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digiproneurship

New types of physical products and sustainable employment from digital product entrepreneurship

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Abstract The goal of the research reported in this paper was to define opportunities arising from combining advanced Information and Communication Technologies (aICT) with advanced Manufacturing and Materials (aMM). In particular, opportunities to improve the production times and costs of physical products which are person-specific, location-specific, and/or event-specific. This led to definition of opportunities for new types of physical products that are person-specific; location-specific; and/or event-specific; and that can transcend previously intractable trade-offs, such as person-specific fit / functionality versus production times and/or cost. Definition of new types of products led to definition of opportunities for new types of sustainable employment. In particular, sustainable employment arising from digitally-enabled distributed ideation, creation and/or propagation of new types of physical products. Such employment is sustainable because it involves reduced utilization of non-renewable resources. Moreover, this type of employment is sustainable because labour content is low, but multi-networking and technology content is high. Hence, such employment is not vulnerable to off-shoring. The new types of sustainable employment defined through the research can be established through entrepreneurship that leads to enterprises which offer physical products through digitally-enabled ideation, creation, and/or propagation. This new type of entrepreneurship can be referred to as digiproneurship (<u>digital to physical product entrepreneurship</u>). Such a term is necessary to distinguish the combining of aICT with aMM from the use of aICT in conventional digital entrepreneurship that is not concerned with the creation of physical products. It was recognized during the research that traditional entrepreneurship training would not be sufficient to enable digiproneurship. Accordingly, a training programme was formulated. Overall, the research shows how distributed ideation and propagation can be extended from the realm of digital products to the realm of physical products by introduction of distributed product creation that leads to the establishment of Factory 2.0 (i.e. Web 2.0 + highly distributed advanced manufacturing).		
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Preface

The research reported in this VTT Working Paper was funded by Tekes (Finnish Funding Agency for Technology and Innovation), Finnish companies, and VTT (Technical Research Centre of Finland). The research was part of the Finnish research and development project with the short name, SPECIAL. This project short name is a summary for the full project name: Rapid Economic Production of Special Products. Special products are created whenever individuals have authority over design and/or production. Traditionally, larger special products, such as ships and oil refineries, are created through processes which are often referred to as engineer-to-order. Smaller special products, such as furniture and clothes, are created through processes which are often referred to as bespoke.

The production times and costs of special products are often much higher than the production times and costs of mass custom products. This is because mass customizers do NOT offer authority to individual customers. Rather, mass customizers, such as Dell, McDonalds, and Toyota, offer choices from their pre-determined list of options. This means that mass customizers know the geometry of their products and configurations of components before any orders are received. As a result, they have been able to drive down their production times and costs by investing in net shape manufacturing processes and assembly automation. By contrast, companies that make special products cannot predict the geometry of products and the configuration of components. Rather, they have to find out what each individual customer wants. This means that investments in net shape manufacturing processes and assembly automation are often neither technically feasible nor economically viable. Consequently, companies that make special products continue to be reliant upon subtractive manufacturing processes, such as cutting and drilling, and upon the manual skills of human operatives (Fox et al., 2001). These fundamental differences between mass custom products and special products are common across industries (Fox, 2003); and lead to profound challenges in the production of special products irrespective of industry (Fox et al., 2009).

The research and development (R & D) direction for the special project is shown in Figure 1 below (Fox, 2007). In particular, the direction was to enable special products

with standard production times and costs. This involves NOT taking the mass customization direction, for example of the automotive industry, which only offers authority over configuration of pre-designed components to customers. Rather, the R&D direction was to identify / initiate innovations which allow individual customers to have authority over design and production; at standard production times and costs. This R&D direction involved international collaboration with leaders in a number of fields including advanced Manufacturing and Materials (aMM). With regard to this Working Paper, expertise in aMM was provided by the second author: Professor Brent Stucker. Recent developments in aMM offer new opportunities for enabling special products with standard production times and costs. These new opportunities are greatly multiplied when aMM is combined with aICT (advanced Information and Communication Technologies). Moreover, aMM plus aICT offers new opportunities for new types of special products and for new types of sustainable employment. An overview of opportunities and how to realize them is provided in this working paper.

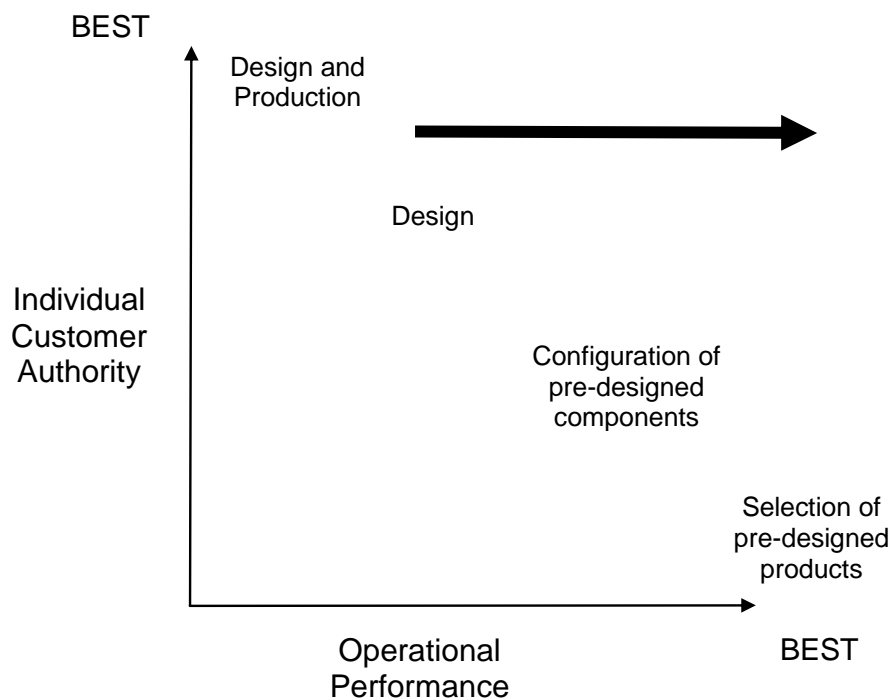


Figure 1. R&D direction of Special project (Fox, 2007).

Stephen Fox and Brent Stucker

Espoo, February 2009

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1. Introduction

1.1 Background

Today, product development, product production and product despatch are often concentrated at the few physical locations of companies' premises. The number of physical locations can become even fewer when companies off-shore product development, product production, and/or product despatch to other countries to take advantage of lower resource costs. The concentration of employment in a few locations leads to nations having regions of disproportionately high under employment and/or unemployment. As a result, nations can have regions of under population with consequent national problems such as infrastructure being under-utilized; long-term territorial integrity being compromised; etc. (Beale, 2000).

However, due to recent developments in advanced technologies there is no fundamental reason for products to be brought to markets through product development, product production, and product despatch being carried out in the few physical locations of companies' premises. Instead, products can be brought to markets through product ideation, product creation, and product propagation being carried out by individuals and communities in any geographical region.

Here, ideation means the forming and relating of ideas. Many established companies are already using digital media to take in the great product ideas of ordinary people, whatever the location of those people. However, such companies are feeding the great product ideas of ordinary people from diverse locations into the few physical locations of existing companies, where they concentrate product development. Here, creation means bring something into existence through digitally-enabled design and digitally-enabled production. Here, propagation means multiplying by reproduction through digital means, for example through digital social networks.

Distributed ideation, creation and propagation can supersede concentrated development, production and despatch due to recent developments in advanced Information and Communication Technologies (aICT) and advanced Manufacturing and Materials (aMM). aICT enables improved information and/or communication by surpassing, in one or

more characteristics, traditional combinations of information and communication technologies. aMM enables improved production and/or components by surpassing, in one or more characteristics, traditional combinations of manufacturing and materials technologies.

aICTs include novel digital interfaces which enable non-experts to create and modify shapes. Further, aICTs include body/place scanning that can collect multi-dimensional data about physical features for input into digitally-enabled design software and onward to aMM. Thus, aICT + aMM is essential to product creation. Further, recent developments in aMM make it possible for digitally-enabled design to take place at any location and for digitally-enabled production to take place at that same location or any other location. Moreover, the aICTs associated with Web 2.0 applications such as digital social networks are essential to the propagation of product ideas and product designs that are created through aMM.

Digital to physical product entrepreneurship that establishes or expands profitable enterprises which offer physical products based on digitally-enabled ideation, creation, and/or propagation can be referred to as digiproneurship. Short definitions of these terms are shown in Figure 2 below.

<u>Definition of Terms</u>
<p>Ideation forming and relating of ideas by individuals or communities</p>
<p>Creation bringing something into existence through digitally-enabled design / production</p>
<p>Propagation multiplying by reproduction through digitally-enabled networks</p>
<p>digiproneurship digital to physical product entrepreneurship digitally-driven entrepreneurship that establishes / expands profitable enterprises undertaking ideation, creation, and/or propagation of physical products</p>

Figure 2. Definition of terms.

aICT + aMM has the potential to generate employment that is distributed across regions which have disproportionately high under employment or high unemployment.

1. Introduction

Moreover, the employment that is generated can be sustainable because it is not vulnerable to off-shoring, and it is environmentally-friendly. Employment that is generated is not vulnerable to off-shoring because it is based on distributed networks in which resource costs are not a major proportion of total costs. Employment that is generated is environmentally friendly because, for example, it involves much lower energy consumption than the established concentration of product development, product production, and product despatch, which often involves shipping of products worldwide from centralized locations. Developments in aMM offer possibilities for new types of products. This is because aMM makes it possible to transcend previously intractable trade-offs such as person-specific fit / functionality versus production time and/or cost; performance requirements versus materials microstructures; and geometric complexity versus production capability. There are many potential markets for the outputs of digiproneurship. These can be markets arising from primary demand or markets arising from derived demand. Primary demand can be digital or physical goods; and can relate to consumer products or social products. Derived demand can be for software, hardware or consultancy which enables digiproneurship. Markets arising from both types of demand can be local or global; niche or mass.

1.2 Research goal

The goal of the research reported in this VTT working paper was to define opportunities arising from combining advanced Information and Communication Technologies (aICT) with advanced Manufacturing and Materials (aMM). In particular, opportunities to radically improve the production times and costs of physical products which are person-specific, location-specific, and/or event-specific.

1.3 Research method

The study comprised literature review and exploratory interviews with experts in aICT and aMM.

1.4 Research reporting

The remainder of this working paper comprises a further four sections. In the next section, the potential for new types of products and employment is explained in more detail. In the following section, the actions required to kick-start one form of digiproneurship are described. In the penultimate section, current and future opportunities for digiproneurship are outlined. In the final section, the conclusions of the research are stated.

2. New types of products and employment

In this section, an overview is provided of new types of production and new types of employment that innovative combinations of aICT and aMM have the potential to establish.

2.1 New types of products

Developments in advanced Manufacturing and Materials (aMM), together with developments in advanced Information and Communication Technologies (aICT), are making it possible for person-specific / location-specific and/or event-specific products to be created much more quickly and at much lower cost. Potential products include, among others: exclusive consumer goods for niche, local markets; consumer goods for niche, global markets; sustainable social products for mass, local markets; and personal social goods for mass, global markets. An overview of selected product types is presented in Table 1 below.

Table 1. Examples of products.

Market	Offer	Example(s)
Niche, local	Exclusive consumer goods	Unique home furnishings, and sauna related products
Niche, global	Targeted consumer goods	Toys and sporting goods
Mass, local	Sustainable social products	Dwellings and agricultural equipment
Mass, global	Personal social goods	Intelligent prosthetics and implants

All of these types of products can have superior characteristics compared to products created through traditional methods. In particular, aMM can enable previously intractable trade-offs to be overcome. For example, design trade-offs such as geometric

2. New types of products and employment

complexity versus production capability can be overcome (e.g. unique geometrically complex products can now be produced as one piece rather than having to be assembled from several pieces); material selection trade-offs such as performance requirements versus microstructures can be overcome (e.g. turbine blades can now have both high strength and high thermal performance); economic trade-offs such as person-specific fit and/or functionality versus production time and/or cost can be overcome (e.g. prosthetics, such as hearing aids with person-specific fit, can be produced rapidly).

aMM enables the production of complex-shaped parts directly from three-dimensional data. aMM has been greatly aided by the advent of additive manufacturing technologies. In additive manufacturing, a 3D computer aided design (CAD) model of the object to be formed is digitally sliced into horizontal cross-sectional layers. These layers are then physically created and stacked to form a 3D object (Stucker and Janaki Ram, 2007). These technologies are fully automatic, can run unattended, and can create multi-material and multi-colour components.

When utilizing an additive approach to production, aMM surpasses, in one or more characteristics, combinations of existing manufacturing and materials technologies. In doing so, **the consumption of non-value adding resources can be radically reduced during the creation of physical goods**. Further, the amount of factory equipment needed and, therefore, factory space needed is radically reduced. As a result, opportunities for smaller, distributed, even mobile, production facilities increase. Some examples are provided in Table 2. Perhaps most importantly, the potential for radically reducing the size of production facilities **enables production at point-of-demand**.

Table 2. Radical reductions in the consumption of non-value adding resources.

Example	1st order effect	2nd order effect
No need for moulds / dies	Less material consumption	Lower start-up costs
Fewer parts to join	Less joining equipment	Less capital tied up in infrastructure
Fewer parts to assemble	Less labour and less assembly equipment	No need to off-shore production to low-labour-cost markets
Fewer obsolete parts/stocks	Less storage space	Reduced factory size

aMM is not limited to additive manufacturing technologies. Any digitally-driven technology which directly transforms digital information (the realm of aICT) into physical goods (the realm of manufacturing) can fall within the scope of aMM. This can include the fabrication of structures which enclose space (such as for housing) whereby

each individual piece could be created using a digitally-driven cutting operation and then assembled at the point of need into a usable dwelling.

When combining aMM with aICT, further time and costs can be reduced. For example, the person-specific physical requirements for medical goods, such as those used for improving teeth location and orientation, can be obtained by body scanning (Istook and Hwang, 2001). The data obtained during scanning can be processed and modified using aICT and transferred directly to aMM equipment to form a person-specific product, such as braces for correcting orthodontic misalignments (Invisalign, 2009). This is just one example of how the combination of aICT with aMM can enable production of truly unique person-specific physical goods at times and costs that are equal to, or better than, the nearest mass produced equivalent. Moreover, it is now possible to rapidly create person-specific goods with performance characteristics that were previously impossible or prohibitively expensive to create. Not least, aMM can eliminate the need for joining of parts made of different materials with different performance characteristics, as aMM enables the direct production of multi-material goods.

It is very important to note that the limitations of manufacturing equipment and the microstructures of materials have previously restricted consumer input to non-physical products (Fox, 2003). For example, a person who reads a newspaper (consumer of the newspaper product) walks down a street and sees something newsworthy. The person takes a photograph of it using a camera phone. The person sends the image to the newspaper. The photograph is included in the newspaper, and hence the person becomes a partial producer of what they consume. While such forms of consumer input are established, it is only now that developments in advanced Manufacturing and Materials (aMM) make possible consumer input into a wide range of physical goods.

From an engineering and design standpoint, aMM technologies are becoming more accurate, they can directly build small products (micron-sized) and very large products (building-sized). New materials have been developed for these processes, and new approaches to aMM are being introduced into the marketplace. From a business-strategies standpoint, aMM technologies are becoming faster, cheaper, safer, more reliable, and environmentally friendly. As each of these advancements becomes available within the marketplace, new categories of physical goods become competitive for production using aMM versus traditional manufacturing (Wohlers Associates, 2008). Combination of aICT with aMM offers a wide range of opportunities for innovation in products and product services. Opportunities exist for individuals (e.g. at home); B2B (Business to Business); and B2C (Business to Customer). Further, opportunities exist for creation of designs; creation of integrated physical components and discrete physical components. Just a few of the product opportunities offered are summarized in Table 3.

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Table 3. Opportunities for product / service innovation.

		Type of Opportunity		
		Individual	B2B	B2C
Involvement in Design /Production	Design	Individual designs a unique flower vase for a loved one	Elevator manufacturer develops unique control panel options for a major customer	Hotel chain offers style options for unique display cases that can be made as mementos of holidays / trips by their guests.
	Production of discrete physical products	Individual uses a 3D printer to build a physical version of a character from a virtual persistent world game. Thus, the synthetic economy and the physical economy are brought together	SME acts as a key supplier to a major shipbuilding company by producing, on-demand, unique plastic goods specific for each ship	Dentist prints a unique toothbrush for each customer with their name and a unique design, while cleaning the customer's teeth
	Production of integrated physical components	Fitted interface for a prosthetic is built based on anatomical data from an individual's own scan	Contractor modernizes an old paper mill, creating robust interfaces with complex geometries between the old and new components	In hot summer, mobile phone retailer in a mall prints mobile phone holders shaped to the arms of individual customers and matching the colours of their sandals / tee shirts

It is very important to note that replacing concentrated product development, product production, and product despatch with distributed product ideation, product creation, and product propagation; makes it possible for individuals or communities to bring products to different types of consumers without needing to make large investment in market research, design facilities, production facilities or despatch facilities. The reasons for this are explained in the following sub-section.

2.2 New types of employment

As summarized in Table 2 above, innovative combinations of aMM and aICT make much more efficient use of materials than traditional production processes, and make it possible for creation of physical products at point-of-demand. This addresses **the global imperative for the elimination of non-value adding consumption of resources**. Further, point-of-demand working can eliminate energy consumption arising from transportation of finished goods. Moreover, creation of physical products at point-of-demand can overturn current comparative DISadvantages in the creation of physical products for global markets. For example, today Finland has the comparative DISadvantages of limited natural resources; far distance from mass markets; and relatively high labour costs. However, aICT + aMM has the potential to make Finland's comparative disadvantages become UNimportant in global value networks. This is because centralized models of physical production can be replaced by distributed models of global value creation. In distributed models, design can take place anywhere in the world, and production can take place anywhere else in the world. As a result, there are opportunities for many jobs to be created in Finland by meeting “derived demand” for the software, hardware and consultancy needed by creation organizations in other parts of the world. These foreign creation organizations may be firms based on established forms of business or enterprises based on sustainable social entrepreneurship. This is in addition to the jobs that can be created in Finland by meeting “primary demand” for physical goods which are used in Finland, Russia, Nordic regions and beyond; or unique designs which can be electronically delivered to consumers worldwide for their creation. Primary demand and derived demand are summarized in Table 4.

Table 4. Examples of Demand for Finland.

Category	Examples	Source of sales
Primary demand	Home furnishing; toys; housing; intelligent prosthetics; unique designs	Most sales inside Finland, only small light weight goods or digital data exported beyond Nordic region
Derived demand	Software for design and production; Hardware for production of physical goods; Consultancy to enable creation in other countries by non-competitors	Most sales to organizations OUTside of Finland in many different parts of the world

2. New types of products and employment

Furthermore, innovative combinations of aMM and aICT make it possible for creation of diverse product types by people without prior knowledge of design and/or production. This addresses **the global imperative for sustainable employment**. In particular, employment that does not depend upon the large scale employment previously offered by industrial plants such as paper mills. In Finland, for example, there are persistently disproportionately high levels of unemployment in some regions. This persistent unemployment could be reduced by enabling a dynamic network of aICT + aMM micro-businesses and SMEs. The jobs created would be sustainable because they would not be vulnerable to outsourcing. This is because they would be distributed among local individuals (working from their homes; from their garages; from their small workshops; from their light industrial premises). They would be distributed among families and communities that have a generational investment and an abiding commitment to the regions of Finland in which they live. Accordingly, the jobs generated by the dynamic new aICT + aMM could NEVER become concentrated in the large premises of multinational corporations and vulnerable to the off-sourcing policies of those multi-national corporations. Further, businesses will be based on difficult to copy innovative combinations of high technologies. Moreover, the labour cost component of aICT + aMM products is relatively low. Thus, these combinations of high technology and low labour input mean that there is no incentive to outsource to low labour cost economies. A summary is provided in Table 5 of the factors that can enable overturning of Finland's current comparative DISadvantages in the creation of physical products for global markets.

Table 5. Overturning Finland's disadvantages in creation of physical products.

Current Disadvantage	aICT + aMM Potential	Future Advantage
Lack of natural resources	Products often make use of relatively small quantities of high quality engineered materials	Finland becomes a leader in the development of high value synthetic and naturally-derived engineered materials
High labour costs	Labour content is smaller, but multi-networking and technology integration content is higher	Jobs will stay in Finland's regions as well as conurbations; and provide high job satisfaction
Distance from markets	aICT + aMM products can be individual, small and light. Therefore, shipping costs are a very minor consideration	Finland becomes a global hub for remote and distributed collaboration in aICT + aMM goods

Important characteristics and effects of aICT + aMM are summarized below in Table 6.

Table 6. Some important characteristics of aICT + aMM products.

Characteristic	First order effect	Second order effect
Overcome trade-offs	Improvements to performance of existing types of products	Opportunities for completely new markets and product offers
Point-of-demand production	Reduced transportation of finished goods and associated environmental costs	Makes existing comparative disadvantages much less important
Not reliant on existing skills	Can create new types of jobs in areas of persistently high unemployment	New jobs are sustainable because they are not vulnerable to off-shoring

In particular, a wide range of people and businesses could offer aICT + aMM products. Some examples of these people and business are listed below:

- artistic individuals who wants to create unique physical goods
- hobby enthusiasts who understands niche market needs
- IT savvy people who are interested in developing novel aICT software tools
- farmers wanting to diversify beyond offering B&B to the occasional tourist
- under-employed persons looking to provide supplemental income for their families
- unemployed people who are reluctant to up-root to major cities to look for work
- machine companies wanting to diversify and/or better utilize its skilled workforce
- SMEs that want to introduce more customer-specific versions of their product offerings
- multi-national corporations seeking to streamline the design and supply of goods which will be integrated into their products.

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As described in the previous section, aICT + aMM has the potential to establish new types of products and new types of employment. However, for this potential to be realized it is necessary to engage in a new type of entrepreneurship. That is entrepreneurship that establishes or expands profitable enterprises undertaking digitally-driven ideation, creation and/or propagation. In this section, an overview is provided of digiproneurship. Then, an example of how digiproneurship can be trained is provided.

3.1 An overview of digiproneurship

Entrepreneurship involves individuals starting new enterprises or breathing new energy into mature enterprises through the introduction of a new idea. Entrepreneurship is associated with uncertainty because it involves introducing a new idea (Drucker, 1993). Digital entrepreneurship involves harnessing the Internet (Hull et al., 2007). Well known examples of digital entrepreneurship include; Facebook; Google; YouTube. These examples highlight that digital entrepreneurship is associated with digital content. By contrast, as shown in Figure 3, the creation of physical goods is essential to digiproneurship.

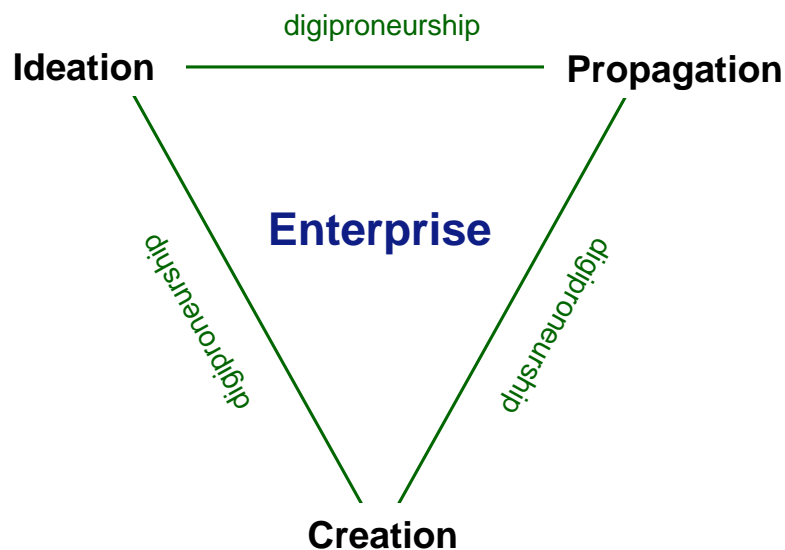


Figure 3. Overview of digiproneurship.

Distributed ideation and propagation of digital content is part of digital entrepreneurship (Tapscott and Williams, 2006). However, the exploitation of aMM to enable distributed creation of physical products is not part of digital entrepreneurship. Accordingly, the term, digiproneurship is used here to distinguish distributed ideation, propagation and creation of physical products; from the distributed ideation and propagation of digital content that is already well-established with digital entrepreneurship. Two examples of potential types of enterprises based on digiproneurship are shown in the Appendices.

Nonetheless, it is important to note that distributed ideation and propagation are essential to reducing the uncertainty traditionally associated with entrepreneurship that involves the production of physical products. In particular, digitally-enabled ideation and propagation of new concepts and potential designs for physical products can eliminate the need for costly conventional market research. Further, digitally-enabled propagation of product designs to point-of-demand aMM facilities can eliminate the need for physical despatch facilities such as large warehouses. Together, digitally-enabled ideation, propagation and creation can eliminate many of the uncertainties that have traditionally caused many entrepreneurial ventures to fail.

The example of digiproneurship training provided in the next sub-section illustrates how uncertainties can be minimized. Further, the example illustrates how traditional barriers to entrepreneurship can be transcended. In particular, these are transcended by facilitating the emergence of enterprise through the self-expression of personal feelings and opinions: i.e. Expressive Enterprise. The structure of the training example is based

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on research by others into the development of adaptive expertise. Adaptive experts are able to discern the specific, and often subtle, features that differentiate one situation from another. Further, they have the ability to modify or invent skills according to the requirements of that situation. Moreover, adaptive experts avoid the unproductive application of previously useful prior learning in new situations. In other words, adaptive experts are able to draw upon their own initiative to deal with a wide variety of different situations (Schwartz et al., 2005).

3.2 Example of digiproneurship training

Training Course Schedule

Ten sessions: two for Ideation; two for Creation; two for Propagation; two for digiproneurship; two for Expressive Enterprise. Sessions followed by remote support.

Training Course Content

Ideation 1

- a) Trainer shows participants three cases of unsuccessful products and contrasts these with three cases of successful products. All are examples of established product types: such as Sinclair C5 (unsuccessful) and Segway (successful).
- b) Participants are asked to express their opinions about why products fail or succeed.
- c) Trainer uses contrasting cases to explain methodologies for product evaluation.
- d) Participants apply methodologies to products which they use themselves e.g. at home.
- e) Trainer gives feedback to participants on their use of methodologies.

Ideation 2

- a) Trainer shows participants three contrasting cases of successful new products.
- b) Participants are asked to express their opinions about these products.
- c) Trainer uses contrasting cases to explain methodologies for generating product ideas.
- d) Participants apply methodologies to generate product ideas based on expression of their own interests, feelings, opinions; e.g a product that is an improvement of a product type that they use at home, in hobby, at previous work, on holiday, etc.
- e) Trainer gives feedback to participants on their use of methodologies.

In conclusion, participants are asked get comments on their product ideas from friends, family, etc., – before next session.

Creation 1

- a) Trainer shows three contrasting cases of design software.
- b) Participants suggest what software would be best for expressing their product ideas.
- c) Trainer uses contrasting cases to explain methodologies for software selection.
- d) Participants use design software to prepare a digital design of their product idea.
- e) Trainer gives feedback to participants on their choice and use of software.

In conclusion, participants are asked to get comments on their product ideas from friends, family, etc., – before next session.

Creation 2

- a) Trainer shows three contrasting cases of advanced manufacturing & materials (aMM).
- b) Participants suggest what aMM would be best for expressing their product ideas.
- c) Trainer uses contrasting cases to explain principles for aMM selection and use.
- d) Participants apply principles to convert their digital designs into physical products.
- e) Trainer gives feedback to participants on their choice and use of aMM.

Propagation 1

- a) Trainer shows three contrasting cases of digital social networks (DSN) such as flickr.
- b) Participants suggest choices of DSN for expressing their product ideas and designs.
- c) Trainer uses contrasting cases to explain principles for selection of DSNs.
- d) Participants apply principles to select DSN.
- e) Trainer gives feedback to participants on their choice of DSN.

In conclusion, participants are asked get comments on their suggested choice of digital social network from friends, family, etc., – before next session.

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Propagation 2

- a) Trainer shows three contrasting cases of number of views via digital social networks.
- b) Participants express their opinions why numbers vary for views using DSNs.
- c) Trainer uses the cases to explain principles for increasing on-line views (e.g. tagging).
- d) Participants apply principles to plan high number of views for their product via DSN.
- e) Trainer gives feedback to participants on their plan.

In conclusion, participants place their product on DSN and are asked get comments from friends, family, etc., – before next session.

digiproneurship 1

- a) Participants and trainer compare DSN on-line comments for each product.
- b) Participants express their opinions why products get different comments on-line.
- c) Trainer uses contrasting cases to explain principles of Web-based marketing.
- d) Participants apply principles to plan on-line marketing of their product.
- e) Trainer gives feedback to participants on their plan.

In conclusion, participants improve their product's presentation on DSN, and are asked to get comments from friends, family, etc., – before next session.

digiproneurship 2

- a) Participants and trainer compare number of positive on-line comments for products, and express their opinions why products got different comments on-line.
- b) Trainer guides participants through an iterative ideation process based upon on-line comments; trainer provides additional software guidance to enable creation of improved product concept; trainer provides additional information on aMM processes, enabling them to better select appropriate aMM processes based upon the design and production benefits and drawbacks of alternative technologies.
- c) Trainer uses contrasting cases to explain principles of Web-based distribution.
- d) Participants apply principles to plan Web-based digital distribution of their products
- e) Trainer provides feedback and guides participants through refinement of their Web-based digital distribution plan.

In conclusion, participants are asked to get comments on their plan for Web-based digital distribution of their product from friends, family, etc., – before next session. In particular, should the product be digitally distributed as: a product concept for instantiation by buyers; as a product design for production by buyers; or as a physical product made by aMM at the closest location to the buyer?

Expressive Enterprise 1

- a) Participants and trainer compare number of views and positive comments for products and participants express opinions about what product has best potential for profitable sales.
- b) Trainer uses contrasting cases to explain principles of product management.
- c) Participants apply principles to rank products in terms of potential for profitable sales.
- d) Trainer gives feedback to participants on their ranking.
- e) Trainer introduces participants to relevant digital production networks for creation of their product.

In conclusion, participants are asked get comments on their ranking of products from friends, family, etc., – before next session.

Expressive Enterprise 2

- a) Participants and trainer contrast number of views and positive comments for products.
- b) Participants decide which one product will be offered for sale on line.
- c) Trainer gives feedback on their decision.
- d) With trainer, the participants review previous nine training sessions in order to:
 - re-evaluate the selected product (Ideation 1)
 - further improve its design (Ideation 2)
 - finalize a digital design that is robust for digital exchange to a buyer (Creation 1)
 - and is robust for physical production by aMM (Creation 2)
 - select digital social media (Propagation 1)
 - maximise number of on-line views (Propagation 2)
 - maximise positive perceptions of product (digiproneurship1)

3. digiproneurship

- refine the product and define channels for Web-based digital distribution (digiproneurship2)
 - plan product management, e.g. price etc. (Expressive Enterprise 1).
- e) Trainer gives feedback and the product is offered for sale via the Web.

Additional Support

Although this comprehensive training introduces participants to all of the various aspects of successful digiproneurship, participants may need additional resources and training, depending upon their background, their product ideas, and the size and scope of their anticipated market. With this in mind, the types of additional support listed below should also be made available.

- 1) **Business Administration** Participants can attend an established course for routine business administration, such as book keeping; completing tax statements; etc. Support can also be provided for administration associated with setting up a business start-up.
- 2) **Skill Knowledge** People who have completed the training course will be able to access relevant skill knowledge on demand in the form of digital skill knowledge objects which can be presented via a wide variety of media, including mobile devices. Skill knowledge enhancement in the areas of digital design (i.e. training on specific CAD packages) and aMM (i.e. detailed knowledge about the capabilities and limitations of specific technologies) may be particularly useful for participants.
- 3) **Participant network** Not everybody who attends the training course will establish a business, but they will have had the training to be able to work in an Expressive Enterprise. This means that Expressive Enterprises do not have to move to a large town or city when they expand. Instead, Expressive Enterprises can increase regional employment by staying where they start and recruiting local people. A participant network will provide access to people who have taken the training course.
- 4) **Global network** People who are interested in Expressive Enterprise will be able to access resources on-line for enabling understanding of different needs and opportunities in different parts of the world. This will be the DSN for Expressive Enterprise. After some time, it will be this network that people will access to view the latest offerings of Expressive Enterprises, and to access digital networks which can create their product offerings at the point of need.

4. Opportunities for digiproneurship

Recent developments in aICT and aMM have enabled enterprises to be established based on digitally-driven ideation, creation or propagation (Freedom of Creation, 2009; Wohlers Associates, 2008). The success of the few existing enterprises is due to their recognition of market needs which can be fulfilled by imaginative product offerings enabled through innovative combinations of aICT and aMM. Pioneers have demonstrated that successful enterprises can be established based upon what is termed “digiproneurship” in this working paper. However, the potential for digiproneurship extends significantly beyond the scope of today’s technological capabilities and business networks. In particular, as aICT and aMM progress, and new business networks are established, the opportunities for successful digiproneurship will expand. Several research priorities have been identified through the development of this working paper. These include research priorities for both aICT and aMM, and for business networks which will arise to support digiproneurship:

Research & development priorities for aICT

- Development of geometric manipulation tools with intuitively understandable interfaces which can be used readily by non-experts.
- Application of shape grammars and computation semantics to enable experts to create versatile parameters for digiproneurship products. These parameters conform to criteria for e.g. safety and brand, but facilitate the creation of person-specific, location-specific, and/or event-specific versions by non-experts.
- Web-based digiproneurship tools which can enable non-experts to set up and operate their own digitally-driven enterprise. These web-based tools encompass market opportunities and business issues; as well as technology characteristics and material properties.

4. Opportunities for digiproneurship

Research & development priorities for aMM

- Continuing the current trend to lower-cost equipment and materials
- Automating and minimizing post-processing of products after production, so that parts can go directly from a machine to the end customer with little or no human-interaction
- Continuing the current trend to increasing diversification of machine sizes, speeds and accuracies
- Interfaces to automatically convert multi-material and multi-color user-specified requirements directly into digital manufacturing instructions without human intervention.

These are some of the advances in aICT and aMM that will spread digiproneurship; and so lead to many new types of physical products and sustainable employment.

As digiproneurship matures, there will be an increasing number of creation facilities that enable digiproneurs to reach customers irrespective of their physical locations. Some of these creation facilities will be the 3-dimensional corollary to today's local copy / publishing centres. They will offer additive manufacturing via object printers that may stand alongside other printers that produce paper documents. Further, companies in all sectors may lease object printers, in the same way that they lease document printers today. As shown in Appendix A, digiproneurs need not own, nor even lease, object printers themselves. Rather, they need only enable particular digital interactions. Creation facilities may also be located within department stores (e.g. for customer-specific exclusive goods such as jewellery). Moreover, creation facilities may also include equipment for subtractive manufacturing as well as additive manufacturing. Such creation facilities may be located in large hospitals (e.g. for patient-specific intelligent prosthetics); home improvement stores (e.g. for family-specific seating); industrial wholesalers (e.g. for plant-specific upgrade fittings). Competition and cooperation among creation facilities that provide services to digiproneurs will be enabled by aICT. Those who establish these creation facilities will themselves be digiproneurs; and aid other digiproneurs in creating physical products. Development of digiproneurship infrastructure will lead to an increasing ability by digiproneurs to ideate, create and propagate competitive new products, resulting in a sustainable model for distributed employment wherever digiproneurship is embraced. This, then, will be Factory 2.0. As Web 2.0 has seen the move from static web pages to dynamic and shareable content; Factory 2.0 will see the move from static factories to dynamic and shareable creation. To make this possible, Factory 2.0 will draw upon Web 2.0 and the distributed ideation and propagation which it enables.

4. Opportunities for digiproneurship

Since the time of the industrial revolution's grim factories, the creation of physical goods has become an ever more specialised domain requiring every more prior knowledge and ever more prior investment. This type of highly concentrated and meticulously planned factory production will continue. However, inherently distributed and often spontaneous Factory 2.0 will flourish alongside it. This will enable production by consumers as envisaged some forty years ago (Toffler, 1970). Thus, the innate potential of people to create physical goods will be realized by fulfilling the latent potential of Web 2.0 to be combined with advanced manufacturing in ever more imaginative ways.

5. Conclusions

- There is no longer any fundamental reason for products to be brought to markets through product development, product production, and product despatch carried out at the few physical locations of companies' premises. Instead, products can be brought to markets through product ideation, product creation, and product propagation carried out by individuals and communities in any geographical region.
- Entrepreneurship that leads to enterprises which offer physical products based on digitally-enabled ideation, creation, and/or propagation can be referred to as digipreneurship. Distributed ideation, creation and propagation can supersede concentrated development, production and despatch due to recent developments in aICT and aMM.
- Potential digipreneurship products include, among others: exclusive consumer goods for niche, local markets; consumer goods for niche, global markets; sustainable social products for mass, local markets; and personal social goods for mass, global markets. All of these types of products can have superior characteristics compared to products created through traditional methods. In particular, previously intractable trade-offs can be overcome.
- Moreover, digipreneurship offers many opportunities for radical reduction in the consumption of non-value adding resources during the creation of physical goods. Further, the amount of factory equipment needed and, therefore, factory space needed is radically reduced. As a result, opportunities for smaller, distributed, even mobile, production facilities at point-of-demand increase.
- Replacing concentrated product development, production, and despatch; with distributed product ideation, creation, and propagation; makes it possible for individuals or communities to bring products to markets without needing to make large investments in market research, design facilities, production facilities or despatch facilities. For example, digitally-enabled ideation and propagation of new concepts and potential designs for physical products can eliminate the need for costly conventional market research. Further, digitally-enabled propagation of

product designs to point-of-demand aMM facilities can eliminate the need for physical despatch facilities such as large warehouses. Together, digitally-enabled ideation, propagation and creation can eliminate many of the uncertainties that have traditionally caused many entrepreneurial ventures to fail.

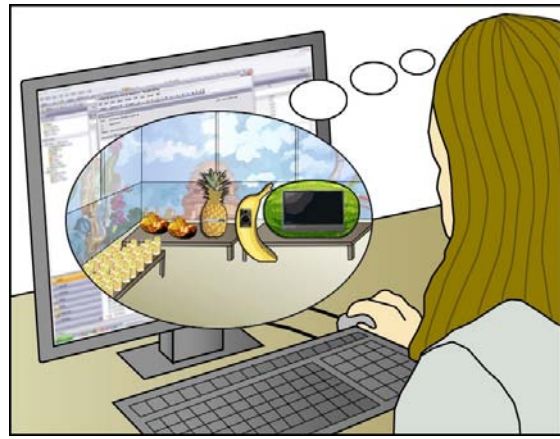
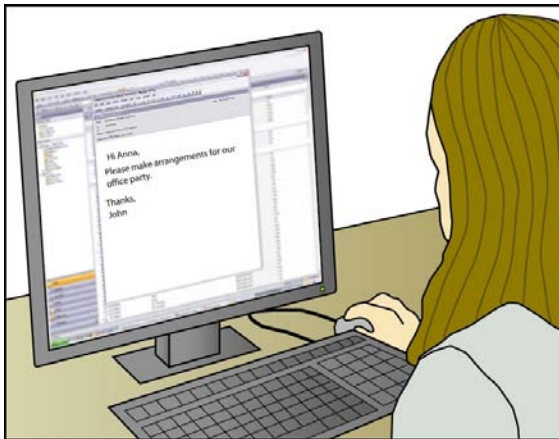
- Creation of physical products at point-of-demand can overturn current comparative DISadvantages in the creation of physical products for global markets. For example, today Finland has the comparative DISadvantages of limited natural resources; far distance from mass markets; and relatively high labour costs. However, digiproneurship has the potential to make Finland's comparative disadvantages become UNimportant in global value networks. This is because centralized models of physical production can be replaced by distributed models of global value creation.
- A wide range of people and businesses could offer digiproneurship products. Some examples of these people and business are: artistic individuals who wants to create unique physical goods; hobby enthusiasts who understands niche market needs; IT savvy people who are interested in developing novel aICT software tools; farmers wanting to diversify beyond offering B&B to the occasional tourist; under-employed persons looking to provide supplemental income for their families; unemployed people who are reluctant to up-root to major cities to look for work; machine companies wanting to diversify and/or better utilize its skilled workforce; SMEs that want to introduce more customer-specific versions of their product offerings; multi-national corporations seeking to streamline the design and supply of goods which will be integrated into their products.
- Digiproneurship training should transcend traditional barriers to entrepreneurship in three ways. First, by facilitating the emergence of enterprise through the self-expression of personal opinion: i.e. Expressive Enterprise. Second, by facilitating the on-going expansion of enterprise through the development of adaptive expertise. Third, by slashing the up-front investment required to bring a product to market.
- Recent developments in aICT and aMM have made it possible for a small number of enterprises to be established based on digitally-driven ideation, creation and/or propagation. The success of these few existing enterprises is due to their recognition of market needs which can be fulfilled by imaginative product offerings that are enabled through innovative combinations of aICT and aMM. Pioneers have demonstrated that successful enterprises can be established based upon what is termed digiproneurship in this working paper. However, the potential for digiproneurship extends significantly beyond the scope of today's technological capabilities. In particular, as aICT and aMM progress, and new creation networks are established, the opportunities for successful digiproneurship will expand and Factory 2.0 will come into being.

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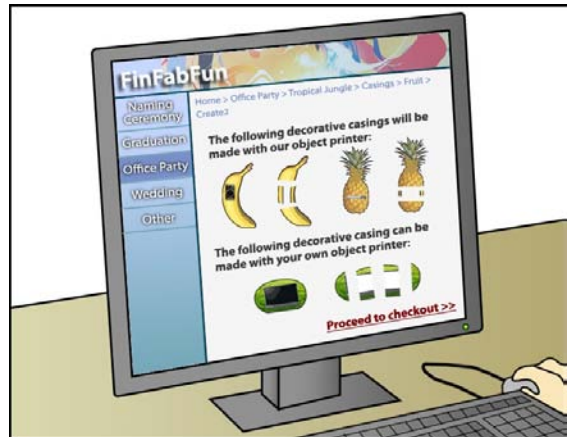
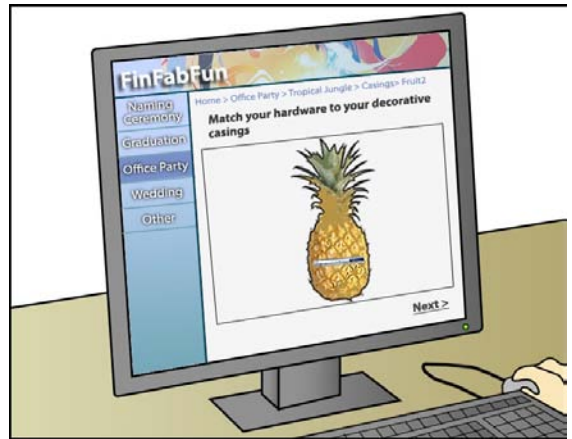
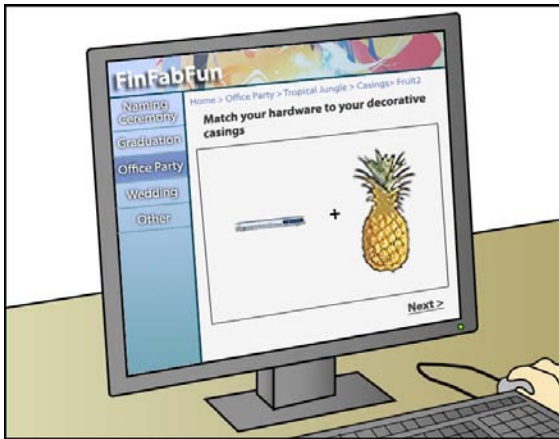
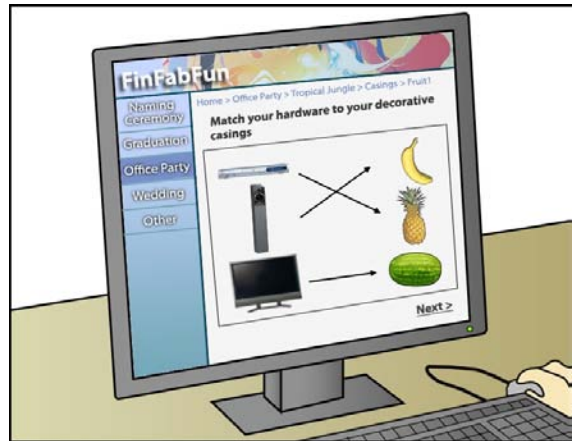
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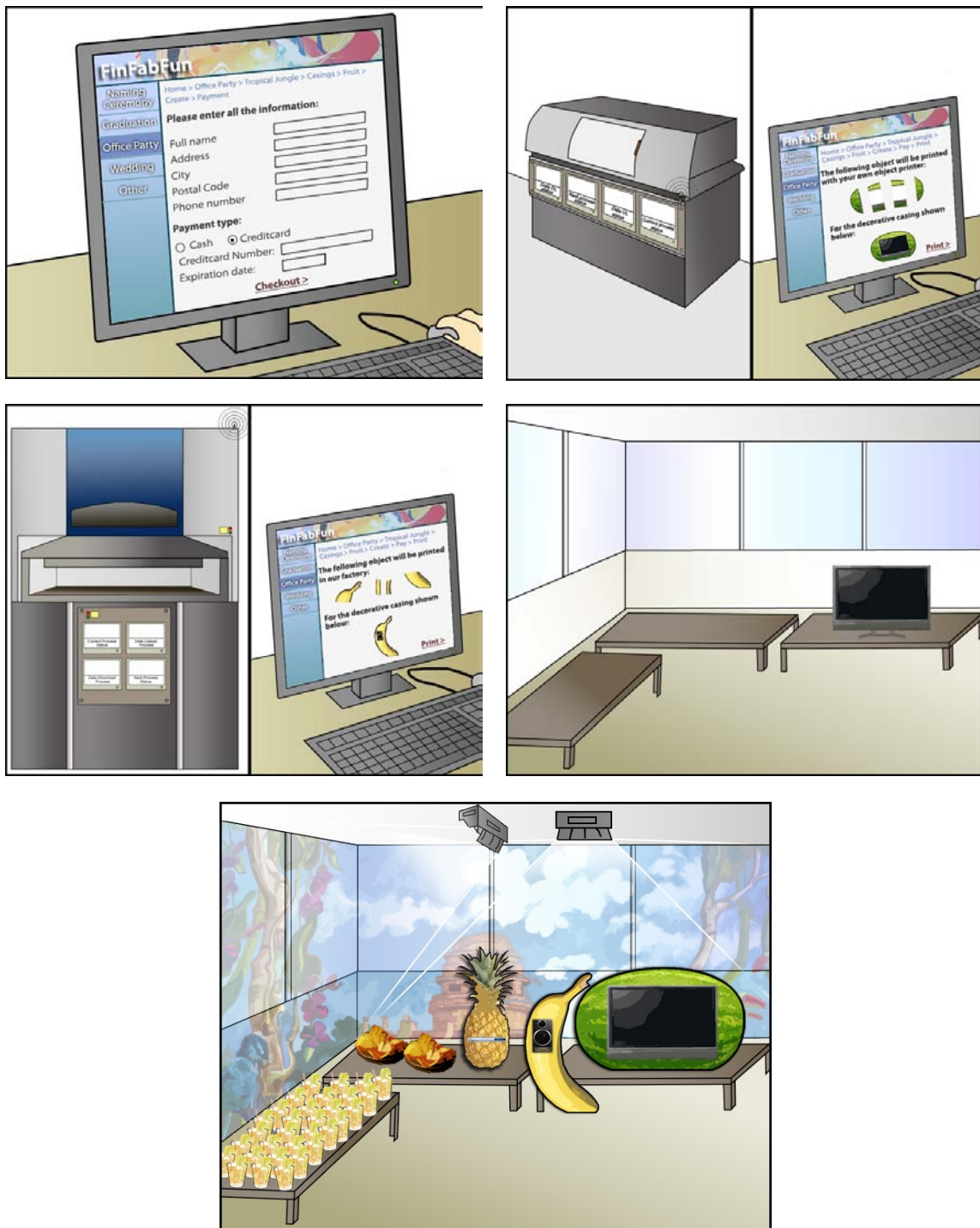
Appendix A

The storyboard in Appendix A illustrates a potential digiproneurship offering that makes it possible for a non-expert individual customer to create very special decorations for an office party.



Appendix A

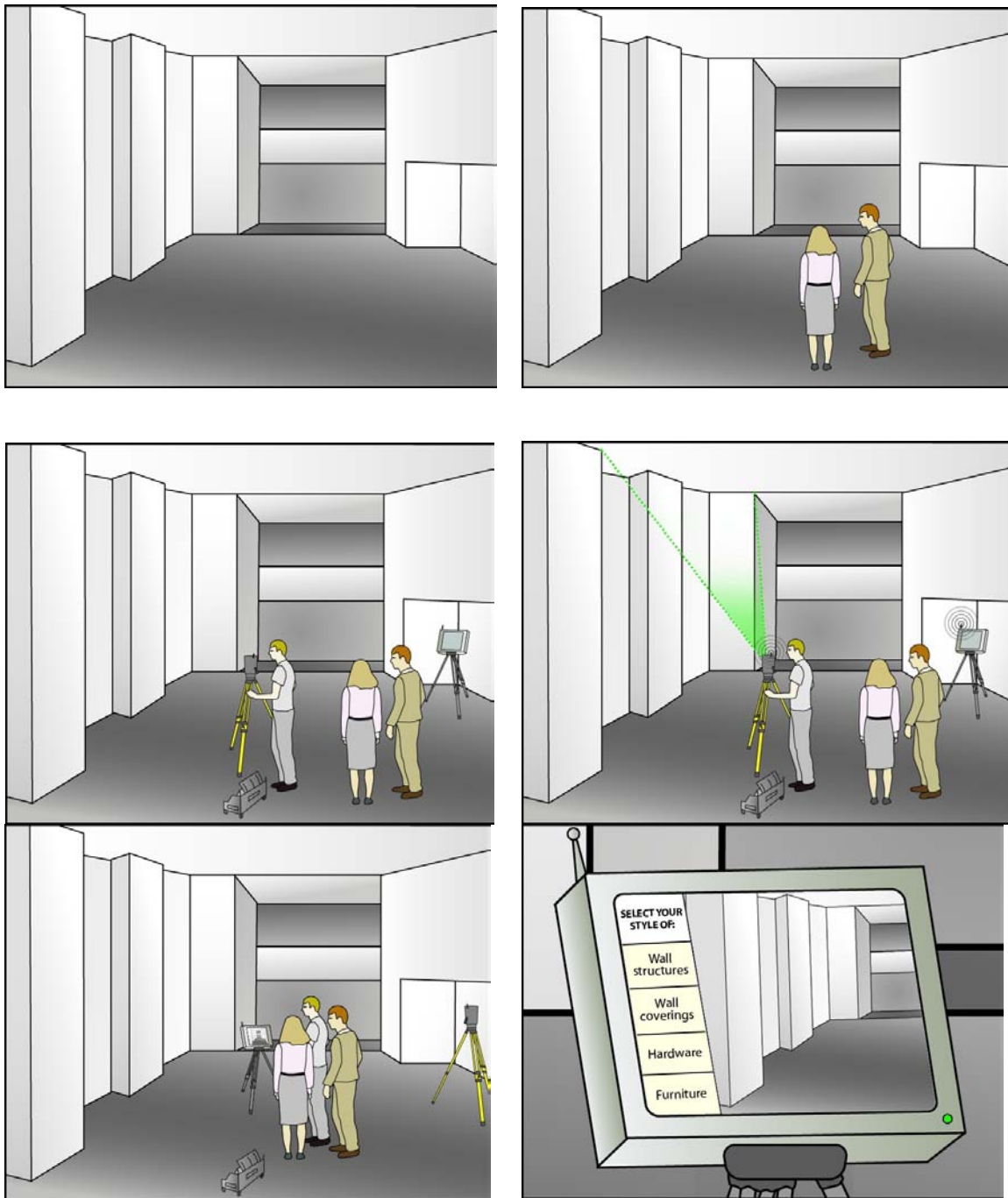




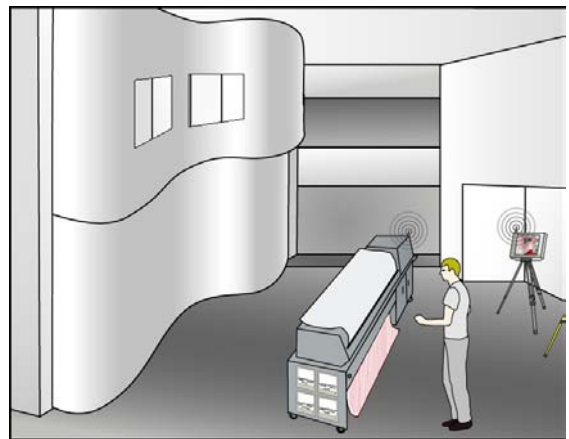
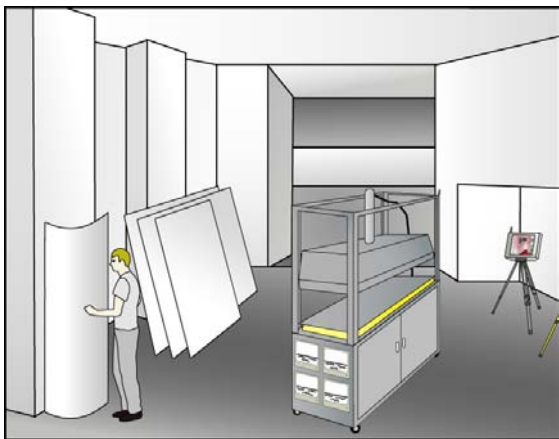
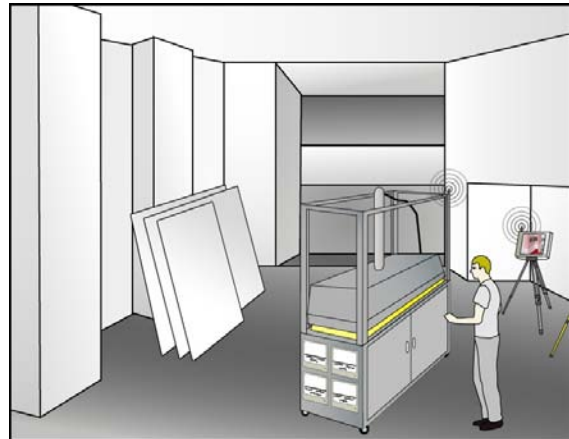
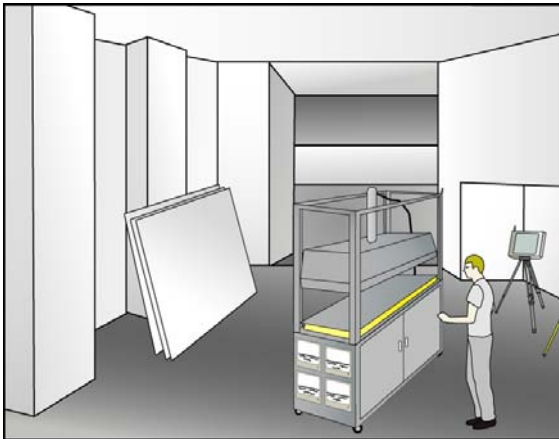
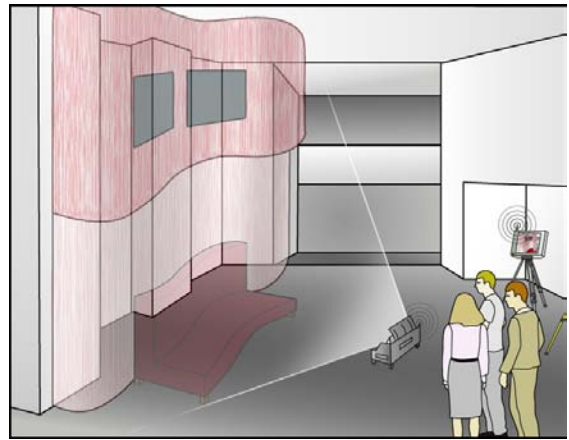
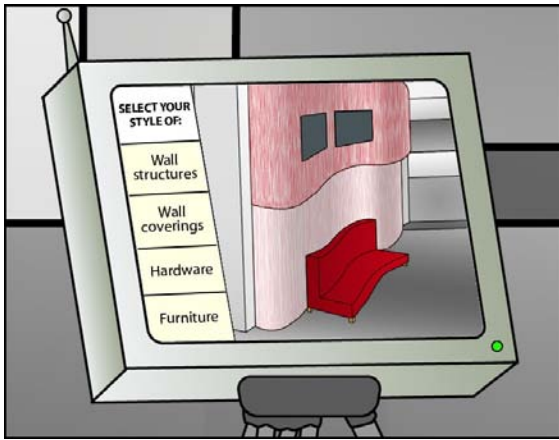
Overall, this storyboard shows how innovative combinations of aMM and aICT open up opportunities for imaginative new product services that are event-specific (e.g. office party) as well as customer-specific.

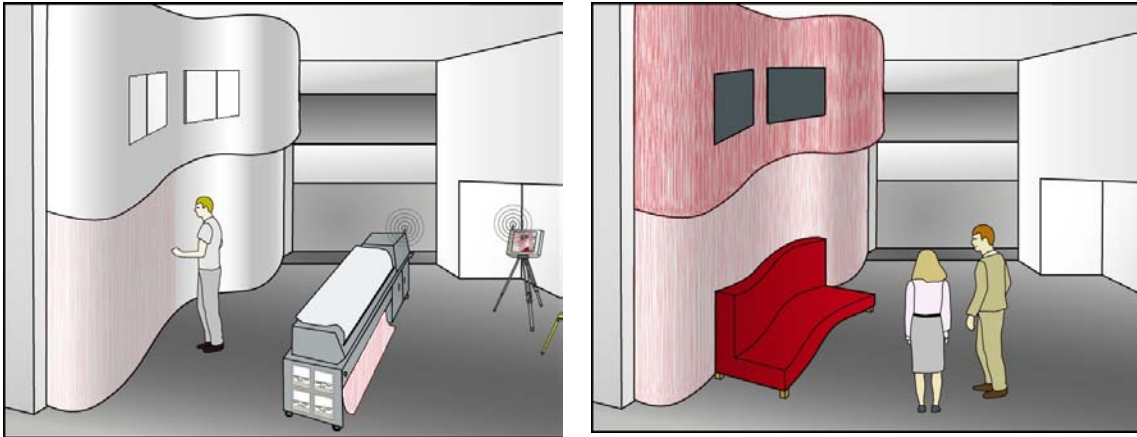
Appendix B

The storyboard in Appendix B illustrates a potential digiproneurship offering that includes: scanning to collect multi-dimensional data about physical features (aICT); novel digital interfaces which enable non-experts to create and modify shapes (aICT); mobile creation of physical components (aMM).



Appendix B





Overall, this storyboard shows how innovative combinations of aMM and aICT open up opportunities for imaginative new product services that are location-specific (e.g. hotel bar) as well as customer-specific.

