

Digital Curation for CAAD Curricula

Bridging Mainstream and Speculative Design Procedures to promote curatorial competences for Architecture

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As the design processes in Architectural practices switch toward entirely digital workflows, architects are gradually required, because of their legal and commercial liability, to provide for both a relatively long term curation of their own digital products and the deposit of authoritative data. But, despite being the sole curation actors for their data, architects receive little education or training in either pertinent competences nor agreed and established procedures to comply with these duties. In this paper, the design of Digital Curation courses within CAAD Curricula will be discussed against the investigation results of the DEDICATE project, an AHRC funded project hosted at the Humanities Advanced Technology and Information Institute of the University of Glasgow.

Keywords: CAAD Curricula, Digital Curation, Generative Design, Digital Fabrication

INTRODUCTION

This paper discusses the need for Digital Curation and Information Management competences in the Architect profession and proposes a Digital Curation module for CAAD curricula detailing its learning objectives. This need is based on collaborations with commercial practices and HEI partners undertaken during the DEDICATE (Design Digital Curation for Architecture) project, an AHRC funded initiative led and supervised by the authors.

EMERGING NEED FOR DIGITAL CURATION IN ARCHITECTURE

There is evidence that statutory project documentation is mainly adapted to be printed and kept in phys-

ical Archives by architectural practices (Lancia 2011). But, the request for producing and depositing authoritative digital data is an emerging phenomenon across many international Building Control authorities and Public Authorities that are urging architectural practices to implement consistent data management procedures.

For example, in Netherlands, since November 2011, the Rgd BIM Norm obliges design contractors involved in public building projects to produce and deliver their products in Building Information Modelling (BIM) formats following the policies of the Rgd BIM standard (Van Rillaer et al. 2012). In the same year, the United Kingdom Cabinet Office announced in the Government's new Construction Strategy that all public works will require BIM documentation in

both native and IFC4 formats by 2016 (Kelly 2011). Professional Indemnity insurance in the UK when using BIM will depend on Information Management policies agreed between the parties, including, for example the definition of the trail of information custody (Bamforth 2013).

The commercial liability of architects extends these emerging requirements, introducing in the profession the need for relatively long periods of reliable digital assets retention. For example, in United Kingdom, the architects' professional liability period amounts to 12 years post practical completion (Speaight and Stone 2005) - a very demanding retention period for digital information to be held in informal repositories such as those found in architectural practices. Where workflows involve complex Digital Design procedures, such as Parametric and Generative Design, Collaborative and Concurrent practices and Building Information Modelling, the management and preservation of assets are especially complicated by the multiplication of dependencies, the use of IPR encumbered file formats and the short-lived platforms adopted for the data production. Further, the rapid obsolescence of CAD packages and their common lack of documentation are long standing recognised problems of CAD data curation and preservation. This is also a threat for practices implementing more traditional Digital Design procedures, such as 2D drafting.

Digital Curation, like its cognate disciplines Data Curation, Digital Preservation, Digital Archiving, and Digital Stewardship, is commonly associated with archival routines and research institutions' policies and objectives. Though, the investigative and operative repertory of Digital Curation is not uniquely represented by research data or other akin controlled productions. Despite this most research institutions, such as the Digital Curation Centre [1], have given prominence to e-science data and other research digital outputs as repertory of their activities. Individual investigators from this discipline have defined more widely the Digital Curation objects of interest as the entire production of digital assets in our

society, including personal digital collections (Beagrie 2008). Digital Curation both extends and specialises the scope of Information Management as it both concentrates on the information assets in the digital domain and approaches the management of data through a life-cycle model spanning information production to its disposal. The 'digital curator' is both a competent interpreter of the products stakeholders' needs and objectives, and an active member of a specific community of practice.

Borrowing from the definition of Digital Curation by Neil Beagrie as "the actions needed to maintain digital [...] materials over their entire life-cycle and over time" (Beagrie 2008, 4) and combining these novel management requirements, it is arguable that architects will soon be expected to take curatorial responsibilities over their data. This renewed scope on the professional services expected from architects urges also a novel approach to the commercial exploitation of designs based on the legal and persistent management of its Intellectual Property Rights (IPR).

The workflows ramifications and the still limited legal pressure on Architecture practices for both implementing consistent data retention procedures and depositing authoritative data in statutory repositories, actually prevent both Digital Curation professional from approaching this field and architects from appealing to their services. As a result, most practices resort to commercial services for information management that do not solve crucial curatorial issues, such as long term data reuse, accessibility, IPR management and authoritative retention.

In such a context, post-hoc data curation procedures, such as those implemented in institutional archives, are neither feasible nor effective. Instead, as Alistair Miles proposed for the project ImageStore, (part of the Digital Curation Centre SCARP initiative) curatorial attention when integrated in the very workflows defining the datasets lifecycle, enhances both the data quality and their preservation viability in informal retention contexts [2].

Curatorial activities should be highly integrated

with architectural design procedures to address with informed decisions the potential threats to data integrity and long-term legal management. As a result, the professional digital curators' interventions on this repertory should be substituted with a competent management by the stakeholders themselves.

Higher Education and Vocational Training are generally lagging behind these new professional requirements. But we might admit as a justification for such a slow response that some of the issues highlighted are still implicit in the technological trends and political initiatives we have indicated above. Nevertheless, in a rapidly shifting landscape one would expect Higher Education to adapt to new phenomena by addressing their future impact, that is shaping it through future generations of professionals.

AUDITS AND ANALYSIS WITHIN DEDICATE

Within the Design's Digital Curation for Architecture (DEDICATE) project the development of a Curation module for CAAD Curricula was especially investigated.

DEDICATE was funded by the Arts and Humanities Research Council (with the ref. AH/J008265/1) and was hosted by the Humanities Advanced Technology and Information Institute (HATII) of the University of Glasgow. Running for nine months, this project was aimed at investigating the policies, requirements and procedures to build a sustainable curatorial framework for the Built Environment related digital assets, minimising their loss risks and maximising their reusability and interoperability within their stakeholder community.

The digital assets, production and management procedures, and infrastructures of a select group of Scottish architectural firms and engineering consultancies were audited using affirmed curatorial tools, original scripted analysis and unstructured observations.

The project partners repositories were first audited adopting methods and tools from three recognised Digital Curation tools: DAFD (Data Audit

Framework Development) which provides an audit methodology and online tools to support and facilitate organisations to establish an overview of their data holdings, policies and practices against best practices and new risks [3]; DRAMBORA (Digital Repository Audit Method Based on Risk Assessment) which offers an audit methodology, complemented by a computer-aided audit software, addressing the assessment of risks implied by the policies adopted by the repositories [4]; and Planets (Preservation and Long-term Access through NETworked Services) that offers a testbed to experiment with the effects of curatorial actions on digital assets, such as format migration [5]. Subsequently, the files and folder structure of a selection of the project partners' projects were ingested in a drive on a UNIX server and analysed with UNIX and PERL scripts to extract the data population distribution in terms of formats, size and typologies. The same files were scanned with Jhove2 to test both the efficiency of automatic characterisation routines on built environment related digital assets and the syntactic integrity of data files against their format documentation. A selection of these assets was then transferred to the Planets testbed to experiment both the effects and the long-term feasibility of the management actions most frequently adopted by the project partners. The observations on the partners' workflows and the interviews with the practices' staff recorded both the specific contextual information attached to the projects selected for analysis and all the procedures and tools implemented by the partners producing, sharing and holding their digital products. These observations focused as much on the production of data as on its management and in both cases compliance to standards such as the Uniclass or the ISO 9001:2008 were considered.

The information gathered through these analyses exhaustively documents the problems and the specific needs and requirements associated with the curation of digital assets in small and medium sized architecture practices.

Despite salient examples from this frame-

work having been reported in the past decades at the Education and research in Computer Aided Architectural Design in Europe (eCAADe) conferences, speculative and experimental procedures, such as the workflows often adopted by students for Generative Design and Digital Fabrication, the results have scarcely explored Digital Curation and Information Management initiatives. To delve into this subject, under the auspices of DEDICATE, two academic collaborations were initiated - the first with the Laboratory for Applied Building Science of the Graduate School of Architecture, Planning and Preservation at Columbia University, and the latter with the Master of Research in Creative Practices of the Glasgow School of Art.

GSAPP's Paris-Atelier 2013

Thanks to Phillip Anzalone, director of the Laboratory for Applied Building Science, project staff visited the Paris-Atelier 2013 Summer School during its conclusive week to document the digital workflows adopted by the course's students and explore both their procedures and issues in managing data files and their understanding of the future impact of information management on the architect profession [6].

The Paris Atelier is an advanced academic program of the Avery Digital Fabrication Laboratory, part of a five years program co-founded by GSAPP & Asaf Gottesman, that endeavours to provide a platform to explore the role of the Architect as a critical maker, that is as a designer both involved in the cultural debate on architecture and active in the actual construction of his/her design. Workshops led by industry partners are offered during the 8 weeks course to develop new means working with computational design, material processes, and assembly of spatial constructions. The course culminates in an exhibition at the Palais de Tokyo in Paris of the students' work. The students presented as a final work a large installation designed in collaboration with artist Tomas Saraceno - an ethereal pavilion built by arranging a field of inflated mylar balloons to describe two NURB surfaces

splitting the Palais de Tokyo exhibit space into three distinct volumes (see figure 1).

The morphology of the pavilion was researched by the students adopting different scripting strategies in Grasshopper and its final version was agreed through direct discussion on the proposed scripted routines within a staged collaboration process.

The students decided to manage their collaboration through a shared folder in the file hosting service DropBox. They autonomously created a folder structure differentiating individual researches, the knowledge base (such as handbooks, publications and teaching material), and the design, presentation and fabrication of the pavilion. In this latter section a system of agreed naming conventions records the versioning of both models and deliverables files whilst the granularity of the folder structures closely matches the changes in direction, the final decisions and the contextual information of the design process rather than a general categorisation protocol.



Figure 1
The Paris Atelier pavilion at the Palais de Tokyo. Image courtesy of the course students.

'Hamlet Waiting for Godot' a research from the MRes in Creative Practices of the GSA

The collaboration with the Master of Research in Creative Practices of the Glasgow School of Art exclusively addressed the assessment of the workflows adopted in digital fabrication, from early conception to module assembly, and took place through assisting a Master student, Gaetano Chianese, in the realisation of his final work - an eight cubic meter pavilion composed of EPS sheets shaped with a Heiz High-Z S-

Figure 2

The HWFG pavilion at the Light House, Scotland's National Centre for Design and Architecture, Glasgow. Installation of the pavilion with superimposed render of the whole structure.

1000-T, a large format CNC router.

This project analysed the role of the script in a theatrical performance giving prominence to its implicit physical participation on the scene. The pavilion was developed as a demonstration of this investigation's results, gathering together text and performative actions in a reclusive physical environment. In this way, its visitors were considered both spectators and active characters of the play. Then, the physical appearance of the text was substituted by QR codes embossed on the external facade of the pavilion linking each face of the object to both acts of the play and multimedia contents hosted in an original website [7].

The Design of the pavilion started with a poser application, DAZ, the actions expected to be enacted by the visitors on human body models. From these posed characters, the negative space of their movements was reconstructed with Rhino creating a surface tangent to their shapes. Then, again in Rhino, this volume was extracted from the mass of the pavilion exterior geometry. With the same process, the technical voids to host cables, speakers, player devices and poles for a reinforcement structure were added to the pavilion. Through Grasshopper and RhinoScript, these geometries were interpreted as horizontal crosscuts, optimised for the fabrication and exported to the DWG format. Subsequently, these files were used in AutoCAD to produce DXF files respecting a set of layer conventions. Eventually, adopting VCarve, these shapes were elaborated to deliver GCODE commands ready to be ingested by the router.

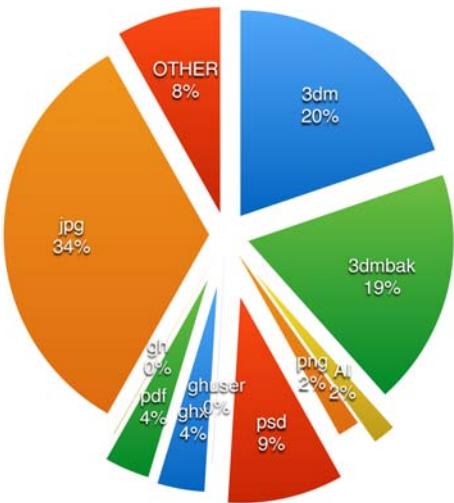
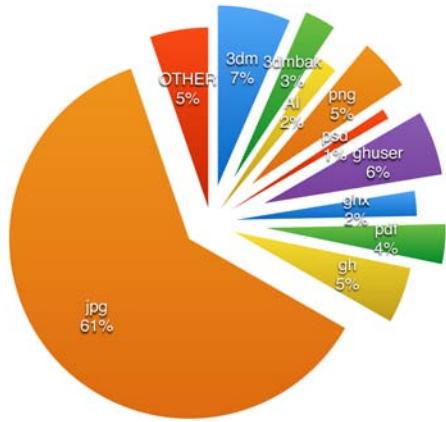
For the fabrication of the pavilion, 168 EPS70 sheets (2400 x 1200 x 25 mm) were cut and assembled in modules with vinyl glue in approximately 2 weeks at the MAKLab, the first open access digital fabrication studio in Scotland. The pavilion was eventually on display at Scotland's National Centre for Design and Architecture, the Lighthouse, during the GSA Graduate Degree Show 2013 (see figure 2).



OPERATIVE FRAMEWORKS IN ADVANCED DIGITAL DESIGN AND TRADITIONAL PRACTICES

These initiatives, were documented and assessed against curatorial criteria and an operative framework that resulted paradigmatically divergent from those of the audited architecture practices, especially for the prevalence of 3D models centred procedures of design representation as opposed to the commercial abundance of both documents representations and relative CAD datasets.

The data files population reported by the analysis of the file repository used by the ParisAtelier students confirm the central role of Rhino/Grasshopper in both their Design process and the creation of visualisations. Opposite to what is recorded within small and medium Architecture practices, the data files population hints at the prevalence of a small group of models used as basis to generate deliverable materials. This is inferable by comparing the number of file types to their cumulated size, i.e. 61% of total file counts are JPG but their total size is only 34%. 3DM Rhino models files account for 7% of the count of repository files but their size is the 20% of the total repository's size (see figures 3 and 4).



The analysis of the data repository of the HWFG project demonstrates the proliferation of intermediate products to accomplish a digital fabrication objective. In this case, the most numerous data files, the 30% of the total files population, are in DWG format. The DXF files are the 13% of the total files number and

whilst, being closely related in the digital workflow to create the GCODE routines, CRV and NC files account for 18% of the analysed data. The 3DM files are just 6% of the audited files but their cumulated size represents 46% of the total repository size (see figure 5).

Because of the implemented Rhino settings, 3DDBAK files show the same demographic figures of their parent 3DM files. Because of the strong emphasis in this project on producing the physical pavilion, a small amount of digital products were intended for the project dissemination, for this reason, PSD and raster images files are almost absent - their number does not reach 1% of the total files number and their cumulated size do not exceed 2% of the repository size (see figure 6).

These latter figures demonstrate an individual workflow, as opposed to the collaborative practices of the ParisAtelier courses, the results are also opposite to the procedures implemented by SME practices. These features of the HWFG project represent a pattern shared by the 'maker culture' initiatives and linked to the data access and reuse practices common to both this and the ampler movement for open source data sharing - in fact, deliverables and visualisation are almost irrelevant in the sharing of information in these contexts.

An aggregate and simplified rendering of the data population recorded in the repositories of SME practices confirm the difference of their operative framework as compared to advanced digital design techniques (see figures 7 and 8).

As DWG files amount to the 22% of all the files population and PDF files are at 24%, the design procedures implemented in these practices are visibly based on the production of digital deliverables correspondent to 2D CAD drawings - the PDF format supports U3D models but in the audited repositories no file in this format was found we can assume the PDF analysed do not hold 3D information.

Further, since the values of size and number of DWG and PDF files are very close, we can affirm that in this context, collaboration is based most probably on the sharing either of editable CAD files or of

Figure 3 Percentages of file types recorded within the repository shared by the students of the Paris Atelier Summer School.

Figure 4 The data population of the Paris Atelier students' repository distributed per size of the file types.

Figure 5
Percentages of file types recorded within the repository of the HWFG project.

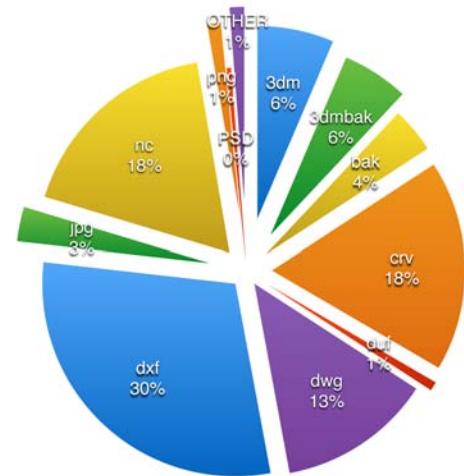
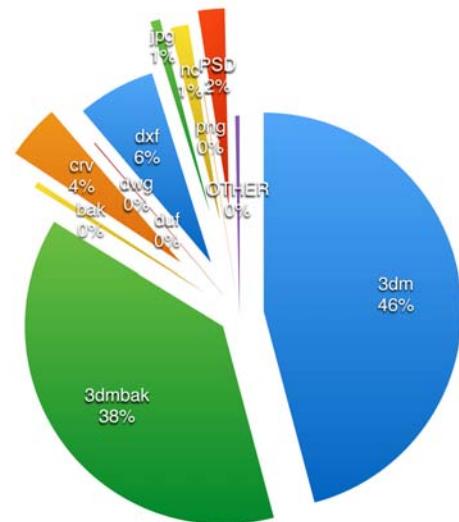


Figure 6
The population of the data files recorded within the repository of the HWFG project distributed per aggregated size of the file types.



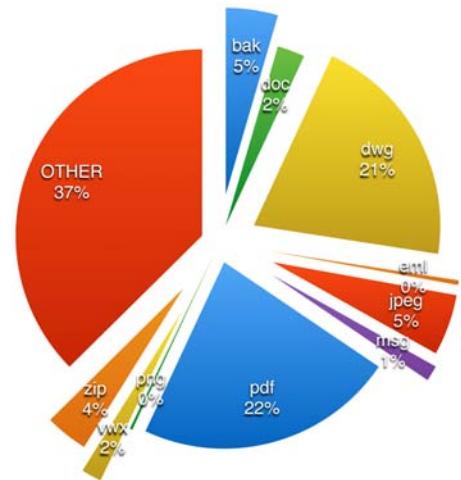
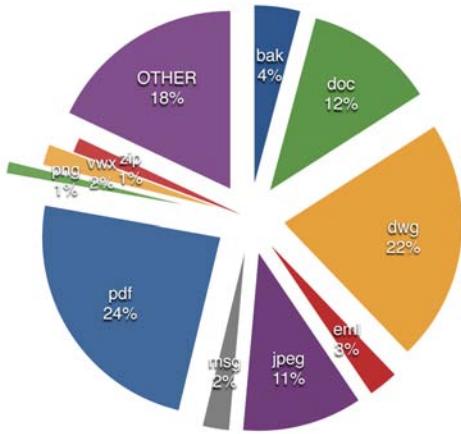
their static digital surrogates. These metric evidences confirm the observations of the procedures of these practices: the information shared for collaboration with external contractors is not intended to be edited but integrated in other workflows.

Meanwhile, the deliverable files addressed to clients and Building Control authorities follow the national standards for the architectural documentation and mirror consolidated practices of managing drawings printed on paper. In such a professional environment, both the communication between parties and the office suites' documents records are associated to CAD data to document and manage the project - DOC files are 22% of the data analysed in SME practices and formats associated with email correspondence, such as EML and MSG, amount to 5%.

Despite the extensive access granted for investigation to the practices' digital assets, the acquisition of unprecedented quantitative information on the digital workflows adopted, these results may be more representative of the local context of Scottish Architecture practices.

Furthermore, analysis of the experimental activities in Advanced Digital Design conducted by students recorded procedures implemented without respecting any professional requirements, although there is a growing community of Architects and Designers, nationally and internationally, exploring a variety of Digital Design procedures within their professional practices.

Once merged, these opposite frameworks result in a set of curatorial challenges, needs and requirements that demand a common curatorial approach for their digital assets and hint at the future convergence of Digital Design procedures for Architecture.



DIGITAL CURATION EDUCATION IN ARCHITECTURE

As professional requirements and integrated Digital Design workflows demand authoritativeness, interoperability, safety, efficiency and legality in managing digital assets, this project stresses that Architects should be able to expertly and autonomously hold

long-term control over their digital products. From this new competence would result numerous opportunities for professional development such as satisfying the political expectations on the redevelopment of the Construction sector, understanding the opportunities for enhanced commercial exploitation of digital assets and facilitating the engagement in cooperative and concurrent Advanced Digital Design procedures. Moreover, this expertise enables designers to both understand and implement curatorial framework updates as the technologies and the tools for both curation and design evolve, and to adapt them to the legal, commercial and creative needs of his/her own business.

At the beginning of the 1980s, Information Management was first introduced within CAAD education in the MIT Master of Science course in Computer-aided design and at the Carnegie-Mellon University, in a four-week module in the professional architectural programme (Purcell 1980). As idiosyncratic CAAD systems development was superseded by commercial package solutions, the interest on this topic was exhausted and, to date, there is no evidence of other CAAD courses held in Architecture Schools addressing the management of design data. Advanced Digital Design practices, such as concurrent and collaborative practices, Digital Fabrication, Generative Design and BIM are now giving unprecedented emphasis to the role of CAAD applications in both the offer of professional services and their documentation. As a result, native digital assets produced through CAAD software have a growing professional importance demanding numerous curatorial actions. For this reason, this project recommends that Digital Curation education should be incorporated into the CAAD curricula.

To define the curatorial competences attached to both the production and management of these complex assets repertory the project borrowed from the DCC lifecycle model its abstract categorisation of the data lifecycle (Higgins 2008). As this model proposes, seven stages in the assets production and management can be identified to specify curatorial actions to

Figure 7
File types recorded within the the repositories of the Architecture practices collaborating with the DEDICATE project as project partners. This is an aggregated and simplified rendition of the actual data population recorded during the project.

Figure 8
The population of the data files recorded within the repositories of the DEDICATE project partners distributed per cumulated size of each file type.

be undertaken at each of them, that is the data production, data creation, data appraisal, data ingestion, data preservation and storage, data access and data transformation stages.

The curatorial competences required at each of these stages can be expressed as learning objectives of a prospected Digital Curation module in CAAD curricula.

Architects should be able to both plan and implement consistent curatorial procedures along the digital design workflows and to formulate data appraisal and selection criteria against a set of economical and professional objectives to formalise information disposal procedures. For example, the Information Requirements framework proposed by the CIC BIM Protocol (Croft 2013) is an early proposal for incorporating in the contractual planning of the roles and relationships between parties and details of the Information Management procedures, including information exchange, access and IPR management. In particular, this protocol, supporting BIM implementation working at Level 2, provides for the appointment of an Information Manager in charge of the processes for information exchange, outputs preparation and data assessment. Although this role has not design related duties, which are instead associated with the BIM Coordinator, the protocol suggests the Design Lead or the Project Lead to perform this role. In so doing, this protocol is including curatorial competences within the Architects' tasks.

Architects should have also the competences to manage the ingestion of digital assets according to agreed curatorial policies to ensure data authoritativeness, persistence and accessibility.

To implement preservation procedures on the assets held in the repository, Architects should be able to establish preservation policies according to professional and legal needs. The preservation of assets should be then be guaranteed by managing the persistent feasibility of data storage.

As professional liability and authoritativeness of data ought to be documented, Architects might be able to monitor and restrict privileges for data ac-

cess and reuse according to professional and legal requirements.

To ensure the digital management and production procedures can document long-term rights and licenses associated with data, designers need to have competences to plan and implement procedures to track the data reuse and transformation according to good practices in IPR management.

These activities must be rooted on a set of technical skills in the management of digital infrastructures, the implementation of standards and the production of Digital Assets.

First of all, architects might have a proficient knowledge of formats, data structure and digital design computing routines to take expert decisions on the digital infrastructure and the procedures for data production to be implemented in their practices.

Then, an advanced knowledge of both metadata standards and data quality assessment parameters is requested to appraise the quality of the digital assets. In particular, Architects should be able to understand both the purpose and the originating digital workflow of the data.

Managing their own repository, Architects should be experts on the preservation routines, functions and strategies and the repository architecture's available options.

To implement a granular access control to the data held in the practice's repository, Architects should understand the techniques and procedures for privileges based data access.

Managing the data transformation and the IPR associated with the assets, Architects should have knowledge of data watermarking, cryptographic techniques options and format migration issues.

CONCLUSIONS

The rising importance of Digital Curation competences in the Architect profession demands updating the education of the future generations of Architecture professionals. Further, the affirmation of the digital cultural market and especially the closer integration of Digital Design with Manufacturing and Con-

struction are also redefining the role of the Architect as a content provider and demanding from professionals a granular control over their data IPR management. As these recent developments also facilitate the commercial exploitation of digital products, such as for example promoting the reuse of elements in BIM workflows (Waterhouse et al. 2013), the integration of curatorial activities in data production can result in numerous opportunities for architects' professional development.

Despite the frameworks resulting from the traditional use of CAAD solutions in Architecture practices and the Advanced Digital Design procedures have different needs and requirements, we foresee the impact of digital innovation in the construction sector will push these frameworks to converge, especially to support the persistent retention and accessibility of digital assets across domains.

The Digital Curation module for CAAD curricula discussed in this paper will offer architecture students the competences to both practice their future profession within this integrated framework and fulfilling political and commercial expectations on the development of the Architect role.

At present, the results of the DEDICATE investigation are being adopted to create a first Digital Curation teaching module to be tested in different architecture curricula. A partial application of this teaching project is expected to be within the forthcoming Master in Built Heritage Conservation of Strathclyde University organised by Cristina Gonzalez-Longo.

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