D4.2 COMPLEMENTING BACKGROUND KNOWLEDGE

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Executive summary

Deliverable D4.2, "Complementing background knowledge", is performed through individual and group interviews with these participants in order to complement the WP background knowledge (state of the art and D.4.1) with knowledge based on direct and systematic gathering of first-person data. In line with the multi-perspective methodological approach characterizing the Project, the aim of this Deliverable consists in enriching WP background knowledge, which is based on third-person data, with first-person data on the participants' view of hypotheses, goals and strategies leading the application of DiDIY-related technologies in education and research, and of the concrete developments of these applications.

This deliverable is coordinated and submitted together with D4.1, "Research Space and Agents".

Revision history			
Version	**Date**	**Created / modified by**	**Comments**
0.0	23/06/15	ABACUS	First draft, resulting from several online documents to which all partners contributed. Informal distribution to partners via Hackpad.
0.1	29/06/15	ABACUS	Extensions and fixes.
1.0	30/06/15	LIUC	Approved version, submitted to the EC Participant Portal.

Table of Contents

1. Introduction

D4.2. closely follows the structure of D4.1, to which is strictly linked. Hence, the first Section is focused on the main actors that have been individuated according to the research conducted through bibliography and online. The second Section focuses on the findings that resulted from the interviews that were conducted with practitioners and related to the possible areas of investigation that were individuated in D4.1. The third and final Section refers to the Dimensions that have been individuated in D2.3 “Knowledge Framework”: practitioners in the field of education were asked to give their views on such Dimensions, also to check whether those Dimensions could be relevant for the coming deliverables of WP4. This effort is also intended to fully exploit the work conducted in other parallel WPs and contribute to the consistency of the whole Project.

On the basis of the Grant Agreement, for the sake of D4.1. and D4.2. the area of analysis is focused on Atoms-Bits Convergence (ABC) and expressly excludes further areas such as new literacies (such as blogs, websites, social media, etc) as well as self-made videos or educational tutorials, which represent tools exploited by DiDIY and DiDIYers in education, but are also better known and already well analysed by scholars.

1.2 Terms and acronyms

CAD	Computer-Aided Design
DIY	Do-It-Yourself
DiDIY	Digital Do-It-Yourself
FLL	First Lego League
GA	Grant Agreement
ICT	Information and Communication Technologies
MIT	Massachusetts Institute of Technology
RCJ	RoboCup Junior
STEM	Science, Technology, Engineering, Mathematics
STEAM	Science, Technology, Engineering, Arts, Mathematics

2. Main stakeholders in the DiDIY in education areas

In D.4.1. a series of stakeholders were identified as important actors in the field of DiDIY. The following list indicates both the category and names of respondents: for categories c. an email was sent to all European organizers of RoboCup Jr. and First Lego Leagues, while for the other categories contacts were individuated in the definition of D.4.1. and through collaboration with all partners of the DiDIY project.

a. People working in the definition of educational policies at the central government level or educators and pedagogues that exploit DiDIY in their activities:

Maria Assunta Zanetti – Director of the LabTalento in Pavia (IT)

Giovanni Nulli and Lorenzo Guasti – Researchers of INDIRE[1] (IT)

b. Teachers and students that participate in DiDIY activities in school:

Costantino Tomasi – Teacher of Physics at Istituto Superiore Alcide Degasperi (IT)

Dario Ferrai – Student at Istituto Superiore Alcide Degasperi (IT)

c. Organizers of competitions that are linked to DiDIY activities (such as RoboCup Jr. or First Lego League)

Robocup Jr.

Belgium	http://www.robocupjunior.be	Joachim Mathieu Vrije Universiteit Brussel
Croatia	http://www.robofreak.hr	Ivica Kolaric
Italy	http://www.robocupjr.it	Giovanni Marcianò
Portugal	http://robotica2015.utad.pt	Fernando Ribeiro University of Minho (Board of Trustees)
Sweden	http://www.robocupjunior.se	Fredrik Löfgren

First Lego League

Austria, Czech Republic, Germany, Hungary, Poland, Slovakia	www.hands-on-technology.org	Stefanie Hauffe
Belgium, Luxembourg, Netherlands	http://firstlegoleague.nl	Sander Ezendam
France	http://www.multimedia-meudon.fr/firstlegoleaguefr/index.html	Erwan Gallee
Ireland, United Kingdom	http://firstlegoleague.theiet.org	Richard Pering
Italy	http://fll-italia.it	Stefano Monfalcon

1 Indire is an Institute within the Italian Ministry of Education that deals with research and innovative education.

Lithuania	http://www.bora.lt/mod/page/view.php?id=47	Ieve Jonaityte

d. Organizers and participants of DiDIY activities that take place outside schools and are related to 3 movements of DiDIY (Makers, Hackers, CoderDojos):

Umberto Rega and Angelo Bongio – FaberLab (IT)

Stefano Micelli – University of Venice and coordinator of the educational contest within the Makers Faire in Rome (IT)

Fabio Missoli – CoderDojo MISO (IT)

3. Areas of investigation

On the basis of the preliminary research conducted in D4.1 some areas of investigation have been individuated as very promising to better assess how DiDIY is used in education and research and to be better prepared for D4.4. Results derived from data collection and analysis. Interviews helped to better assess some aspects and further advance in the understanding of those areas. The text in italics replicates the questions included in D4.1, which were at the basis of the interviews, together with the tables on DiDIY dimensions. Interviews were conducted using skype in most cases, once it took place in person, while twice respondents answered in writing. Interviews that were conducted live lasted from 25 minutes to more than one hour.

3.1 The role of creativity

The many uses of DiDIY in education and research have one element in common: creativity has a crucial role and is often relieved from the burden of the actual "making" of the outputs (if you can imagine it, you can create it). Thus pupils really have the opportunity to work on their ideas, shaping them mostly in a non-physical environment, and even the last part of the process does not require them to have particular dexterity. How do teachers and students use this unique feature of DiDiY?

All interviewers agreed on the importance of creativity as a crucial feature of the DiDIY process and model. In many cases, in particular when students are involved in competitions, the creative element is at the core also of the evaluation, and students are confronted with "themes" (such as in First Lego League) for which it is necessary to individuate solutions.

Most interviewers agreed also on the fact that the very process linked to DiDIY in education as illustrated by Papert:

- learning by designing meaningful projects and sharing them in a community;
- manipulative objects for supporting the development of concrete ways of thinking and learning about abstract phenomena (object to learn with);
- powerful ideas from different realms of knowledge;
- self-reflective practice. Documentation is a wonderful vehicle for making self-reflection concrete and being able to share its products with others,

leads pupils to proactively use their creativity together with the others, and in most cases, as also demonstrated by the interviews that were carried out during the Italian Finals of First Lego League, creativity was a collective process rather than an individual one, and in many cases solutions were found without even knowing who was the person that proposed them. An important side effect of "collective" creativity is that each member of the team can add her competences and skills and contribute to improving those of others, while at the same time contributing to the success of the DiDIY activities and researches.

Another element linked to creativity is the fact that few respondents signalled that, according to them, students became creator also at the educational level, as they were the ones that would create contents, rather than just receiving knowledge and acquiring competences from the teachers.

3.2 The role of sharing

Thanks to new social media and the growth of the Free Software and open source hardware movements (that are a fundamental component of DiDIY) pupils work on common projects and share working spaces with their colleagues-friends. Does this lead to new ideas or to conformism?

Interviews confirmed the importance of sharing in DiDIY for education activities, and all practitioners signaled the fact that without social media, Free Software and open source hardware, it would have not been possible to carry out many of the activities that they did. Still, in particular when dealing with competitions, many students took advantaged of shared knowledge they found online but once they elaborated their solutions, they decided not to share it with others.

A few signaled that linguistic barriers (in particular for students that attend primary and secondary schools) made it particularly hard to share (or access) information in a foreign language.

This is true also for First Lego League (and indeed Lego Mindstorms does not belong to free software and hardware) where cooperation, within and among teams, is regarded as a core value and a sharing site called Lego Digital Designer,[2] where all materials are shared using pictures and animations step-by step of all software and hardware evolutions.

Each of the Movements (Makers, Hackers, CoderDojos) described in D4.1 and the technologies involved (many of which belong to free software and hardware) have their sharing platforms, and a variety of resources for teachers as well as for students, with videos, blogs, tutorials, etc. but the novelty of those movements need them to be further updated with tutorials (possibly in different languages). Besides, even where there is a common model, such as that purported by the newly rebranded CoderDojo Foundation (once Hello World Foundation), the activities are implemented differently also on the basis of the traditional educational know-how that each country has.

It is interesting to note that, as it is with all technologies (and beyond), there is a small group of early adopters (which sometimes become trend-setters), and then the big group of followers. When what was “niche” becomes mainstream, the early adopters move to a new “niche” and this is true also for DiDIY, which is progressively becoming popular (although a small group of students still regard the DiDIYers as “nerd”) and thus we saw that well established technologies such as Arduino were replaced by others less known.

Considering the crucial importance of sharing, and considering that DiDIY is also defined by sharing technologies, it will be important for the continuation of the DiDIY project itself, to include also sharing technologies such as educational blogs, video tutorials and possibly also educational gaming as dimensions of DiDIY, definitely as important tools, but possibly also as fully fledged DiDIY technologies, although their output is indeed less “physical” than that of other DiDIY technologies such as a 3D printer or Arduino board.

3.3 The role of teachers

How can DiDIY be exploited to ease / emphasize the transition from a teacher / curriculum-centered school to a student / experimentation-centered education (“flipped classroom”)? Is DiDIY also transforming the role of teachers accordingly? How? What new competences are expected from them? All these aspects need to take into account that DiDIY educational activities are also related

2 http://ldd.lego.com/it-it .

to environments different from schools (such as labs, museums, robotics academies, etc.) and educators that are not teachers.

Respondents to the interviews were all aware that, when dealing with DiDIY in education, the role of teachers will be subject to deep changes.

In most cases the DiDIY teacher is seen as "facilitator", "coach", or "coordinator" and the new role requires also that the teacher is able to transfer to student skills and competences that are not usually taught, such as teamwork, time management, working for objectives (and not to fully complete the annual curriculum). This is even more important considering that the technologies involved are new, and teachers themselves in many cases are not more proficient in their use than students.

Teachers are also aware of the importance of teaching a method rather than teaching technologies that are to be obsolete when kids will complete their studies. In this context the languages and technology that students learn become ancillary, simply a way to express the power and importance of making. The shift from student to Maker is a shift from follower to leader, from consumer to creator. This shift reflects the constructivist role that many agree to be key to 21st century education. Still, according to practitioners belonging to movements such as Makers, Hackers or CoderDojos, it is important that trainers (who are mainly volunteers and usually have a good technical background) also acquire competences and skills that are typical of a teacher, as "expert" in no way means also "able to share".

3.4 DiDIY and learning flows

How does the learning process happen during "make to learn" activities? Who are the stakeholders involved and which is their role in the process (teacher, students, educators, DiDIYers, etc)? What are the similarities with learning flows that happen in other fields (e.g., in companies)?

Learning flows in DiDIY activities are usually different from those that happen in more traditional educational processes, where the teacher transfers to pupils notions and knowledge so that they can elaborate them into competences.

Considering that most DiDIY activities take place in teams, competences flow from a member to the other with no particular hierarchy. Indeed teachers, as "coaches" can suggest what is best, but in most cases the very novelty of the technologies involved makes the par with the students.

Interestingly both in competitions (such as RoboCup Jr. and First Lego League) and in movements (such as in CoderDojo), teams are purposely composed of senior (with more competences) and junior (with less competences) members, so that it is favoured a sort of spiral flow of communication.

In those cases teachers or educators have different roles: they organize the team, they set the challenge that students need to face, they intervene when the team is stuck and try to make the team individuate the cause.

This learning flow is maximum when the competences of students are almost equal to those of teachers and when new challenges are set, while it progressively diminish the higher the difference in competences is and for already well established challenges.

3.5 How is school as institution responding to the use of DiDIY

Papert indicates that school as institution could have greatly benefited from the computer age, but was somehow reluctant to do so. Will DiDIY have better chances to allow for major changes within the educational system, also taking into account the concurrent existence of multiple forms of do-it-yourself aimed at substituting schools (such as MOOCs)? Are there Governmental funds to help schools acquire DiDIY technologies?

In many cases schools as institutions seem to be more willing to fully exploit the potential of DiDIY in education compared to what they did with computers.

First of all there is general consensus at the governmental level that STEM (Science, Technology, Engineering, Mathematics) subjects are crucial for the very future of European and industrialized countries.

Thus Ministries, Universities and schools have started to identify which curricular and extra-curricular activities were best suited to make more students be involved in STEM. And many found that DiDIY activities could be a very good option.

With this general understanding, as of now, policies and programmes are still very different among countries, although most of them support, or are going to support STEM (and consequently DiDIY).

Many European countries are supporting the use of DiDIY in education through European Funds such as the European Social Fund (for the training of teachers) and the European Regional Development Fund (for the purchase of hardware and infrastructure).

DiDIY activities in the Netherlands are mainly supported by scientific universities, with the aim to “lure” more students into STEM, so that they will enroll in scientific faculties.

In Portugal schools receive funds by the government through the National Agency Ciência Viva[3] while in the UK there is a national programme that does so.

In Italy, the Ministry of Education is working to include some robotics activities in most schools. Besides, the Italian National Institute for Documentation, Research and Educational Research – INDIRE is running a variety of researches on the use of 3D printers and other DiDIY technologies, as well as computational thinking approaches and is leading an experiment in 7 pre-schools and elementary schools.

At the same time, a group of other 7 schools benefited from training in the use of 3D printers that was provided by FaberLab, (a fablab created by the local Confartigianato, the association of handcrafters) which invested in this kind of activities so that students, once graduated, could immediately work in the many local small firms.

In Lithuania, a new programme will be launched in 2016 and will include also Arts, so that STEM will become STEAM. Past activities were of the Robotics Academy, which encompasses many uses of DiDIY were supported by the Association of Teachers as a pilot initiative that would benefit the whole educational system.

In many Countries the “movements” are also collaborating directly and indirectly with schools either through the training of trainers or labs with pupils.

Thus we see that a general common understanding of the importance of DiDIY as tool to learn STEM is then supported in many forms, and again is implemented in a great variety of directions at the school level, taking into account that schools in many European Countries are independent and have a certain degree of freedom to decide which activities to propose to their students.

3 http://escola.cienciaviva.pt/home/

In general, apart from technical schools, most DiDIY activities are still extra-curricular. In many cases, from Lithuania to Italy, to Portugal, respondents highlighted some difficulties in implementing DiDIY activities in schools with old-fashioned principals, and resistances by teachers that deal with more traditional subjects. Many also fear that DiDIY would reduce time for the curricular programme (and it is not by chance that DiDIY activities become less when students get close to examinations). Finally some have difficulties in understanding how to grade students, because DiDIY is often linked to team-work and because in DiDIY the process is more important that the result.

To the contrary, there are also many enthusiasts who are convinced that schools will progressively implement structural changes in their curriculum and also in the way traditional subjects are taught, transferring the DiDIY mindset also there.

In general, the concurrent pressures of Governments (which see STEM as very important and DiDIY as a good approach to them), parents (which become aware of the "movements" and support them), students (who see DiDIY very positively) are forcing schools as institutions to change, and the best schools are already doing so also through DiDIY and innovation in general.

3.6 DiDIY in education and gender issues

Considering that DiDIY is used in many countries as a special tool to attract more students and make them study more STEM subjects, and considering that STEM faculties have a very low percentage of female attendance, one possible areas of interest could be that of evaluating if and how DiDIY could attract more women to STEM classes and faculties. Interesting (and worth studying if/how the same thing is happening in DiDIY) is the "When Women Stopped Coding" issue: the share of women in computer science started falling at roughly the same moment when personal computers started showing up in U.S. homes in significant numbers.

According to interviews, the participation of girls to DiDIY activities is still well below 50% (35% in the UK and Ireland, 20% in Italy, 15% in France, Germany, 10% in Lithuania and Croatia). And this is mainly due to the prejudices that girls have regarding STEM subjects and even the idea they have of jobs such as that of an engineer (mostly associated with a nerd).

Still, the results that girls had in some competitions testimonies to the potential of exploiting DiDIY to attract more women into STEM subjects. And this is in line with the expectations Governments have in securing that more women take part in STEM.

The principal of an Italian technical school (where the percentage of female students is well below 10%) that took part in an informal conversation suggested that for her the path that led from the use of a 3D printer a to the inclusion of more girls in her technical school would have also meant that girls would have been able to earn their living and have become more independent.

Among the "movements" that are using DiDIY in this case it is important to mention the Rails Girls, which aims to open up technology and make it more approachable for girls and women. The first event, held in Helsinki in November 2010, got over 100 interested girls signed-up for the workshop. Since then the free events have expanded to Shanghai, Singapore, Tallinn, Berlin, Krakow and many more attracting thousands of girls to the world of web building.

3.7 DiDIY and special education

There are many promising tests and trials on the use of DiDIY that are being applied to special groups of students (persons with motor and dexterity disabilities, visual impairment, mental and behavioral disorders). Will this help them better integrate in schools and also create something particularly relevant for their needs?

Most practitioners did not have a direct experience with special groups, also due to the novelty of the approach. Still, there are a few example of disabled students that take part in and advantage from participating to DiDIY activities.

This is the case, for instance, of a group of students with dyslexia or dyscalculia that were able to exploit Mindstorm thanks to the fact that it uses an iconic software. Lego was also used to help autists.

In the UK, robotics are used both at the school level and in science museums to work with special needs students, who seem to respond well to physical stimulation.

A group of girls that participated in training delivered by FaberLab worked for the creation of a pair of glasses to be 3D printed so to be able to support the weight of a small camera that was supposed to help visually impaired people (a sort of Google glasses) move more freely in urban areas and gather other information relevant to their needs.

In another Italian school a physically disabled student who moves on a wheelchair programmed Arduino with his classmates and teacher so that doors automatically open when his wheelchair (marked with a RFID badge) gets near them.

Besides, also students that have difficulties in concentrating greatly benefited from DiDIY as it gave them self-motivation and intermediate small tasks.

Finally, on the other extreme of the spectrum, DiDIY is being tested for gifted students, who in too many cases drop out from school because they cannot settle to the curricular activities. The very nature of DiDIY and the fact that it facilitates problem solving (rather than just the finding of the solution) makes it particularly suited for gifted students.

3.8 DiDIY: from STEM to STEAM

At present DiDIY in education is mainly used in close relationship with STEM subjects (and if other subjects are involved, they have an ancillary role). Is there a main role for DiDIY in other subjects, such as humanities, arts, etc?

At the governmental level, the growing success of DiDIY in schools (all practitioners indicated that the number of participants is increasing) seems very much linked to the importance that Governments of all industrialized countries and European countries in particular attach to STEM subjects. As of now, and on the basis of the very partial information gathered, only Lithuania has decided to include Arts in the STEM acronym, which is then transformed into STEAM.

At the practical level, though, many have highlighted that the most important aspect of DiDIY in education has little to do with technologies, and is mainly related to the understanding and exploitation of a mindset and a learning method that can then be used in many other contexts.

Still, the DiDIY mindset and method, according to most teachers, and the consequent close relationship between students and teachers is indeed facilitated by the very collaborative nature of many of the DiDIY activities (first of all the competitions) and some see it very hard to replicate it for different, more traditional subjects, where gap in knowledge between teachers and learners is much wider than in technical subjects were students are almost at the same level as the trainers.

One unique example of the holistic exploitation of DiDIY technologies and mindset is that of a team that participated in the Italian Finals of RoboCup Jr.

The Alcide de Gasperi School from Borgo Valsugana initiated a project called Robotics and Robo-Ethics coordinated by Prof. Costantino Tomasi and with the full support of the school principal Paolo Pendenza and its teachers. The team created a robot called Ulisse (Ulysses) and small specialized groups were formed to work on the software and hardware parts, using Lego, 3D Printer and Arduino. At the same time, all members of the team also participated in a great variety of activities related both to Ulysses and what it represents (the never-ending quest for knowledge, freedom, curiosity: laboratories were held in philosophy (on robo-ethics and how society is influencing individuals), literature and arts (how Ulysses is depicted in some classics of Italian literature and international movies).

It is important to highlight that the approach of flipped classroom and learning by making was not confined only to the technological and robotics part, as in all subjects students were encouraged to take an active role: this resulted in the collective re-writing of a post-modern Odyssey (where Helen is the main character of Rossum's Universal Robots) and even in the creation of a logo for the robot made of electric circuits (and somehow similar to that of the DiDIY project itself).

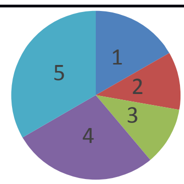
Finally, in the interview that was conducted with Prof. Tomasi, it was highlighted that, besides making this a very stimulating project (for teachers and students), the activities were able to involve a student that had very bad marks and, also thanks to this project, was able to find a new approach to learning that resulted in him passing all courses at the end of the school year.

4. Views on some DiDIY Dimensions

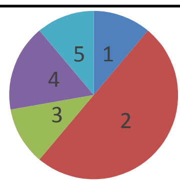
In the second part of the interview, the same respondents were asked to express their opinion regarding the Dimensions that were individuated in D2.3 “Knowledge Framework, initial version”.[4] For each Dimension a Likert scale has been proposed to respondents with opposite positions at the extremes.

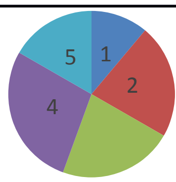
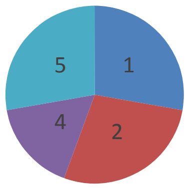
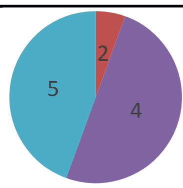
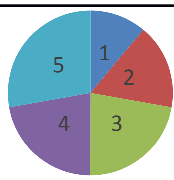
As clearly highlighted by the replies, the most interesting fact is that at present the DiDIY world is so fragmented and with no clear leadership that most dimensions do not have a polarized answer. The only one that has a common and shared understanding from the majority of respondents regards DiDIY and timespan, where the vast majority believes that DiDIY is meant for long lasting activities.

[The numbering in the pie charts refers to the percentages allocated to the five possible categories of answers]

DiDIY and outcomes					
aimed at creating artifacts[1]	–[2]	neutral[3]	+[4]	aimed at performing services[5]	
16,67%	11,11%	11,11%	27,78%	33,33%	
DiDIY and production					
only related to hand made things[1]	–[2]	neutral[3]	+[4]	the production of ideas[5]	
11,11%	22,22%	22,22%	27,78%	16,67%	
DiDIY and professionalism					
only for non-professionals[1]	–[2]	neutral[3]	+[4]	also for professionals who maintain their DiDIY mindset[5]	
16,67%	22,22%	11,11%	33,33%	16,67%	

4 See D2.3 Sections 3.1 and 3.2.

		DiDIY and innovative technologies			
only driven by the use of innovative technologies[1]	–[2]	neutral[3]	+[4]	possible also with traditional, well-established technologies[5]	
16,67%	33,33%	22,22%	16,67%	11,11%	
		DiDIY and creativity			
creative processes[1]	–[2]	neutral[3]	+[4]	repetitive processes[5]	
11,11%	50,00%	11,11%	16,67%	11,11%	
		DiDIY and open communities			
openly sharing knowledge in communities[1]	–[2]	neutral[3]	+[4]	individuals operating alone[5]	
22,22%	27,78%	22,22%	22,22%	5,56%	
		DiDIY and sustainability			
related to the target of sustainability[1]	–[2]	neutral[3]	+[4]	unrelated to sustainability[5]	
11,11%	27,78%	11,11%	27,78%	22,22%	
		DiDIY and individual decisions			
voluntary activities[1]	–[2]	neutral[3]	+[4]	activities performed to order[5]	
16,67%	33,33%	16,67%	22,22%	11,11%	

DiDIY and routine					
non-routine activities[1]	–[2]	neutral[3]	+[4]	activities performed routinely[5]	
16,67%	16,67%	33,33%	16,67%	16,67%	
DiDIY and aesthetics					
finalized to produce beautiful results[1]	–[2]	neutral[3]	+[4]	unrelated to beauty[5]	
11,11%	22,22%	22,22%	27,78%	16,67%	
DiDIY and profit					
activities satisfying in themselves[1]	–[2]	neutral[3]	+[4]	activities for profit[5]	
27,78%	27,78%	0,00%	16,67%	27,78%	
DiDIY and timespan					
activities spanning relatively short amounts of time[1]	–[2]	neutral[3]	+[4]	long lasting activities[5]	
0,00%	5,56%	0,00%	50,00%	44,44%	
DiDIY and processes					
focused on the processes of doing[1]	–[2]	neutral[3]	+[4]	related to the products of such processes[5]	
11,11%	16,67%	22,22%	22,22%	27,78%	

DiDIY and open releases					
openly released outcomes[1]	–[2]	neutral[3]	+[4]	outcomes that are maintained proprietary[5]	
22,22%	22,22%	11,11%	22,22%	22,22%	