationship more complex except by this point (period 4) participants should have teased-out the relationship between price and demand and so it was likely that there would be some increase in cognitive load. Besides understanding the complexity of these relationship there is the need to manage them and deal with the situation where participants are struggling. As described later, Cognitive Prompts and Reflection Triggers help, in extremis, to reveal the linkages and where the simulation has a *Tutor Support System* (Hall, 1994) there are reports provided to the tutor to unravel the impact of decisions on results and explore inside the models. The other types of linkage were not used in the pricing simulation.

Model Stylisation

Stylisation is the extent to which the simulation model differs from being an exact replica of the real world and thus parallels how fine art movements moved away from Realism to Impressionism, Expressionism, Surrealism etc (Gombrich, 1994) - all of which are aesthetically meaningful and perhaps represent a maturing of fine art. Stylisation serves to improve cognition and to an extent reduce cognitive load and improve engagement. For the pricing simulation the first stylisation was the choice of scenario - a company selling meal boxes that contained all the ingredients for purchaser to prepare a meal in their own kitchen. This choice was based on learning purpose - the need to have several customer segments each with different price sensitivities and values (both tangible and intangible). These segments allowed participants to identify price sensitivity and link to the price sensitivity assessment rubric. A second stylisation was that although elasticities were different for each market sector, initial prices and nominal market size was the same for each market as were the basic unit and fixed market costs. This contrasts to the *real-world* situation where nominal market size, starting price, basic cost and fixed market costs would differ for each sector. Stylisation helps clarify and amplify links between decisions and results but not to the extent that the links are obvious or trivial.

Model Simplification

Simplification involves deciding the complexity of the model, the decisions, the results and the parameters driving the model. Simplification has a major impact on cognitive load and the duration of the decision-making cycle. Although price elasticity differed for each market sector, for the pricing simulation the marketplace model was simplified with static demand that did not include seasonality and random variations or other elements of the marketing mix. Additionally, it was assumed that price changes were communicated instantly to prospective and existing customers and would not cause competitors to change their prices. Also, although capacity has a major impact on pricing decisions, capacity was a single fixed parameter that participants could not change and did not vary market sector to market sector. The results were limited with a single goal of maximising profit contribution and did not include market share, profit percent, return on investment or liquidity. Simplification involves removing decisions, results and relationships that are not directly necessary to meet learning objectives and tries to balance the need for discussion and reflection and the time to do this. Both stylisation and simplification are based on learning needs and attempt to minimise Extraneous Cognitive Load (Sweller, 1998). Stylisation and simplification attempts to stop extraneous cognitive load being imposed during design (Chandler, 1991).

Ambiguity Management

Model complexity is a characteristic of the relationships between decisions and results. In contrast, ambiguity is a separate characteristic of decisions and results. Ambiguity is important as it forces learners to think about their decisions and results. Meta-compositional ambiguity design involves balancing the ambiguity level (the amount of thinking needed) with the time taken to handle ambiguity when making a decision or interpreting results.

Price setting in the real world is very ambiguous and it is also impacted by other parts of the marketing mix. In the pricing simulation ambiguity was constrained by only making pricing decisions although ambiguity still had to be reasonably high to ensure that participants thought deeply about how prices impacted demand, revenue and profit contribution based on customer's needs, wants, values and sensitivity to price.

Hall (2015) suggested that the degree of ambiguity should be based on the importance of the learning rather than just be based on the *real-world* situation. This meant that the impact of the price decision on demand and through this profits was ambiguous but the impact of the later (less important) sales forecast decision on costs was unambiguous and the ambiguity of the value change decisions fell between the two.

Ambiguity is not static. As a simulation progresses participants learn more about the effect of decisions and get better at interpreting results causing ambiguity to decrease. Ambiguity is also affected by the *economic* and *business* progressions where seasonal patterns, stochastic sales variation, changes in elasticity, etc. can disguise the effect of price on demand and, consequentially, lengthen the simulation. During design, it was decided that as seasonal patterns and stochastic sales variation could be discussed during the ending review and adding them to the simulation would increase duration and hence reduce learning efficiency without increasing learning effectiveness.

Granularity

Hall (2009) defines granularity as the number of possibilities that exist for a decision and the degree of detail for results. Granularity impacts time - the length of time taken to make a decision and interpret a result. Highly granular decisions involve participants entering a number and the choice of number requires the greatest amount of cognitive processing and take the longest time. Low granularity decisions involve choices between a few options and take the least time. High granularity results consist of raw data and processing this data reduces granularity. For example participants could be provided with highly granular accounting information, with performance measures (such as profitability, growth and liquidity) lowering the granularity and charts or dashboards having low granularity.

In the pricing simulation prices were granular as they could be set to the nearest whole number in a range between 70 and 200 (131 possible values). Likewise sales results were also granular (ranging between 30 and 300). But for options like menus from a Celebrity chef or "ugly" vegetables were low granularity binary, Yes/No decisions where cognitive load was low and, so, the value option decisions should be made faster than the price decisions.

The granularity of results was limited with demand and results with few significant figures. Sales demand was to two or three significant figures and granularity was lessened by having initial prices, sales demand and costs the same for each of the four market sectors. The alternative would be to have different initial prices, demands and costs for each sector. This was rejected for the pricing simulation as it would lead to additional processing as participants dealt with the additional granularity and it was felt that this would not be relevant.

Cognition prompts

The length of time around the cycle has implications in terms of the necessity for reflection (Gosen & Washbush, 2005; Gosen, 2004) and there is a need to plan for this and reinforce it. If insufficient time is provided for a period this will lead to role overload (French & Caplan, 1972) and will impact learning and engagement. Fripp (1993) and Hall (1995) emphasise the need for sufficient time to reflect and conceptualise. Cognition prompts are pre-planned textual statements positioned in the decision-making cycle (figure 2) to stimulate reflection and concept formulation thus:

1. immediately before decisions are entered,
2. immediately after simulation (before analysing results)
3. and immediately after result analysis (before re-planning).

The prompt before decision entry makes participants review and reflect on the decisions that they are about to enter. The prompt after simulation and before the results are analysed suggests issues to focus on and can be used to introduce new reports. The prompt after result analysis and before re-planning serves to suggest discussion areas and introduce future tasks and decisions.

For the price simulation, after reviewing the first period's results, participants received a *price sensitivity rubric* that provided a structured approach to assessing price sensitivity. This was designed reduce ambiguity and initial confusion by getting participants to revisit and improve their assessment of price sensitivity. After simulating the second period and before analysing results a prompt introduced a new report that showed the impact of idle capacity on costs. Cognitive prompts are introduced to ensure a timely focus on specific learning needs.

Reflection Triggers

Unlike cognition prompts that are pre-planned, reflection triggers are textual comments produced reactively by the simulation to stimulate thought and discussion. Reflection Triggers occur at two points in the decision-making cycle.

1. After entering decisions (before simulation)
2. After simulation and are provided as part of the period's results.

As appropriate, the pricing simulation provides comments about each sector's profit levels and how purchasers felt about value changes were made after simulation. Besides stimulating thought and discussion, reflection triggers can help reduce ambiguity. In the pricing simulation, after implementing a value change, comments were made by purchasers describing their positive or negative views of the value change. For example, children of Family Box purchasers commented that they *"liked the naughty (ugly) vegetables"*.

TEMPORAL IMPACT OF META-COMPOSITION

A simulation's duration is a key design and adoption constraint (Hall, 2005) and this leads to asking whether we can quantify the impact of meta-composition on duration. Hall & Cox (1994) empirically linked simulation duration with the number of decisions made for eleven simulations ranging in duration from two hours to two and a half days. Their study found that duration was highly correlated with the number of decisions made. The systems dynamics response of these simulations was basic rather than natural (Figure 1 a & b). That is to say meta-composition was not used in their design with no task or viewpoint progressions, no purposeful use of economic, business and issues progressions, decisions were highly granular, no attempt to manage ambiguity or use of cognitive prompts and reflection triggers Thus the Hall and Cox study provides a starting point to assess the impact of meta-composition on duration.

In 2004 one of the eleven simulations was radically customised for a client to raise specific, relevant management issues (Challenging the Sales Force). This customisation increased the number of decisions from 9 to 15 (an increase of two thirds) but the client required the simulation's duration to be no more than a day (8.5 hours) although this increased the original simulation's duration from 6.75 hours (an increase of 26%) it was much less than the duration based on the Hall and Cox formula (12 hours). This reduction in duration was achieved mainly by the use of task and topic progressions where decisions and reports were introduced progressively and to a lesser extent by making four of the decisions low granularity (yes/no decisions). Ambiguity was not managed and Cognitive Prompts were not provided but there were a few Reflection Triggers. The progressive introduction of decisions reduced the total number of decisions reducing the probable duration to 9 hours (Hall & Cox formula). Feedback from the client based on running the simulation eight times (with some 200 participants) showed that the task/topic meta-composition had successfully reduced duration and, in the words of the client, *"the continuous introduction of new ideas kept everyone interested"* and bearing in mind that the participants were sales people *"Throughout the training, there were never problems with people checking email, voicemail and so on"*. Both comments suggest that besides providing relevant learning, meta-composition impacted engagement.

The experience with the 2004 simulation suggests that one can assess the impact of task/topic meta-composition on duration and extend this to cover other meta-composition aspects of the pricing simulation. Without meta-composition, participants would make 24 decisions each period (144 decisions over six periods). Based on the Hall & Cox formula this would indicate a duration of about 14.7 hours (figure 4). The temporal-topical progression reduced the total number of decisions that could be made during the simulation to 68 (a reduction of 53%) with a duration of 9 hours. By applying a capacity limit across the whole business simplified the simulation requiring a single price decision to be made and this could reduce the total number of decisions needed by a further 11 (to 57) with a duration of 7.5 hours. Ambiguity reduction (through cognitive prompts and reflection triggers) could reduce the need to revisit decisions and the number of decisions needed by a further 18 decisions (to 39) with a duration of 5 hours.

As shown in Figure 4, one can suggest that the impact of meta-composition decision reduction reduced duration to 5 hours but there was a need to reduce it further to two hours. This was achieved through the low granularity (yes/no) decisions, structural simplification, stylisation, cognitive prompts and reflection triggers.

CONCLUSIONS

The completeness of the meta-compositional elements described here and whether there are other elements that impact learning and simulation duration is a potential area of investigation. In all probability, there are other elements as the meta-compositional elements described parallel the graphic compositional elements explored by McCloud (1993 and 2006). However, other parallels might be drawn from art and the work of Poore (2003), Dow (2013) and others.

Another issue is the extent to which meta-composition can be used to analyse an existing simulation design just as one can analyse the composition of a picture. Poore (1903) not only described fine art composition "musts" but also touched on "must nots". For business simulations "must nots" might include incorporating elements that are not directly germane to learning purpose yet add to cognitive load, duration and reduce learning. In dynamic systems *"noise"* has a blurring effect (Longtin, 2003) and impacts the desired response (Antonic et al, 2007). For business simulations one suggests that there is a parallel - *cognitive noise* - that is caused by including inappropriate parameters, decisions and results.

The way meta-composition the reduces the number of decisions and through this cognitive load goes part way to explaining duration. However, there is still a need to quantify how other elements (structural simplification of linkages between decisions, the model and results, model stylisation, model simplification, granularity, cognitive prompts and reflection triggers) impact duration and how "must nots" like cognitive noise increase duration and impact learning. However one has to wonder whether this can be done empirically but must be done heuristically based on the experience and skills of the simulation designer.

Meta-composition provides a third dimension to business simulation design beyond creativity and craftsmanship. Creativity was illustrated here by the choice of scenario (meal box supplier) that allowed pricing to explored in an engaging way appropriate for SMEs. Business simulation craft skills include business modelling, software design and business theory. For the pricing simulation these included modelling price elasticity and financial outcomes and the business factors associated with consumer responses to price and drive value.

Meta-composition provides a way of focusing design on cognition (effective learning) and cognitive load (efficient learning) independent of the real-world situation modelled. Poore (1903) suggested that *"without composition, there can be no picture"*. This paper suggests that *"without meta-composition, there can be no learning."*

Figure 4
Possible impact of Meta-Composition decision reduction

	Decision	Duration	
Without Meta-Composition	144	14.7 hours	Based on Hall & Cox formula
with Temporal-Topical Progression	68	9.0 hours	assuming all decisions are highly granular
with Simplification	57	7.5 hours	Single Capacity Limit
with Ambiguity Reduction	39	5.0 hours	wholly effective ambiguity impact

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