

# Labelling the problem in causal diagrams

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## Abstract

System dynamics and systems thinking focus their modelling on a ‘problem’, but somehow the elements of the problem — such as concerns, objectives, or sought action — are not labelled in such terms on their causal loop diagrams (CLD). A new variant of causal diagrams, known as descriptive causal diagrams (DCD), initially developed for use in spatial planning, is structured around the ‘planning problem’ and provides the necessary labelling. The article juxtaposes the two types of causal diagrams, DCD and CLD, with respect to problem labelling.

## 1 Introduction

Many system dynamicists and/ or systems thinkers strongly defend that modelling must start with a purpose: typically a ‘problem’ or, at least, an expression of an ‘issue’ or concern. [Sterman \(2000, p.90\)](#), for instance, sums this up memorably as: ‘*Always model a problem. Never model a system.*’<sup>1</sup> However, despite the strong voicing of the problem-based modelling, the relevant causal diagrams<sup>1</sup> do not contain any labelling of the problem elements, such as ‘concern’, ‘objective’, ‘action’, or ‘outcome’. Consequently, the causal diagrams are more about the dynamics of the *system* than about the problem. Let us illustrate this with an example of a ‘textbook’ type of CLD, such as in [Figure 1](#).

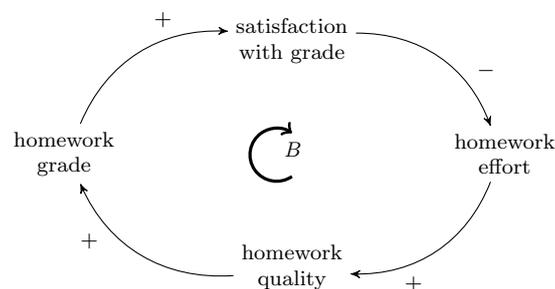


FIGURE 1 A typical ‘textbook’ CLD does not contain labels such as ‘action’ or ‘concern’

Figure 1 describes how a ‘normal’ (that is, non-obsessive) student can maintain her or his homework grades. The ‘action’ and ‘concern’ of the problem are implied — for instance, the action is likely to

<sup>1</sup>This concerns chiefly the causal loop diagrams (CLD).

be at the ‘effort’ node, while the concern is probably the ‘grade’. Nonetheless, the problem elements are not labelled with any ‘meta-information’ — contrast with Figure 2.

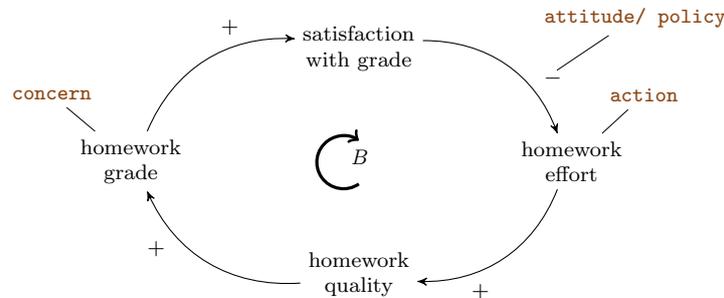


FIGURE 2 Meta-information could appear on a CLD, to label elements of the problem such as ‘action’ or ‘concern’

Figure 2 features labels for the parts of the problem, so it becomes evident what the ‘concern’ is and exactly where the ‘action’ is. The labelling of the problem elements could also demonstrate (and guide, in a learning phase) the reasoning of the problem analyst — for instance, does this ‘action’ correspond to that ‘concern’? And this labelling would make the reading of the diagrams more comfortable for the problem solver — for instance, to identify safely and conveniently all concerns or all actions.

Besides the key elements of the problem, Figure 2 also labels a crucial ‘non-element’ aspect of the problem: the attitude (or policy) of the student — in this case, the ‘normal’ or ‘reasonable’ student who is alarmed with a low grade and tends to recuperate, and does not make an extra effort without a need. On the other hand, ‘obsessive’ students would have a plus sign between ‘satisfaction’ and ‘effort’, which could either take them on a reinforcing trip to the top, or to discouragement and failure. Hence, much meta-information can be added to a classic CLD to label key elements and aspects of a particular problem, which is valuable to anyone interested in the problem — for instance, in its definition, solution, simulation of the solution, verification, assessment, or implementation.

While problems in system dynamics/ systems thinking practice are documented in the text that accompanies the CLDs, it seems that there is no tradition in labelling the problem on the diagrams. Added evidence comes from the fact that the specialised system dynamics software have no pre-defined options for the special labelling of ‘meta-information’, other than generic plain text annotations. Without clear problem-labelling on the diagrams, the message that we should be modelling problems (and not systems) may be not strong enough — at least, it is not reinforced in the common objects of work: the CLDs. Thus, younger system dynamicists or system thinkers may be led to start modelling in ‘exploratory’ modes, creating ‘system diagrams’ instead of ‘problem diagrams’ — that is, without a definite problem in view — something for which they are often reprimanded by their elder peers.

## 2 Causal Loop Diagrams (CLD)

Guidance for developing CLDs has been issued by several prominent scholars, such as Richardson and Pugh (1981), Roberts et al. (1983), Richardson (1991), Coyle (1996), Maani and Cavana (2000), Sterman (2000), and Homer and Oliva (2001). The development of CLDs has been accompanied by various observations and recommendations for improvement, and some of these may provide

insights to the problem-labelling issue. For instance, it has been considered desirable to distinguish stocks and flows in CLDs (Richardson, 1997) (Sterman, 2000, p.167), which also implies appropriate labelling, but this has not been incorporated into mainstream practice. In addition, a number of CLD analysis contributions could potentially benefit from some kind of labelling or notification on the CLD itself — for instance, feedback loop dominance (Ford, 1999), influential system structure (Mojtahedzadeh et al., 2004), model structure analysis (Oliva, 2004), and soundness of argument (Cavana and Mares, 2004).

While all these labelling issues remain to be explored or implemented, let us consider a resolution to the special issue of problem-labelling, which has already been implemented into a new kind of causal diagrams, known as ‘descriptive causal diagrams’ (DCD).

### 3 Descriptive Causal Diagrams (DCD)

Spatial and environmental planners — for instance, urban and regional planners, and the impact assessment professionals, correspondingly — have a remarkable appreciation for forecasts. Their diverse origin of academic preparation, ranging from geography to civil engineering and from architecture to environmental engineering, reflects their varied attention to ‘systems’ and related instruments of analysis and study such as CLD. So, while the ‘convinced’ ones — typically from an engineering background — can work well with the standard versions of CLD and the information therein, there is a special challenge to cater to the ones who lock onto specific forecasts, or ‘what is likely to happen’.

In this context, progressive experimentation with modifications on standard CLDs has led to a number of causal diagram variants (Perdicoulis and Glasson, 2007; Perdicoulis et al., 2007; Perdicoulis, 2008; Perdicoulis and Piper, 2008), which selectively converged to the more stable form of descriptive causal diagrams, or ‘DCD’ (Perdicoulis, 2010). Driven by the needs of spatial and environmental planners — but not confined to this scope of applications — and building on system dynamics/ systems thinking CLDs, DCDs evolved to have three distinct features, described below.

**DESCRIPTIVE CHANGE** Change in DCDs is expressed descriptively, and not in relative terms, which is a significant deviation from CLDs. Let us assume, for instance, that the value of an upstream element increases; *ceteris paribus*, in a positive link polarity, the value of the downstream element would also increase. Whereas the standard CLD arrow conveys the symbol of the link polarity (+), in the DCD the arrow conveys the change to the downstream element (‘increase’). Thus, DCDs make an ‘information commitment’ that deprives them of the general validity or flexibility of CLDs’ ‘relative change’ — for instance, the same positive link polarity could also accommodate a ‘decrease–decrease’ pair of changes.

**ELEMENT TYPES** System elements in DCDs are classified according to their role in the problem — for instance, ‘concerns’, ‘intended outcomes’, or ‘action’. If used in the encompassing extended causal thinking (ECT) planning method, DCDs have a defined set of element types in the ‘XYZ’ model of problem definition: X, or the action, which is typically sought; Y, or the concerns; and Z, or the outcomes — either intended (Z) or forecast (Z’). It is important to highlight that ‘problem’ in ECT is not synonymous to ‘difficulty’, but it is closer to the sense of a fully defined mathematics problem — see Perdicoulis (2010, pp.58–66).

**MANUAL SIMULATION** So far, DCDs are prepared for use with qualitative information, which makes simulation suitable for a ‘manual’ mode — literally, done by hand, as in CLDs. However, whereas CLDs can be transformed to SFDs for numerical simulation, DCDs remain qualitative throughout the simulation phase. This limits the number of iterations to one, or generally to

a small number, but permits a closer interaction of the user with the model upon processing the qualitative information.

The rules of DCDs are slightly more elaborate than those of CLDs, and extend beyond the differentiation of system elements. The semantic categories of DCDs include all of those found in CLDs plus two more: the action and the effects (Perdicoulis, 2011). In addition, causality is differentiated in two types: physical causality, with the same sense as in CLDs, and logical causality, which reveals reasoning — for instance, expressed in terms such as ‘means’ or ‘therefore’.

## 4 Juxtaposition

To appreciate the differences between CLD and DCD, let us consider an example from academia: the publishing strategy of a university department. The case is treated generically, and the problem can be expressed as: ‘what should we do to boost publications in our department?’. Figure 3 presents the analysis of the problem and two suggested complementary answers in a classic CLD format. After some inspection, it may be possible to identify the main elements of the problem, but they are not immediately evident because they are not labelled.

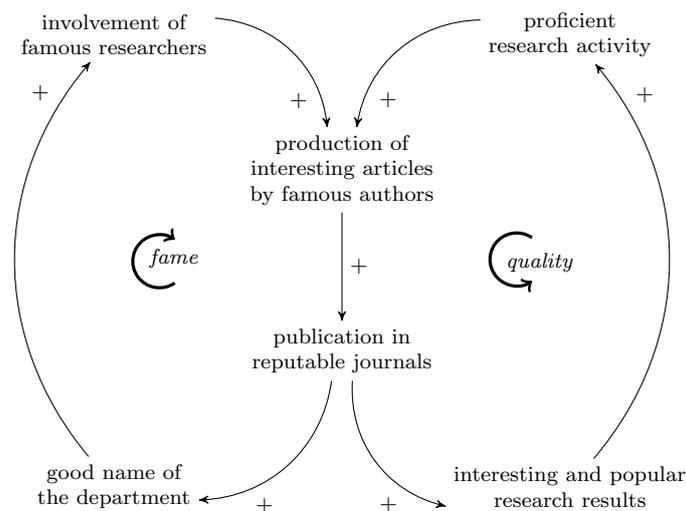


FIGURE 3 The CLD for the publishing strategy identifies two reinforcing loops

Figure 4 is a simplified (non-standard) DCD, intentionally made similar to the CLD of Figure 3. However, the notation on the arrows of the DCD shows ‘information commitments’ about the causal relationships: the dashed arrows convey logical causality, and the solid arrows convey physical causality. The snake-like arrow is a ‘check’ operation to see how well the problem is solved — and it seems that the solutions are synergistic and effective.

Another difference in the DCD is the labelling of the elements of the problem in an ‘XYZ’ notation. Hence, it is easy to know where to start — typically with the concern (Y) — and how to proceed with defining objectives (Z), figuring out what to do (X) for each objective, forecasting the likely outcomes of each action (Z’), and finally closing the loop by returning to the concern (Y) to verify whether or not the suggested solution is effective. Although loops are labelled in the DCDs presented in this article, this labelling was optional in the Mk.I DCDs.

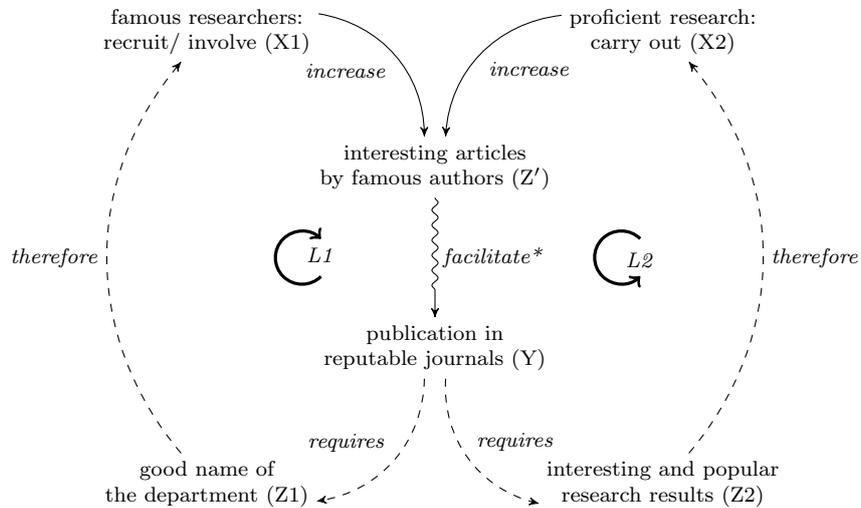


FIGURE 4 The DCD for the publishing strategy reveals an alternative perspective, labelling the parts of the problem in the 'XYZ' terminology

Figure 5 presents some visual enhancements to the previous DCD, which further facilitate the identification and classification of the different elements. The notation used here is an evolution from the DCD Mk.I, aimed towards space economy: for larger strings of text, rectangles occupy less space than circles. The spatial arrangement of the elements is typical in DCDs, and in this case follows a top to bottom direction, from concern to forecast outcomes.

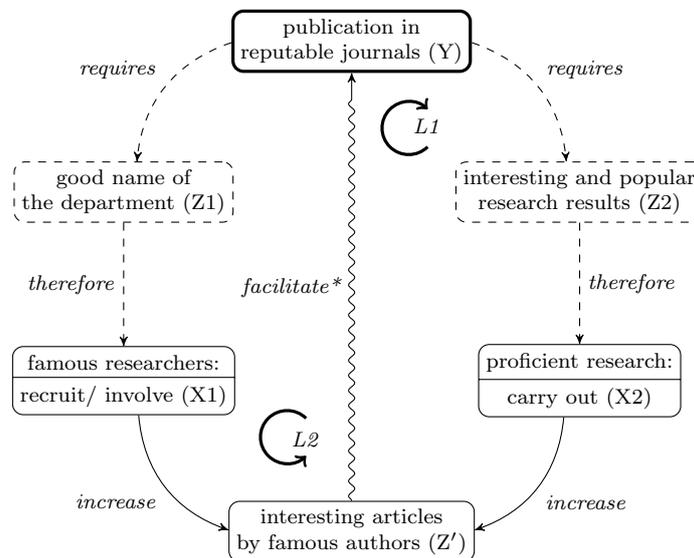


FIGURE 5 The elements of the problem are identified somewhat easier if they are represented as different shapes

## 5 Discussion

‘Meta-information’ labelling on causal diagrams can clarify important aspects, such as the problem elements or structure, as demonstrated with the DCDs, or potentially other issues, such as the pending issue of differentiation between stocks and flows in CLDs, as mentioned earlier. In the case of problem-labelling, this meta-information would also permit the definition of a problem-structure, whether in a teaching mode, verification mode, or a reading/ communication mode. This would elevate the causal diagrams to a ‘problem-platform’, which could be a ‘next level’ objective for CLDs — perhaps ensuing in the fashion of DCDs. While problem-labelling is incorporated in DCDs, which function as a specialised, problem-oriented type of causal diagrams, CLDs could adopt such labelling as an option.

The addition of extra information on causal diagrams is capable of super-charging them, and perhaps rendering them un-readable or confusing. Furthermore, coordination is necessary across various meta-information or labelling schemes — for instance, problem-labelling on the one hand, and stock-flow differentiation on the other. While individuals potentially have the capacity to generate such conventions, their management would be effective and useful only under the guidance of a single authority — whether this already exists or not. Software developers may have an important role in this matter, both for the creation and management of labelling schemes. This task is probably more demanding than the typical ‘annotation’ features of system dynamics/ systems thinking software, amounting to a more sophisticated and organised scheme.

In their current development state, DCDs are an option for people such as planners in the public or private sector, who are interested in structuring their problem and can be satisfied with qualitative simulations — while the exploration of a quantitative interface remains an option. Without a pressing need for modifications, DCDs are still subject to fine-tuning as they are still at the beginning of their existence. This article already incorporates three recent innovations for DCDs, as suggested in [Perdicoulis \(2011\)](#).

## 6 Conclusion

The development of descriptive causal diagrams (DCD) was motivated by the need to identify the key elements of a problem on a causal diagram, such as concerns, actions, and outcomes. DCDs, with their special conventions, come as a practical demonstration of effective practice to a long-standing issue in system dynamics and systems thinking, namely problem-based modelling. Although DCDs are currently geared towards qualitative information, the problem-labelling experience could also reach system dynamics through the classic causal loop diagrams (CLD), by incorporating optional problem-labelling layers. Keeping a constant focus on the problem is valuable training for system dynamicists and systems thinkers as problem-solvers, and consolidates their modelling skills.

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