

# The genesis and pursuit of breakthrough innovation with the Drupal ecosystem as a living-lab for R&D management

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**In order to use imagination as a sound R&D management method, we need laboratories and experiments to test the validity of visions. In this paper, we explore the opportunity to conduct empirical research on the design of an innovation support system. In our case, the Drupal ecosystem is seen as an emerging living-lab for R&D management. The Drupal ecosystem has an intrinsic and high-technological culture and is therefore becoming an interesting innovation medium. A case study will introduce the Drupal ecosystem and its spontaneous innovation phenomena. An experiment, based on the Drupal case, is undertaken with a course called Web Service Development for Business, which has been running two years. This course demonstrates how self-organization could become an operational method via action research: planning, acting and reflecting. In our current reflection phase, we can imagine an opportunity to study the gaps between theory-based innovation management and information technology alignment. This allows us to design the Enterprise Innovation Planning system to provide information technology support for breakthrough innovation.**

## 1. Introduction

Whether R&D management and innovation management will actually result in useful improvements is not a trivial question, particularly in light of the complex adaptive environment in which they function. The development ecosystem of Drupal, an Open Source (OS) Content Management System (CMS), illustrates how self-organization can lead to innovation. The development in the Drupal ecosystem stand in contrast to what is know in management literature were data analysis instead of self-organization is used. As Christensen (2006) explains, data can only provide information about the past and so theory is needed for extrapolation.

Design trends can be observed in order to build robust theories within a complex adaptive environment. One design trend began with Schumpeter's (1975) creative destruction. The design behind this theory is to split innovation into a dichotomy of simple, versus breakthrough problems. Similar dichotomies are, amongst others, component/architectural (Henderson and Clark 1990), continuous/discontinuous (Hamel and Prahalad

1994), incremental/radical (Freeman and Soete 1997) and sustaining/disruptive (Christensen 1995).

Another design trend was initiated by Porter's (1980) competitive advantage. This design focused on managing business value. It moved to the resource-based view (Wernerfelt 1984; Barney 1991) and then shifted to the dynamic capabilities framework (Teece, Pisano and Shuen 1997; Eisenhardt and Martin 2000). A third, more fragmented design trend, is based on alliances. Some related theories, which incorporate this trend, are theories on absorptive capacities (Cohen and Levinthal 1990), ambidextrous organizations (Thusman 1996) and open innovation (Chesbrough 2003).

The above design trends lead to theories, and theories can lead to systems design. Two examples of such systems are the Applegate and Co. big-small design (2003, p232) and Christensen's disruptive growth engine (2003, p278). As the theories converge, a more robust framework becomes available to develop design innovation systems. However, empirical research to test and improve design systems is unknown.

In this paper, we explore the Drupal ecosystem as a living-lab for R&D management research, which allows

for empirical study. A living-lab means that the laboratory is a real environment. Considering we want to investigate innovation, it seems rational to work with a living-lab. Self-organization is the reason we see the Drupal ecosystem as living-lab for R&D management. Self-organization is about spontaneous emerging phenomena. Heilighen (2006) illustrates emerging stages of high order systems in which interactions lead spontaneously to coordination. We shall illustrate that the Drupal ecosystem can spontaneously transform into an open innovation project through its intrinsic culture and diverse businesses.

Spontaneity causes some phenomena to challenge current management research. Other phenomena add new insights into design opportunities. The main difference between our research and current innovation literature is the concept to *cultivate self-organization* instead of the need to control innovation. In the Drupal case, innovation is spontaneous, so there is less need for managerial control, which affects several management theories. Spontaneity also affects technology. Drupal is an emerging technology, as it is constantly developing, and its use of technology is always changing. It is because of these changes and challenges that we decided to consider the Drupal ecosystem as an appropriate laboratory for R&D management research.

Drupal is an Open Source (OS) Content Management System (CMS). Over the past six years, its business ecosystem has grown and some recent success stories have highlighted Drupal shops' work to some larger companies. We start this paper by introducing Drupal as one of the players in the CMS market. We make a reasonable assumption that Drupal has become the dominant design in the market. Interviews are done with companies to gain a view on the emerging phenomena.

Self-organization is the main aspect in our experiment, and for our research, we utilize a course called Web Service Development for Business (WSDB). WSDB is an intensive course given to first year Master of Business and Technology students. Knowing how to program is not a pre-requisite of the course, so the students are often overwhelmed by the information and skills they have to learn. The first year of this course has to be mediated by a tutor. Data shows how, over time, the mediation has been undertaken by the course website. This shift illustrates the relevance of scaffolding. Scaffolding is a term we find in educative and cognitive research and is broader than information technology (IT) support; e.g., it also includes prior-knowledge as a support structure.

The WSDB experiment was applied using the action research method. Action research means being actively involved in change via iterative steps of planning, action and reflecting. While action research by Massachusetts Institute of Technology (MIT) Professor, Kurt Lewin dates back to 1944, it is still a controversial scientific method. In recent years, the method has been accepted by social studies, educational practice and software development programmes. Currently, there is a move to use action research as an innovation management method, and the inclusion of self-organization via computer-mediated learning is seen to improve action research, which we shall call *methodological scaffolding*. In the

planning phase, a medium is designed. In the action phase, self-organization is cultivated using scaffolding. During the action phase, novelties emerge, but they only become clearly identified in the reflection phase. At that point, the fragile scaffolds can be redesigned to become robust support structures, which would initiate a new planning phase.

In a more theoretical attempt, the Enterprise Innovation Planning (EIP) system is designed as a high-level support structure for breakthrough innovation. However, the WSDB experience can be used for more practical planning. In the first EIP action phase, we do not expect a great impact on innovation management, but we expect to create a medium with which we could have more insight into strategy. To make such a medium more concrete, we can become inspired by novelties or spillover effects, which have emerged during the past action phase.

In our current reflection phase, we can expect a further reinforcement of the Drupal ecosystem as a living-lab (later called Drupal-labs). With WSDB, we show the opportunity for micro-spinoffs. Micro-spinoffs stand in contrast to PhD-based spinoffs. The opportunity for micro-spinoffs is seen as a low-end market disrupt for business schools. We also expect an opportunity for academic spinoffs to be used at the high-end of the market by the emerging Technology Transfer Offices (TTO). One can imagine more pro-active TTO to pursue breakthrough innovation if they are properly supported by an EIP system. For low-end and high-end targets, we reach out to people in academia as well as in the Drupal community in order to make our projects co-evolve.

## 2. The Drupal case

There is a topic of ongoing debate in the Drupal community as to whether Drupal is a CMS or a web development framework. It is this hybrid nature, which tells us a lot about the Drupal project. Drupal is not just an OS CMS. It is a project comprising gifted people, who want to make a difference; it has a culture of high-tech (technological) excellence and therefore, it is impossible to categorize the project as having only one of the two features. As an example, there is also a debate as to whether the Drupal code should be object-oriented or not. Some people demonstrate that the current design has benefits over an object-oriented paradigm and that both paradigms need to be implemented. Thus, as soon as it is suggested that Drupal is purely X, there would be another suggestion proving the opposite. It is because of this high-tech excellence culture that Drupal is becoming an open innovation project.

The Drupal culture affects the businesses it attracts. The business ecosystem of Drupal is significantly distinguishable from some of the related OS projects. Often, other projects have one major company behind them. For example, the CMS WordPress has Automattic, while the software platform Eclipse has IBM's RationalDivision. Many point to the company Acquia as performing that role for Drupal, but the differences are significant. While RationalDivision has changed the

licensing in order to make their code OS, Drupal started as an OS and a lively business ecosystem existed before the founding of Acquia in December 2007. We shall illustrate that Drupal's power is its diversity, making it a great experience on which people become hooked. A famous quote in the community frames the experience well: "come for the software, stay for the community."

Open Source (OS) projects are generally considered disruptive innovations, as they redefine the economic value of software development. They are mostly not seen as the leader of the technology. For example Tuomi (2005) criticizes Linux for not being genuinely innovative, as Linux is simply re-implementing functions that exist in Windows. Drupal is a very different case; Drupal is the leader in new functionalities, and the other CMS systems adopt them. Until now, Drupal was often seen as too complicated for most CMS, for example, compared to WordPress, while it was not considered to be sophisticated enough for a web development framework, for example, compared with Ruby on Rails. In 2006, IBM's developerWorks did a SWOT (Strengths Weaknesses Opportunities and Threats)-analysis, showing the unique features of Drupal that make it a perfect tool for web development.<sup>1</sup> Indeed Drupal's disruptive position makes it suitable for innovation research.

### Content Management System trends

To illustrate the role of Drupal in the CMS market, we use Google Trends.<sup>2</sup> It can be criticized that using Google Trends is not academic, as it took us no effort to build the data analysis. Our research contribution is the interpretation, based on our participatory experience, not the data analysis itself. This tool also makes it easy to verify, counter-argue and compare the data.

Google Trends simply returns how often a keyword has been searched over time. Our first chart is to illustrate that the CMS market is re-opening and OS products are taking the lead. This becomes clear by comparing the five trendiest systems: Drupal, WordPress, Joomla, Lotus and Sharepoint. Drupal, WordPress and Joomla are the most common OS systems. The two most common business suites are Lotus (by IBM) and Sharepoint (by Microsoft). In Figure 1, we can see that before 2004, only the business suites were of interest, and clearly, Lotus was dominant.

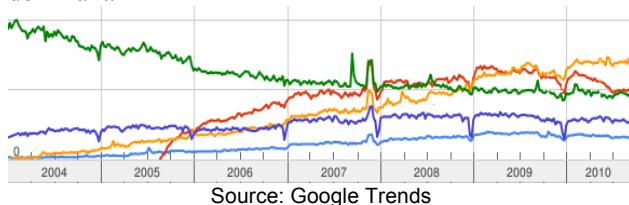


Figure 1. Search trends of Lotus (green), Sharepoint (purple), WordPress (orange), Joomla (red) and Drupal (blue)

<sup>1</sup> <http://www.ibm.com/developerworks/ibm/library/i-osource1/index.html> (consulted 2 November 2010).

<sup>2</sup> See <http://www.google.com/trends> (consulted 2 November 2010).

Lotus lost its trend significantly between 2004 and 2007, and by 2008, OS systems overtook the lead. Sharepoint seems to have been quite stable for the whole period. The sudden appearance of Joomla in 2005 is misleading. We shall elaborate the Joomla case in more detail later.

Drupal has been slowly gaining in popularity, but not as fast as, for example, WordPress. So one can question why we consider Drupal (and not WordPress) to become the dominant design. While Joomla and WordPress focuses on being the best CMS, Drupal is a hybrid that also tries to be the best web development framework. By comparing Drupal to four technical oriented CMS we discover a very different picture, for example, take Phpnuke, Plone, Typo3 and Drupal. Compare the period 2004-2005 (in Figure 2) to the period 2004-2009 (Figure 1). Before 2004, Phpnuke was dominant and again, Drupal was not so popular. By 2008, Drupal clearly prevailed.

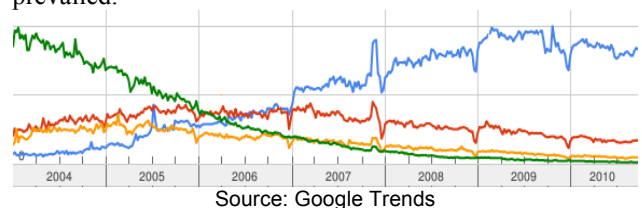


Figure 2. Search trends of Phpnuke (green), Plone (orange), Typo3 (red) and Drupal (blue)

Notice how first, Plone declined and Drupal continued to grow; and shortly after, Typo3 declined. We can suggest reasons for why such an event (Figure 2) is not likely to occur to Figure 1. Notice (in Figure 1) while Joomla declined, Drupal did not grow. The reason for Joomla's decline is better understood when we look at its history. There used to be a CMS called Mambo, yet its community was "forked" (it split in two groups). Figure 3 illustrates how the fork creates a loss of momentum. Now Joomla, Mambo and WordPress are compared. Notice how the loss of momentum allowed the slower, emerging WordPress to take the lead. Joomla's community reacted disappointed when it experienced its 1.5 release. So many Joomla shops are currently converting to Drupal because of the greater business opportunities it offers.<sup>3</sup>



Figure 3. Search trends of Mambo (green), WordPress (orange), Joomla (red) and Drupal (blue)

Based on our assumption, the important question is why Drupal is not becoming trendier. This would require a deeper study, but we can speculate. First, Drupal 7 has been slow to roll out and we expect a boost from the new

<sup>3</sup> <http://buytaert.net/joomla-vs-drupal-business-models-and-commercial-ecosystem> (consulted 2 November 2010).

releases. Second, the most recent trend is to create a Drupal distribution, but these distributions have different names, so they are not added to Google Trend. By looking at the growth in job requests (Figure 4) for each OS CMS, we can identify some evidence for our speculation that Drupal is becoming the dominant design.

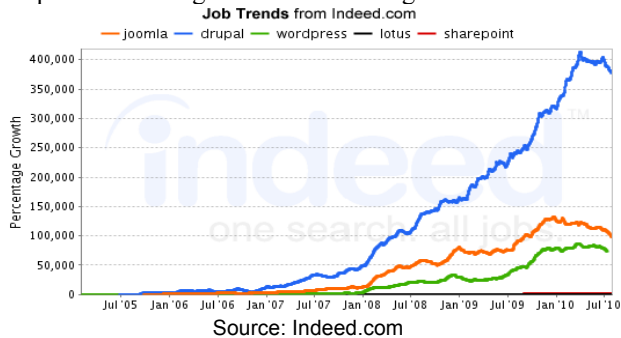


Figure 4. Job trends of Drupal (blue), WordPress (orange) and Joomla (green)

However, even the job trend is not enough reason to expect Drupal to become the dominant design. Our claim is based on the behaviour of complex adaptive environments. We expect the market to emerge into a place where Drupal is a lot fitter. It is expected the change will be related to innovation platforms and enterprise systems.

To illustrate how Drupal is transforming into an innovation platform, let us look at how Drupal has avoided a “fork” with Deanspace. Deanspace, which later became known as CivicSpace, was founded in May 2004 for the presidential campaign of Howard Dean. The large amount of resources available made Deanspace’s development drift away from the Drupal. However, the recognition of new Application Programming Interfaces (APIs) in Drupal’s next release and of the great Drupal community made them rejoin the project in March 2005. In some sense, Deanspace can be seen as an early (and spontaneous) example of how different distributions can lead to innovation for Drupal. Today, Drupal is easily able to develop different distributions and so create IT support structures to aid innovation.

Drupal has become an enterprise-oriented system. For example, Gartner (2009)<sup>4</sup> has put Drupal in the visionaries’ quadrant of the “Magic Quadrant for Social Software in the Workplace”. Joomla and WordPress are not even on the graph. Recent business successes add to the credibility of Drupal as an enterprise solution. To investigate the changes and successes further, we need to get a better understanding of the behaviour that defines the Drupal ecosystem.

### Social-technical people

People express their love of Drupal in unusual ways, like knitting socks or baking cakes with the Drupal-icon, creating a Drupal song, wearing clothes decorated with the Drupal-icon and creating Drupal games. Let us call

these examples, emotional *expressions about* technology, which are different to emotional *expressions by* technology. The former also occur in relation to other technological companies with a strong brand (e.g. Google, Apple and IBM). The latter can explain the incentives of OS communities.

The idea of presenting emotional expressions using coding is difficult to understand for non-developers. Another way to illustrate emotional expressions using technology is given by Wesch’s anthropological studies on Youtube. Wesch (2008)<sup>5</sup> explains how the videocopycat is a way that the Youtube community expresses their appreciation for a particular video. In the Drupal community, we see how the love of a project is an incentive that leads to free contributions like: development, translations, event organization, writing documentations, testing usability or giving free Drupal courses, etc. Notice that such contributions are not restricted to Drupal; they are common to many technical Internet projects.

Management literature on the intrinsic bond between OS developers — or more general contributors — and their projects fails to describe clearly the emotional social-technical relation. An alternative view can be retrieved from Florida’s (2002) *creative class*. The concept seems appropriate to describe OS development. Some examples that define the creative class are an intrinsic drive that blurs the boundaries between work and off-work hours, a broad social network, striving for responsibilities and leadership.

Another theory that may add to the understanding of creative workers is Davenport’s (2001) notion of the attention economy, which suggests that attention is a scarcer resource than money — at least for creative people. The attention economy may give us an insight into how to deal with the shift from extrinsic to intrinsic values. Classically, a company tries to attract excellence by paying staff more money. We have noticed that the main concern for Drupal businesses is to keep their employees happy. This may seem a small difference, but it is a difference that makes a difference.

The Drupal ecosystem is full of creative workers. We can take the founder as a prototypical example. In 2001, Buytaert started Drupal as a hobby alongside his PhD studies. In 2006, he co-founded the Drupal Association (a not-for-profit organization), and later he co-founded two more companies: Acquia in 2007 and Mollom in 2008. When asked why he focuses on collaboration (personal communication), his immediate response was “*it is fun and easy*”. He elaborated that the isolation he experienced while working on his PhD was in great contrast to the collaboration he had felt on the Drupal project and indeed, he liked the latter better. One would expect to see a certain amount of reluctance with his current workload, but he says he is always engaged with work on Drupal. Buytaert likes to be challenged and tries to compensate for any weaknesses by collaborating with people who are better than he is, as it challenges him to do better too. Indeed, he fits Florida’s profile perfectly. We see the

<sup>4</sup> <http://acquia.com/community/resources/library/2009-gartner-mq-social-software> (consulted 2 November 2010).

<sup>5</sup> [http://www.youtube.com/watch?v=TPAO-IZ4\\_hU](http://www.youtube.com/watch?v=TPAO-IZ4_hU) (consulted 2 November 2010).

Drupal ecosystem as a medium that attracts this kind of creative worker.

### *An emerging business ecosystem*

A rich business ecosystem with an impressive diversity has emerged around Drupal. The dozen companies interviewed in this study were all different on some level. Most firms are funded using their own money. Some are funded by cooperatives or venture capital. Businesses may be locally organized, may be virtual firms or may be a mix of both. A panel discussion at the Drupal conference in Copenhagen 2010, clearly illustrates the different perspectives of the various shops.<sup>6</sup>

However, we can also see some similarities. The companies are relatively small; most employ around 20 people, despite the market being very large. The businesses could grow easily if they wanted, but their values — having as much fun as possible and having an impact on the Drupal projects — keep them agile. Indeed this fits perfectly with Christensen's notion of heavy-weighted teams pursuing disruptive innovation.

In order to grasp the diversity of the business ecosystem, we will expand on some individual stories told by the interviewed companies. The order of the stories will enable readers, without any knowledge of the business ecosystem, to understand their dynamics. In no way does the order comment on the importance of the respective companies. The stories will make clear that the idea of having an order of power is contrary to the Drupal culture. Instead, there is a fair distribution of power, aiming to reinforce the Drupal project as much as possible.

### *Business narratives*

The interviewed businesses do not mind changes and challenges. There exists a sense of responsibility, which resulted in setting the values of Drupal first, before concentrating on their businesses values. Such a culture is indeed fit for a complex adaptive environment. We can see this in Liza Kindred's story about Lullabot. She tells that she was hired in January 2006, as Lullabot needed someone to say "no" to potential customers. In Lullabot the feeling existed that the demand for Drupal was so large that more shops were needed. Consequently, they changed their business model to become more of a Drupal training company.

A large market demand can offer other opportunities for change. Matt Cheney explains that Chapter Three was a consulting firm in the summer of 2006. By 2008, its business was site building, themes and training. The team became an Acquia training partner. While they provided the curriculum, Acquia was providing marketing and sales for the training. This enabled them to focus more on what they really wanted to do. We see in this approach, an interesting example of how larger, existing firms can form

alliances with the small-sized Drupal shops.

The largest of the core Drupal shops is Phase2, with 40 employees, half of them developers. Jeff Walpole explains that Phase2 was a custom Java shop in 2001. He wanted Phase2 to be thought of as a leader in software development. However, the Java market was already mature and the new trend was towards outsourcing to India. Therefore, the team looked for other projects, and switched to Drupal in 2005. Today, they have several distributions, they have collaborated on major sites like the Whitehouse site in 2009 and are well known, among others things, for their expertise on governmental sites.

In contrast, Four Kitchens is one of the smallest companies, employing 12 people. Four Kitchens focuses on high, demanding performance and scalability sites, by caching, server architecture, database optimization, etc. While the company is now highly specialized, we see that it did not start that way. Todd Ross Nienkerk explains that in early 2006, the team was working with WordPress on a publishing site. They liked their team and wanted to be creative with the Internet. The switch to Drupal only occurred at the end of 2006, yet by 2007, they had large/high-demanding sites, like fundraising for the Wikimedia foundation.

Palantir was founded in 1996. Tiffany Farriss explains that it was primarily a consulting firm, but it had a CMS of their own, which had 60 clients in 2006. In 2007, one event changed their approach. They had worked on proprietary software for a number of clients, including one, who had used it to build 120 sites. After the projects had been completed, they discovered that the proprietary software company was stopping its client support without telling its clients. She explains that this was a breaking point, and they decided to focus their attention on Drupal. Organizing the Drupal conference (Drupalcon) is one way to dedicate time and attention to Drupal; some examples include Palantir who is organizing Drupalcon in Chicago on May 2011, Chapter Three did Drupalcon San Francisco in 2010 and Development Seed did Drupalcon Washington, DC in 2009.

Development Seed is another interesting company. Today, they are well known for data analyses and their Open Atrium distribution. Eric Gundersen explains that they were working with non-governmental organizations (NGOs) in Peru on micro-finance when the news of Deanspace reached them. They start working on converting Drupal into Spanish. He sees Development Seed as a self-founded R&D company and with Open Atrium they did inspire many Drupal shops. Now their strategy is directed at speed and at dealing with lots of data. This is demonstrated in the Searchlight project, which looks like an advanced R&D project. In our opinion, Development Seed is developing the knowledge, expertise and experience that the community will need in order to pursue Drupal-labs.

Trellon has provided important and systematic sponsorship for Drupal conferences. Trellon is a development shop, which began operating in 2003 with another OS CMS project called Scoop. In 2004, Trellon switched to Drupal. At first, it appeared that Trellon is very common to the other Drupal shops. Yet Michael Haggerty explains that although the team's contributions

6

<http://www.archive.org/details/PanelManagingADrupalConsultingFirm> (consulted 2 November 2010).

were quite tangible, Trellon was less celebrated and interconnected with other shops. We believe this lack of connection was caused by the differences in business culture between the shops. While it may be hard for the shops that experience the clashing cultures, it is actually a great opportunity for the Drupal ecosystem to develop, and to undertake policy research. Trellon illustrates the friction of different business cultures, while Chapter Three illustrates the synergy. This friction/synergy spectrum can lead to research on *business interfaces* for the Drupal ecosystem, which should be examined further in future research.

The story of Commerce Guys also starts with a conflict, but a very different one. Prima Supply is a company selling restaurant equipment that developed an important e-commerce module called Ubercart. However, the particular business has no strategic interest in Drupal and so a conflict arose. This conflict resulted in a competing e-commerce module called Drupal Commerce. Both systems now co-exist in Drupal. The conflict illustrates how internal competition emerges. Mike O'Connor suggests that Commerce Guys has a strategic interest in Drupal development, which leads to co-development events. Some examples are the feature module with Development Seed and the migration module with Cyrve.

One might think that working with Drupal business ecosystems only leads to conflict with extrinsic business values. So let us illustrate a case where this is not so. When interviewing NodeOne, it was astonishing to hear about the magnitude of the businesses pitch. It gave the impression that NodeOne was not at all like the other shops. However, they are the company behind “Drupal the Card Game”, the “Kitten Killers” (a Drupal rock band) and the “human Drupal icon” used during the Paris conference. Thomas Barregren explains that NodeOne has a clear and effective internal and external strategy. So again, this illustrates the diversity and complexity of the Drupal ecosystem.

### *Emerging strategic management*

The shift from extrinsic to intrinsic motivation has led to an *Internet dilemma*. Companies do not know how to make a profit. They make strategic decisions based on experience in non-digital markets. Such strategies do not fit with the Internet. As no other knowledge exists, the Internet dilemma is, in essence, an innovation dilemma.

A key motivation of a creative project like Drupal is to allow creative destruction to become its core value. For example, during the 2007 Drupal Barcelona conference, the keynote presentation by Buytaert explained how the Internet was eliminating the middleman, e.g., Amazon versus bookshops, iTunes versus music stores, etc. He raised the question: “How can Drupal eliminate the webmaster, developer and the designer?” The audience of webmasters, developers and designers reacted with applause. When a company disrupts its own core activity, it may appear as if it is trying to make itself redundant.

By trying to eliminate its own core activity, a company will be more aware of the hard-to-trade skills hidden

within the bulk of its activities. In other words, stripping away the easy problems and focusing on the hard problems, enables a company to create a competitive advantage. When companies expose themselves to hard problems, they become experts in their domain (developing, designing, consulting, training, etc). Therefore, while Drupal may try to eliminate one kind of middleman, it simultaneously creates a medium for creative workers.

In the previous business narratives, we can see several other emerging phenomena. Business leaders recognize the relevance of being agile (flexible and responsive companies employing around 20 people). This selection also creates an opportunity for bigger companies to become involved. Acquia is viewed as a gatekeeper between classic businesses and the more agile Drupal shops e.g., when it supported the training of Chapter3. Here, we recognize a pattern of core versus module development. This is present for coding and now it may emerge for businesses.

We understand that core-versus-modules is a suitable design for open systems. For coding there exists Application Programming Interfaces (APIs). We have suggested earlier a *business interface* to allow other business cultures to interact with the Drupal ecosystem. We see Acquia and other Drupal shops becoming gatekeepers to a larger market and we expect to see the spontaneous emergence of business interfaces within such companies.

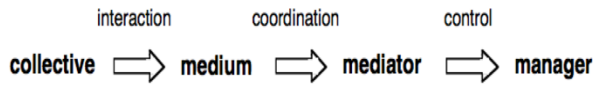
We recognize interfaces as a pattern to design open systems. Next to the business interface, there should be an opportunity for a teaching interface and for an R&D interface too. There is a limit to what can emerge spontaneously, however the friction/synergy that currently exists can be an inspiration for systematically creating interfaces to cultivate the Drupal ecosystems. From studies on self-organization in open systems, we should get a better understanding of how the spontaneous-to-systematic shift actually works.

### *Higher order system stages*

Self-organization phenomena arise within systems far from equilibrium. Therefore, “things” only emerge if enough diversity exists and if a process of natural selection can systematize the effects. Variation and selection automatically tend to create higher order systems out of independent components. This happens through the selective retention of stable assemblies (Heylighen 1999). This can result in so-called complex dynamic hierarchies (Simon 1962). Heylighen (2006): expresses the emerging stages of higher order systems as follows:

Every collection of interacting agents has an aspect system that is simply the medium carrying the interactions. While this medium initially exploits the agents’ activity to survive and grow, selection will make it evolve it into a cultivator that improves the collective fitness of the agents by attenuating conflict and promoting synergy. We have called the next stage of this evolution the “mediator” (see Figure 5). A mediator reduces obstruction, waste of resources and risk of conflict or cheating, and increases complementarity and mutualism by constraining or

directing the agents' autonomous actions so as to achieve the best possible coordination. In the final stage, which we called "manager", the mediator intervenes actively to make agents perform the precise actions that most benefit the collective.



Source : Heylighen (2006)

Figure 5. The emerging stages of the higher order system

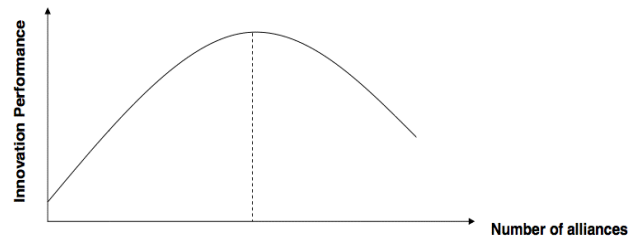
Drupal is currently seen as a medium that is emerging to a mediator. It has a lively diversity with astonishingly little redundancy. Indeed, many conflicts are already solved and synergetic effects are recognized. Consequently, spontaneous coordination arises. When this becomes systematized, Drupal becomes a mediator.

In the interviews, some people were concerned about the concept of "the manager". What is commonly known as a manager is effortful and sometimes forceful control. However, on the contrary, Heylighen suggests it is a self-organizing control. In addition, there is no strict distinction between each stage and not all systems evolve to become managers. For example, our society has some control over its inhabitants via institutions (legal, political, educational, etc). However, a hive (e.g. ants, bees, termites) has more control, as the dynamics of the hive can actually define what type of agent is bred (e.g. worker, soldier, queen). A hive is a system that sits between our society and a full meta-system transition, which would be the manager; for example, our body manages our cells.

### *An alternative view on some management literature*

The Drupal case and the theories on self-organization allow us to give a very different view on existing management literature. We shall look at two examples to develop our claim, one on innovation management and one on IT-alignment. This illustrates the possible opportunities for R&D management research, and, as this is not the focus of the current paper, we shall keep it brief.

Deeds and Hill (1996) illustrate that a positive relationship can only develop between innovation performance and a certain number of alliances (see Figure 5). Once the threshold is reached, more alliances will be counter productive, because they become too difficult to manage. Indeed, the interaction becomes a bottleneck.



Source: Deeds and Hill (1996)

Figure 6. The optimal performance depends on the right amount of alliances

In the Drupal case, interactions are coordinated but not controlled. Coordination arises like a kind of cultivation of the ecosystem, which allows for an unlimited amount of alliances because they are absorbed by the system. Drupal absorbs alliances via its IT support. The IT was created to support OS developers, which has given the developers much visibility. As an effect, it has become relatively easy to figure out who is the expert for a particular module. If another company develops a business interest in that module, they find an ally in the developer. Some stories illustrate how developers function as negotiators within their own companies. In most cases, this leads to collaboration between the companies. In some cases, e.g., the Ubercart versus Commerce module, this can lead to internal competition. The fork does not always have to be negative. As illustrated by Deanspace, the exploration can still lead to integration later on.

By cultivating self-organization, we can make IT-alignment more useful for innovation support and respond to the remaining negative remarks on IT alignment (Yolande, Blaize and Reich 2007):

1. Alignment research is mechanistic and fails to capture real life.
2. Alignment is not possible if the business strategy is unknown or in process.
3. Alignment is not desirable as an end in itself since the business must always change.
4. IT should often challenge the business, not follow it.

None of the above remarks holds for the Drupal case. What we observe with Drupal is agile alignment, or what we like to call *methodological scaffolding*. Methodological scaffolding is action research with IT support that transforms during different phases. The support structure is designed during the planning phase, it becomes scaffolding during the action phase, and then it becomes robust (redesigned) during the reflection phase. The IT alignment actually emerges across the iterations, so it does capture real life (remark 1). The iterative method of action research is a strategy to deal with uncertainty (remark 2). Business needs do change as the emerging IT makes previous business a commodity (remark 3) and so, the IT alignment challenges the business (remark 4).

### *Cultivating self-organization with IT support*

A variety of IT support — like a repository for

contributions (code, documentation, translations, etc.) and communication channels (forums, Internet Relay Chat (IRC), groups, issue-queues, events organization sites) — exists to coordinate interactions. However, with activities shifting, there is always a gap between what can be supported by IT and what needs extra effort to manage. For example, a repository for distributions is an emerging IT support need.

The case of Deanspace was a rare and spontaneous phenomenon. Today, companies are systematically creating different distributions, like OpenPublish by Phase2, Open Atrium by Development Seed or Commons by Acquia, etc. Therefore, the gap to collaborate increases as the extra work about distributions can not be pushed to a repository. The development of new IT-based support for distributions is a reaction to try to close the gap. However, because of the shifting activities, there will always be some gaps within IT-support. As long as the gap is small, this is not an issue. In such cases, these gaps are niches for businesses. As soon as this gap becomes more common, the IT-support needs begin to emerge.

We see in Drupal an emerging open innovation ecosystem. More (1996) illustrates how a whole business ecosystem emerges around entrepreneurial activities, like the Starlight Telecommunication case in Somalia. Chesbrough (2003) illustrates with the XEROX PARC case, how many wrong decisions can lead to the creation of a business ecosystem without capturing its value. With the Drupal case, we can understand how creating IT-support, as a public infrastructure for the ecosystem, can increase the fitness of all the agents of the ecosystem. However, this may not be the solution for which many corporations are hoping. Most companies are still extrinsically motivated, which brings us back to business interfaces.

We may identify current scaffolding structures for business interfaces. Like the support for “roles” within the ecosystem. Today, only the most trustful people in the community maintain some roles, like the core maintainers, conference organizers, document managers, etc. These roles give the people power to control key aspects of the Drupal project. Infrastructure to support control is relatively new. The foundation can function as an institution to protect and support the values of the Drupal community. Companies like Acquia can function as gatekeepers between the Drupal shops and bigger markets. Still, organizational support is only part of the picture. We see new IT-support emerge that will maintain it as an open system. Today, scaffolding exists like “Drupal certification to rock”.<sup>7</sup>

So, what is the next level of IT-support that can develop if roles become more robust and communication channels become clearer? From the narrative, we recognize three issues: business specialization, training and product development by R&D. Drupal is a social-technical hybrid and each issue relates to its features. The social dimension could become the business interface, the technical dimension could become the R&D support, while training combines both. To understand the possibilities, we must be pro-active and work on

pioneering projects, and what better way to do this than with an educational project.

## Web Service Development for Business

There are many opportunities to carry out a study, but they have to be appropriate to the local need. We seized an appropriate opportunity in 2006 and designed the Web Service Development for Business (WSDB) course. The basic objective for WSDB is to teach business students how to manage software development. The basic objective is inherited from prior course called “Programming”. Getting the incentives right, so that students would actually learn valuable skills was not reached with prior course. We decided to take a radical different approach.

The students first needed to develop ideas. Then they needed to explore recent API opportunities to build their projects. Drupal was used for these projects, as the so-called mashup machine. This meant that Drupal was used as a development framework to integrate the APIs, but simultaneously, it functioned as a CMS to provide customer services. Indeed, we made an effort to reach such a hybrid. Students were inspired to take risks because their marks did not depend on how robust the project was, but rather on whether their prototype was convincing enough. Similarly, criteria were defined to ensure that students interacted with each other to reach their goal. The students were overwhelmed by the information and skills they needed to learn. All these features were carefully chosen to create the proper medium for self-organization to emerge.

The WSDB course also functions as research on computer-mediated learning. Christensen (2008) elaborates that new businesses training services could actually lead to the disruption of established business schools because of their approach, like computer-mediated learning support function and modular courses. While we liked this idea, we did not think the case was developed enough. Therefore, we conducted our own experiment and this has led to some strong claims about disruptive innovation regarding business schools. Before we explain these claims, we first need to give a general overview of relevant pedagogic theories.

### *Learning support using scaffolding*

In pedagogic studies, we find there are relations between IT support and computer-mediated learning. In fact, IT support is only a subset of a broader concept called *scaffolding*. Scaffolding was first introduced by Bruner (see Wood, Bruner and Ross 1976) to describe children's oral language acquisition. As children lack prior-knowledge as a support structure, other scaffolding is have to be created to make children learn. Clark (1997, 1998, 2008) uses scaffolding to explain how the environment can have a cognitive support function. For example, one can do limited mental calculations, but by using pen, paper and some simple rules, complicated

<sup>7</sup> <http://certifiedtorock.com> (consulted 2 November 2010)



calculations can be undertaken. We can see how events like conferences are actually scaffolds for collective decision-making using simple constraints, such as time and special distribution.

Bruner's notion of scaffolding relates closely to Feuerstein's (1991) theory of Mediated Learning Experience (MLE). MLE is a method that makes learning more effective. Its techniques include creating the right incentive for the student and creating well-formulated exercises so that the student feels in control. Vygotsky (1978) makes a distinction between independent problem solving and a Zone of Proximal Development (ZPD). ZPD is the zone that can be learned by someone if helped by a teacher. Mediation and scaffolding can expand both the zone of independent problem solving and ZPD. In the WSDB course, we have some data to prove how prior knowledge can be a scaffold that leads to content-based mediation.

The students had to create blogs about their projects. Such projects went well beyond their own capabilities (it was part of a ZPD). During the first year, the tutor had to correct almost every blog (see Figure 7). This was not the students' fault, but because we lacked experience on how to teach them the ZPD, which meant the course material had to be corrected on a weekly basis. This enabled us to understand how the students experienced the ZPD. Indeed, anticipation is well placed to create action, but only feedback by experience can be used to construct knowledge.

Students were both interested and surprised. Early posts had titles like "So I am a Belgian, but yesterday's course was a culture-shock".<sup>8</sup> The second year was a transition year to allow first-year students to finish their projects. The course had a test run in a master-after-master business programme during the first two-year and it became part of "the first year of the Master for Business Technology" curriculum from the third year on. In that year, coordination was only needed at the start of the course. In the fourth year, coordination by the tutor dropped to a minimum. Some questions were not at all trivial, but the collective feedback was as good as any feedback the tutor could provide.

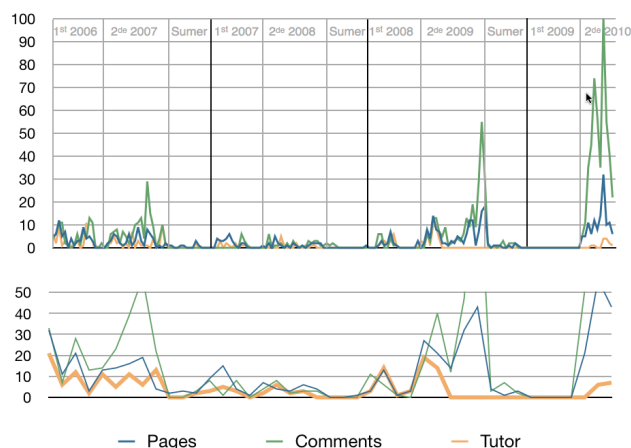


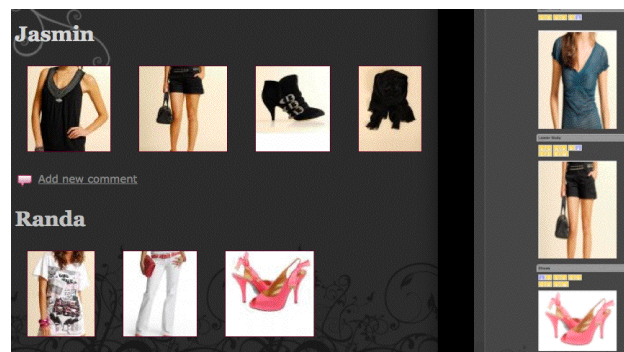
Figure 7. WSDB posting activities over time, the top graph counts per week, the bottom graph counts per month. Separately counting the amount of pages the students posted, the amount of comments students gave and the amount of feedback the tutor had to provide. The numbers of students are: first year, 15; second year, 20; third year, 33 and fourth year 34

A few interesting spillover effects occurred in the third year; some students were selling their projects. However, the best students made something so creative it could be a prototype for a new business service. To improve the output of prototypes, corrections were made in the fourth year. This resulted in more prototypes but also more failures as normally, only the best and most confident students would pursue the creation of a prototype.

The construction of prototypes went beyond the expectations of the study. A pattern started emerging in the projects: by providing a free public service, the users created a unique medium. The medium then developed a competitive advantage, which could be used to target a particular market. Indeed, once again, we saw the idea of cultivating self-organization in a medium, but this time it was used as a business model. The strategy looks like an elegant method to deal with the Internet dilemma.

### WSDB prototypes, the online-wardrobe case

To provide an example, we will examine a project during its third year. There were other excellent and creative projects, but this one required little technical knowledge, which is what made it even more extraordinary. The project was called the online-wardrobe, and was created by El-Ali Randa. The idea was to have an online-wardrobe by uploading images and clustering them by user, as illustrated on the left of Figure 8. Images were organized by giving them tags, like trousers, skirt, sweater, shoes, etc. This made it easy for the user to have control over the wardrobe. This extra information could then be used for other functions, like the three images galleries on the right of Figure 8. Other users could play with existing images and create combinations. The online-wardrobe is fun and encourages the uploading of images. By capturing the activities of the users (e.g., possible combinations of clothes), some interesting data could be elicited for the garment industry, and it is easy to imagine how El-Ali Randa could explore the business opportunities of her medium to provide customers with information about the garment industry.



Source : WSDB project 2009 by El-Ali Randa

<sup>8</sup> See <http://mosi.vub.ac.be/webdev/?q=node/46> (consulted 2 November 2010).

Figure 8. A snapshot of the online-wardrobe site

It is because of the state-of-the-art web technology that it became possible to create such a mashup and this is how business students can create their own micro-spinoffs. Business students often create small shops to exercise their commercial activities. A micro-spinoff is defined as a simple website or shop that can break through the market boundaries and develop to become a medium where innovation can be cultivated. While micro-spinoffs are expected to innovate less than actual PhD-based spinoffs, they could have small but direct revenue and grow over the years. If we could further institutionalize the support of micro-spinoffs, we could actually improve the research competence and make them a real alternative to current academic spinoffs.

### *Reflection and planning Drupal-labs*

The imagination of micro-spinoffs fits a larger historical trend. Mokyr (1990, 2002) illustrates how lowering boundaries to knowledge has increased innovative opportunities. Today, the Internet has destroyed the boundaries (Friedman 2005). We see this effect as an opportunity. In evolutionary terms, bifurcations can emerge that split a growth path in two directions. We see micro-spinoffs forming a low-end market opportunity as one arm of the bifurcation. The second arm is a high-end market opportunity to pursue breakthrough innovations systematically. This requires us to look more closely at current practices relating to academic spinoffs.

Today, the Technology Transfer Office (TTO) is institutionalizing academic spinoffs. Debackere (2010, p 23) clarifies the stages that the TTO has gone through to achieve its current function: from an isolated operation relating to one professional service to a fully diffused activity throughout the university. In this last stage of development, we see the TTO achieving a more pro-active role in the universities. With the WSDB experiment, we see how education can lead to new knowledge. Indeed, innovation is an inherent part of the curriculum.

We can also understand how the difference in core values between businesses and academia makes academia more fit to pursue breakthrough innovations. While businesses require the prospect of economic value, breakthrough innovations are a particular source for new knowledge, which is the core academic value. Of course, breakthrough innovations have the prospect of high-revenue, but this is never certain; however, the prospect of new knowledge is certain. In this respect, we can imagine how academic spinoffs may graduate through the market and become breakthrough innovations. The low-end market disruption by micro-spinoffs could create the necessary pressure to make academic spinoffs move up-market. We would expect it to emerge as a bifurcation or not at all. The high-end opportunity is something we may create by more pro-active TTOs. We see micro-spinoffs and pro-active TTOs as future experiments. Like the WSDB course, it should be researched in an isolated

living-lab environment.

Another challenging task ahead is to bring experiments out of the laboratory and into real situations. We will look at how to bring back this experience to the Drupal ecosystem. We see forking and integration (unforking) as a way to be innovative within Drupal, whether it is a specific module, a distribution, a training package, a research project or any other opportunity. While a repository exists for some aspects, many of the other aspects cannot be contributed, because structure or repositories to regulate contributions do not exist. The repositories are one concern, but the learning about forking and integration would require different IT support that crosses each element in the repository. We would see such IT support as a reinforcement of the Drupal labs.

Several opportunities can be imagined: expanding WSDB, micro-spinoffs, pro-active TTOs and Drupal labs. Which of these choices is pursued depends on the alliances that can be forged. While this may appear trivial, it is not at all. From scientific studies, we learn how laboratories can construct phenomena (Rouse 1987, Latour 1987). Indeed, first they create scaffolding and then more robust support. This happens through a turbulent interaction of well-defined actors (Latour 1999). From these science studies, we see an opportunity to design a new support system, which is more closely related to the self-organization features we have seen so far.

### **Enterprise Innovation Planning**

From the Drupal case, we learn how to use a methodological scaffolding method that makes IT support emerge over the phases of planning, acting and reflecting. We have a larger and more abstract, theoretical view on novelty regulation and we can research how to put this into practice. Novelty is the intersection between discovery, creativity and innovation, which seems to have its own system design (Kiemen 2008). Novelty regulation seems paradoxical, as knowledge is needed for regulation while *novelty is the absence of knowledge*. A metaphor of sailing against the wind can be used to clarify novelty regulation. Sailing against the wind needs a support mechanism to reverse the force of the wind. Similar novelty regulation needs scaffolding to reverse the bias created by prior-knowledge.

Enterprise Innovation Planning (EIP) is designed as an innovation support system based on novelty research (Kiemen 2009, 2010). The name EIP is inspired by Enterprise Resource Planning (ERP). Before the ERP system existed, there were super-accountants that had a holistic view of the company's resources. Now, more people may acquire a holistic view via the ERP system. Today, we see visionary leaders in a similar position as super-accountants before ERP. Notice that super-accountants still exist — the systems only improved the support, they did not replace the accountant or innovator.

With a deeper understanding of the Drupal ecosystem and with the experience of the WSDB course, we can aim to make the EIP system more real. From the research on

novelty, we can identify coordination between four anticipation processes: internalizing, externalizing, directing and learning. The general EIP design (Figure 9) has a Management System (MS) aligned with each of the novelty processes. Groups internalize the innovation, businesses externalize it, and strategy gives it direction.

The Group-MS and Business-MS will create the boundaries of an open system as well as the flow of forking and integrating. Because breakthrough innovations have uncertain effects, the Strategy-MS is not controlling but coordinating the flow. The uncertainty comes from the lack of knowledge. Therefore, a separated management system is dedicated to learning novelties.

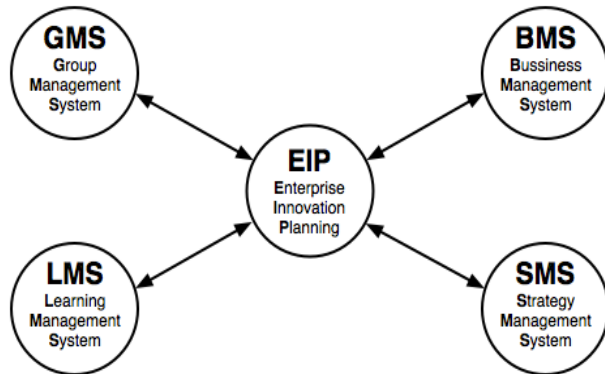


Figure 9. EIP blueprint with management systems aligned to the novelty regulation processes

The EIP is a hyper-novelty model, meaning that each part of the management system is a novelty model of itself. Thus, 16 key performance indicators arise (Table 1). The four indicators for Group-MS are given by Latour’s analysis on science (1999, p 100). We have transformed it slightly to fit the EIP. In the Business-MS, we can recognize strength & opportunity as the indicators of a SWOT analysis and market & process as the indicators of action-planning. The Strategy-MS is inspired by innovation literature, but no analysis seems to combine them all. The four indicators of the Learning-MS come from a software-agent study on creativity (Kiemer 2003, 2006).

<i>Group</i>	<i>Business</i>	<i>Strategy</i>	<i>Learning</i>
Resources	Strength	Bundles	Associations
Public	Market	Brands	Tags
Allies	Opportunity	Networks	Motivations
Peers	Processes	Cultures	Experiences
<i>Actors</i>	<i>Spinoffs</i>	<i>Values</i>	<i>Knowledge</i>

Table 1. Key performance indicators for each management system, each aggregate creates some novelty

Each novelty model creates some novelty: the Group-MS creates new actors, the Business-MS creates new spinoffs, the Strategy-MS creates new values and the Learning-MS creates new knowledge. It then becomes a hyper-novelty model as the four novelties combine create innovation. Each management system should challenge

the other, creating a turbulent medium where innovation emerges out of the co-evolution between actors, spinoffs, values and knowledge.

As we have experienced with WSDB, the mediation depends on the right incentives for the user. We need a proper and useful design, as there are limits to the use of imagination. In fact, we do not expect the details of our model to be correct, but they should contain some truth on which we can act. Anticipation will lead to actions and the actions create experience that makes the details of the design emerge. In the WSDB course, we found some criteria to evaluate the projects, but this was only possible after a mid-term test. The test allowed us to discover the gap between the developing projects and our course goal. Events like mid-term tests allow us to cultivate self-organization.

### EIP-system planning path

The collective blogs on the Internet form a large and unstructured content-based mediation. The power of blogs to create change is well known. What we need in this study is to understand blogs as scaffolding structures for learning (content-based mediation). A dedicated group can go far in a small amount of time. We need the diversity of small, agile groups from an EIP system. Coenen (2006) shows how different types of content (e.g., blogs, forums, etc.) have different knowledge sharing effects. Therefore, we need a variety of content types. Content mediation is considered the first scaffolding structure, but to provide a scale, we require more advanced IT support.

Most content-based mediation has no time constraints. However, we need iterations. The WSDB was done using action research. The summer provided a moment of reflection and planning, and each year, a new group of students would take the course. While experience arises during the action phase, the reflection and planning phase is a kind of natural selection. Cultivating an ecosystem is like maintaining a garden. You need different actions during each season.

Some speculation can help the process go beyond content-based mediation, but we must be aware that we expect practice to correct our anticipations. We see the IT support for Group-MS as a hybrid between the groups and projects. In Drupal, a group is a content-based mediation system gathered around a topic (see groups.drupal.org). This is too unstructured for EIP; however, projects also exist that are a bundle of resources (e.g. code). These projects are too structured (see drupal.org/project), yet a hybrid would allow groups to develop states, like the issue-queue (e.g., open, need work, closed). We should have other meta-information suggesting ways to support forking and the integration of groups.

A Business-MS would be a knowledge-system or CMS, focused on the first three columns of Table 1. It would make visible how business worthy the project is and what still needs to be improved. Therefore, the IT support for Business-MS focuses on the scaffolding effect of structured knowledge, like cognitive maps, balanced scorecards or stage gate processes, etc.

The reason why the indicators of Learning-MS are not part of the Business-MS CMS is that those indicators are meta-relations to find knowledge; they are not knowledge itself. The IT support for the Learning-MS is seen as an advanced social bookmarking system. Particularly, the associations and tags are seen as social bookmarks, the motivation could be more of a semantic-web aspect. It should enable users to tag concrete actions and so build up an unstructured knowledge base that can be used as an input source to build the Business-MS CMS.

The Strategy-MS is based on the novelty-model process “directing”. Directing is only needed to create control over learning. Thus, without directing the system, it would grow spontaneously; with direction, we expect strategic growth. We do not expect that IT support of Strategy-MS is needed in an initial EIP iteration. In a first iteration, we should get a flow of learning and we would be glad of the spontaneous growth. However, Strategy-MS is seen as the most valuable addition to R&D management as it could create a living-lab for management research. We expect to get a better idea of IT support for Strategy-MS after the first EIP iteration. Our current speculation is too naïve to be mentioned.

## Conclusion

Imagination and vision is needed to deal with complex adaptive environments and to manage innovation, but it has its own constraints. Imagination should be used with caution. It is needed to act, but it should not dominate our results. In past IT projects, we have seen how the process of building a tool for users can cause disillusionment. In the case of breakthrough innovation, asking users is not a solution either, as they do not have the technical knowledge to imagine possibilities. A famous quote of Henry Ford says: “*If I had asked people what they wanted, they would have said faster horses.*”

When users are the developers, a very different situation is created. A high-tech community like Drupal is therefore a very interesting medium. We see the medium behaving in a self-organizing way. This medium is implicitly applying state-of-the-art innovation management and even goes beyond known practices concerning IT support for innovation. This medium is considered an R&D living-lab that should get more attention and care by researchers studying innovation management.

We had to go deeper into pedagogic studies (scientific studies and cognitive studies) to understand better the relevance of prior knowledge as a support structure. This brings us to the famous quote of Louis Pasteur: “*In the fields of observation chance favours only the prepared mind.*”<sup>9</sup> We have illustrated how a prepared mind can observe how Drupal is spontaneously becoming an open innovation medium. Likewise, we have illustrated how this can be used in a hybrid research experiment like the WSDB.

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<sup>9</sup> Originally in French: “*Dans les champs de l'observation le hasard ne favorise que les esprits prepares*”.

Our research investigated how a medium can self-organize itself into becoming a mediator and how to use this as methodological scaffolding. With imagination and prior knowledge, we can design or plan new systems. The planning should focus on creating the proper medium. Then the medium should be cultivated in order to steer the self-organization into the direction of the design. The reflection phase has a different purpose than the planning phase. Reflection is a phase that allows us to refactor the fragile scaffolds to more robust support structures. The planning phase is used to imagine new designs that will create new actions.

In this paper, we have shared our latest reflection and identified novelties to pursue, like micro-spinoffs, proactive TTOs and Drupal-labs. Regarding the EIP system, we are still in a planning phase and other projects may become concrete before we act on EIP. The EIP system is, after all, an ambitious project and we may not yet contain the needed aspects to allow action.

We would not like to speculate on the details of these projects, as we understand any attempt to forecast details on breakthrough innovation, is naïve. Instead, we would like to use our own scientific insights and find partners to make our project co-evolve with other projects. One such emerging project is about pre-publishing, which would actually help academic research to catch up with the Internet, while allowing the Internet community to self-develop into a medium for research.

A last but significant task is to continue the WSDB teaching. The current material is still scaffolding and should become more robust and clear so that more people can use it, like creating proper educational materials. We also see a pattern for educational renewal. While courses are still based on existing knowledge, the WSDB has allowed knowledge to be created through teaching. In this sense, innovation is an inherent part of the curriculum and we still provide students with the appropriate skills.

Education is too often seen as a cost structure, where a proper design can create innovation through education, which is very different from educational innovation. Educational innovation is concerned with how to improve teaching. Innovation through education tries to obtain direct value by creating new knowledge. The education output has no economic value during the course, though there may be a direct output later on, like the potential business value in the online-wardrobe case. Our view is inspired by how businesses have become moving targets. Why should education not become such a moving target too?

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