PROJECT DESIGN AND ACHIEVING EDUCATIONAL CHANGE: FROM STATPLAY TO ESCI

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Abstract

Educational Design encompasses many aspects of educational software development, but needs to be extended to Project Design (PD) by inclusion of a strategy for dissemination. This crucial aspect of PD should be considered from the start, and usually involves commercialisation. Models for commercialisation are diverse, and the choice can have enormous implications for many aspects of the project and for its chances of success. The case for PD is illustrated by a brief account of StatPlay, a large multimedia project for learning of statistical concepts that was largely successful educationally but failed to achieve commercialisation. The more modest PD of ESCI (Exploratory software for confidence intervals) is also outlined. Taking commercialisation seriously should lead to policy changes by universities and funding bodies, and should include increased attention to intellectual property issues, and the provision of professional support for aspects of commercialisation. Formulating a comprehensive PD from the start, and attending to commercialisation issues throughout, should yield more successful projects.

Keywords

project design, educational software, learning statistics, commercialisation, project management, educational innovation

Introduction

It is notoriously difficult to achieve widespread educational innovation. Even if a local trial gives evidence of educational effectiveness, it is *very* hard to achieve wide take-up. Fullan and Stiegelbauer (1991) described attitudinal, institutional and cultural obstacles to successful spread of educational change. Teachers are too busy, established practices too entrenched, and the shiny-eyed innovator too easily dismissed as a biased enthusiast. To make a worthwhile difference to the world an innovation must be educationally effective, but must also have a realistic and powerful mechanism for proliferation.

Educational computing has innumerable tales of local trials that elicit enthusiasm and are pronounced effective, but are not taken up elsewhere. In this paper I propose that *Educational Design* (Cumming, Finch & Thomason, 1999) must be extended to *Project Design* (PD). The critical feature of PD is that plans for proliferation—which usually requires commercialisation—are integrated into the project from an early stage.

StatPlay was a multimedia project that during 1994-99 developed materials for statistics learning. From the start we worked towards taking StatPlay to the world but, despite great classroom success, we did not achieve commercialisation. I will give a brief account of StatPlay and identify some lessons for the PD of educational software.

ESCI (pronounced "esky"; Exploratory software for confidence intervals) is my recent, more modest project aimed at improving the visual interpretation of confidence intervals (CIs) and promoting their use. Like StatPlay, its general goal is to improve statistics understanding, but its scope is narrower. Its design (Cumming & Finch, 2001), including the strategy for proliferation, reflects lessons from the StatPlay experience, especially the StatPlay difficulties with intellectual property (IP) and the numerous steps necessary to achieve large-scale commercialisation. I will introduce ESCI, outline its PD, then suggest some overall conclusions about PD that may assist more projects to develop to the stage that the software and materials they produce are actually used more widely.

StatPlay: Multimedia for Understanding Statistical Concepts

After decades of advocacy by reformers it is now likely that statistical practice in psychology may at last change for the better (Finch, Cumming & Thomason, 2001; Wilkinson & Task Force on Statistical Inference, 1999), although rapid progress is certainly not assured (Finch, Thomason, & Cumming, in press). One obstacle to reform has been widespread and well-documented misconceptions about some core statistical concepts. Improved statistical understanding is required if reform is to succeed.

In 1993 Neil Thomason and I (the 'principals') conceived the notion of StatPlay. Thomason, Cumming and Zangari (1994) described its design rationale. The goal was deep understanding of basic concepts, as a contribution to statistical education and reform. StatPlay would present vivid graphical representations and invite students to regard these as 'take-home' visual images to serve as anchors for understanding. Multiple representations (including perhaps images, graphs, numbers, and formulas) would be offered, whenever possible linked together dynamically on the screen. The whole would be highly interactive, and invite exploration of target concepts.

StatPlay Classic

We considered carefully how to build StatPlay. We weighed up Hypercard, Authorware, Director, and Visual Basic. We carried out trials, and sought expert advice. We eventually chose Visual C++ as being necessary to achieve excellence of interface design, together with smooth, immediate interactivity. The disadvantage was that it is a full programming language—not an authoring environment—and so we could not build software ourselves, but would have to raise grants and employ software developers.

During 1994-1997 the first version of StatPlay, now known as StatPlay Classic (Figure 1), was built, largely by Mark Zangari and Jan Les. Classic ran under the 16-bit Windows 3.1. Successive versions were used at La Trobe University and the University of Melbourne. Classroom reception was good and controlled evaluations gave evidence of effectiveness (Cumming & Thomason, 1995; Cumming, Thomason, Howard, Les & Zangari, 1995).

An important development was the multimedia recording and playback facility Sam (as in 'Play it again…'), which gave learners access to an extensive set of 'demos' (Les, Thomason & Cumming, 1997; Les, Cumming, Thomason & Finch, 1997). Sam allowed easy recording of a demo—any brief interaction with StatPlay, with voice commentary—then a learner could play back any chosen demo to hear and see an explanation or example, perhaps with guidance for the learner's next challenge. Sam demos were especially enthusiastically received in the classroom. Demos could be used to build a whole curriculum; Sam could also be used by students or tutors to record demos to express their understanding, or to pose a question.

StatPlay Classic has been used, since 1994 and currently at La Trobe, and since 1996 at the University of Melbourne. In 1997-98 it was used at Melbourne by more than 3,000 students each year in more than a dozen departments, and some unsupported use continues. It is also used by colleagues in a small number of other universities, with dissemination limited by StatPlay's uncompleted state and our inability to offer support.

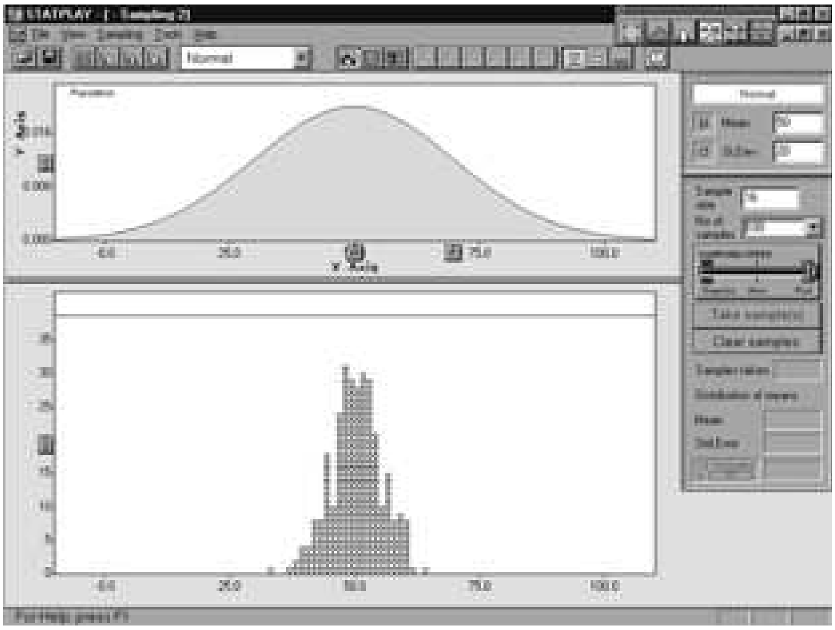

Figure 1: The Sampling Playground of StatPlay Classic. The 'mean heap' (below) is the distribution of means of many independent samples from the population (above). Many aspects of the simulation are under user control. The standard error (SE) is easily seen and remembered as the standard deviation of the lower distribution. The Central Limit Theorem can be explored by drawing a population of any desired shape in the upper panel: The lower distribution remains approximately normal in shape.

StatPlay 1.0

We wanted a better, cleaner interface but realised that building our own would require more programming effort. In 1997 we had an important choice: We could work further on StatPlay Classic and seek its commercialisation as a first-version product that would cover important parts of a foundation statistics course, but far from a whole course. Alternatively, as part of upgrading to 32-bit Windows 95, we could start again more or less from scratch, design and build a much-improved interface and work towards 'StatPlay 1.0' having wider coverage of concepts. After careful weighing of pros and cons we chose the ambitious course: We left the usable but incomplete Classic and started work on version 1.0.

In 1997 Jack Zhang joined as software developer, and Robert Maillardet as part-time designer and manager. Sue Finch worked on specifications, classroom materials and research. We had three full-time software developers; seven people attended team meetings. We formalised the development of comprehensive written specifications, and the management of software development, with weekly reviews of progress against the detailed plans. These arrangements were very effective and great progress was made during 1997-98. Figure 2 shows the clean, spare style of our interface of 1.0.

Funding

StatPlay was funded mainly by five CAUT-CUTSD grants (1994-99) and by multimedia development grants from the University of Melbourne (1997-99). There was a joint Melbourne-Monash grant in 1999, and consultancy income of the principals was also used. The total was about A$650,000—not including principals' time. In addition ARC funding supported closely related research (1996-2001). About 8 person years of software development, and 7 person years (including principals' time) of design, specification, management, materials development, classroom work, and numerous other tasks, went into StatPlay.

An enormous amount of time went into efforts to find funding. A consequence of piecemeal funding was that we always had to propose new developments, when what StatPlay really needed was careful testing and revision to produce a robust version we could promote to the world. It is a *very* long road from a wonderful prototype to a rounded-out, robust, tested, refined and fully documented product accompanied by proven learning materials!

Intellectual Property

In mid-1997 La Trobe and Melbourne Universities agreed to assign the IP in StatPlay to the principals, with reasonable conditions. In the case of Melbourne this required of us 15 months of work, as the University's IP administration and policy were in a state of flux. In 1997-98 we submitted a provisional patent application (with support from the University of Melbourne) for the Sam multimedia utility, and spent much time and effort seeking—without success—a commercial partner to exploit Sam's techniques, hoping this would finance further development of StatPlay.

We were nervous about the IP aspects of CAUT-CUTSD grants, as the rules changed from year to year and were poorly worded. However our biggest IP problem was raised by the 1999 Melbourne-Monash grant, for which Kevin Korb joined us as a StatPlay principal. The project was delayed by the 6 months it took to achieve an IP agreement and even then there was no assignment, only a commitment to assign at completion of the project. (By September 2001 we have still not been able to finalise this assignment.)

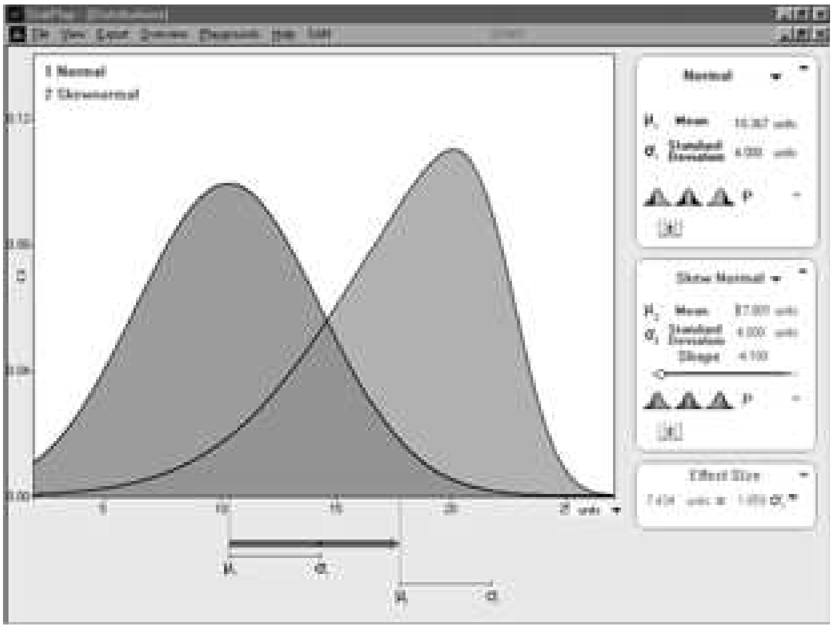

Figure 2: The clean, spare interface we constructed for StatPlay 1.0. Many elements allow interactivity: Click and drag to change the display immediately and smoothly, and to see immediate changes in linked aspects. For example if the left mean symbol is dragged, the left distribution moves, the effect size arrow (below, between the means) changes length, and the relevant numerical values at right are updated continuously.

Commercialisation

We realised from the start that commercialisation was needed if StatPlay was to be available to statistics learners worldwide. Strong interest by Australian editors of major international publishers led us to submit through them prototypes and proposals to head offices in the US and the UK. In 1998 I visited a number of these in the US. Their assessments of StatPlay, based on independent reviews, ranged from positive to extremely positive, and we were offered several contracts. The problem was that publishers wanted a product covering the full introductory course. Our plans required a minimum of 2-4 extra person years of development effort to produce such an expanded version, and no publisher was prepared to make the up-front investment to support this work. Had we been able on grant funding to take StatPlay to the brink of being a product covering a full first course we would certainly have had at least 3 major international publishers vying to take it up.

We prepared business plans and summary proposals, and made innumerable presentations to venture capital sources, business angels, software publishers, and various government bodies. The response was invariably positive and encouraging, but did not lead to the investment StatPlay needed. This endless work diverted our efforts from development of StatPlay and, of course, our academic day jobs did not go away.

One promising commercial partner (to be referred to as CP) reviewed StatPlay in 1998. After independent assessments, presentations, and much work on a business plan, CP's Board approved in principle the investment of more than A$630,000. In conjunction with a major international publisher, CP undertook market research internationally. CP's Board reviewed the proposal and confirmed its intention to invest and to manage the project. We worked closely with CP to develop the business and development plan in great detail, to expand StatPlay and market it worldwide. Eventually, despite our great efforts, in late 1999 CP withdrew. Various management and business model problems contributed, and CP stated that IP difficulties were crucial. We were immensely disappointed and frustrated, and exhausted after years of effort towards commercialisation. All funding had run out, and our software developers had to leave.

CP's solicitor was faced with a formidable pile of paper defining StatPlay IP. The pending status of the Melbourne-Monash grant's IP was stated to be a problem, as was uncertainty of IP in relation to the five CAUT-CUTSD grants, despite a public statement (at last) in mid-1999 that DETYA did not claim IP ownership. Several aspects of the CAUT-CUTSD IP that were identified as questionable by CP's solicitor have never been fully resolved.

It is a tragic waste to have an effective product little used, especially when it represents some 15 person years of effort. We would still be pleased to hear from any potential commercialisation partner, although now a development team would need to be assembled. We hope to make StatPlay in its current state available on the internet, but at this stage even the small remaining hurdles, including IP, loom large, and additional support to achieve this availability would seem extremely cost-effective.

PD and Models for Products

StatPlay afforded a number of models for products: Should it be software integrated into a statistics calculation package, such as SPSS? Should it be stand-alone discipline-neutral software, intended to supplement a statistics textbook in the student's discipline (e.g., biology, psychology, business)? Should StatPlay be tailored to fit with leading statistics textbooks, in various disciplines, and sold in a bundle with such texts? Should the main income be from sale of one-use workbooks, or of the software on CD, or from downloads of the software? In discussion with publishers and other potential commercialisation partners we explored numerous possibilities.

Central issues included software licences and copy protection; whether students would be willing to pay for a software tool in addition to a textbook; to what extent we needed to include statistics calculation facilities in StatPlay; and whether learning materials accompanying StatPlay could be generic or would need to be tailored for each major discipline in which students take introductory statistics. These issues had immense implications for what we built, how much time and money was needed, and the chances of successful commercialisation. Such issues are crucial in the commercialisation component of PD.

Our choice of Visual C++ committed us to a large project requiring substantial funding, but was necessary for excellent graphical representations, smooth interaction, and the wonderful Sam demo facility. Our decision in 1997 to build our own clean interface undoubtedly made StatPlay 1.0 better than Classic. Had the commercialisation with CP proceeded there is every chance that a fine product would have reached the world market, thus vindicating our ambitious 1997 decision. With hindsight it would have been better to work further with Classic, publish it as a first-version tool, then if that was successful develop subsequent versions with increased coverage and perhaps an improved interface.

Our diverse funding sources gave complexity of IP, and dealing with IP took vast time and energy. We were told we were an early case, IP policy was being developed, and later projects would have an easier road. I hope so, although I am not convinced. IP uncertainty, or even complexity, can be fatal to the chances of commercialisation.

The main lesson of StatPlay is that a major educational multimedia project has many aspects, which interact in complex ways and may each influence the prospects for commercialisation. For example, our choice of Visual C++ (which I still regard as correct and essential for achieving the StatPlay we wanted) had implications for funding needed, and thus for IP complexity, both of which were key elements in the ultimate failure of commercialisation. The commercialisation component of PD is crucial and requires work throughout the life of a project. There are many models for commercialisation that need to be considered.

Models for Commercialisation

What models for bringing to the world software for statistics learning are most likely to be commercially successful? Experiments in the market continue: Here are some examples:

- *Textbook with ancillary software* Smithson (2000) is a fine textbook that emphasises CIs, sold with a CD containing limited ancillary software.
- *CD with text and software* AktivStats (Data Description Inc., Online) is a CD offering a hyper-textbook on the screen, with video clips, datasets, small simulations and a statistics calculation facility. It aims to be cross-discipline.
- *Shrink-wrapped software, with associated books* Fathom is powerful software with an excellent interface. Software licences are for sale and also textbooks written specifically to exploit the software are available (Key Curriculum Press, Online).
- *Workbook plus CD* Visual statistics 2.0 (Doane, Mathieson, & Tracy, 2001) is a workbook with CD that covers the first course and aims to supplement a discipline-specific statistics text. There are many exercises and data sets. The software offers calculation facilities and simulations, but does not approach StatPlay's interactivity.
- *Excel worksheets on the web* Rodney Carr (Online) offers over the internet XLStatistics, an inexpensive set of Excel worksheets that illustrate many statistical concepts and provide data analysis facilities.
- *Java applets* A variety of Java applets (e.g., Globally Accessible Statistical Procedures, Online) are available online, many of them free, but generally without links to a full curriculum.

These options, and more, are currently being tested in the market. Of course different educational domains may need variations on the models that have been chosen for statistics. It remains unclear which options might succeed, and under which conditions.

Educational developers may find commercial issues tedious or distasteful, but in most cases commercialisation is the only way that even wonderful materials will make an educational mark in the world, and can be assured of ongoing maintenance and development as software, hardware, and educational expectations change. Many product model options, and ways to commercialise, need to be considered from early in the life of a project: Doing so is the vital extra ingredient that PD has over Educational Design.

ESCI and Visual Understanding of CIs

Reform of statistical practice in psychology (Wilkinson et al., 1999) requires among other things increased use of CIs. Cumming and Finch (2001) presented a tutorial account of CI use, with particular attention to CIs for the standardised effect size Cohen's *d* (also known as *d*). These CIs are little-known to psychologists, but their use needs to become routine if reform is to succeed. Their calculation requires use of noncentral-*t* distributions and an iterative algorithm, not mere application of a formula.

I developed interactive graphical worksheets, running under Microsoft Excel, to illustrate the concepts and allow users to find CIs for their own data. These worksheets are the start of ESCI, which has the general aim of encouraging better understanding and wider use of CIs. ESCI will emphasise CIs represented visually, for example as error bars on graphs. Cumming and Finch (2001) is illustrated by screen images from ESCI and readers may obtain the software at small cost (ESCI, Online).

Microsoft Excel for Interactive Graphical Simulations

Try this simple experiment: In an Excel worksheet enter a few numbers and insert a simple chart of those numbers. Use View-Toolbars-Forms to show a toolbar, click the scroll bar icon and insert a scroll bar in the worksheet. Right click the new scroll bar, select Format Control and point the Cell link to one of the numbers. Then use the scroll bar to change the chart dynamically—yes, graphical interactivity is as simple as that! If you position cells that change (e.g., sum of the numbers) behind the chart, dragging the thumbnail in the scroll bar will change the chart smoothly and continuously.

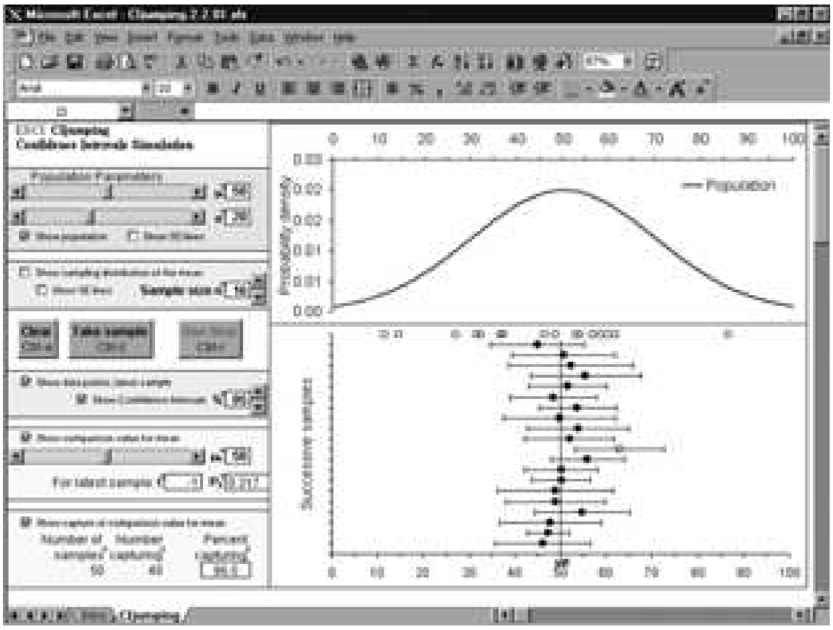

Figure 3. The ESCI worksheet ***CIjumping****, illustrating variability of the CIs based on successive independent samples from a population. The horizontal line of open circles is a dotplot of the latest sample. The open-circle mean has a CI that does not capture* μ*. Many aspects of the simulation and the display are under user control. Click the Run-Stop button to see a stream of independent samples cascade down the screen.*

That is the basis of ESCI. Figure 3 shows an image from **CIjumping**, an ESCI simulation with a fragment of the functionality of StatPlay. A different ESCI simulation allows exploration and calculation of CIs for Cohen's *d*, and uses Excel's Goal Seek to carry out the iteration. The user sees two noncentral-*t* distributions 'hunt' back and forth on the screen as they home in on the correct CI. I hope this helps the user understand something of the process as well as obtain the values of the CI.

Excel provides basic data handling, statistical calculation and graphing facilities, but if Excel development is pushed too far it becomes a Visual Basic programming exercise that may approach in complexity the Visual C++ task of developing StatPlay. Excel does, however, offer a practical way to achieve limited goals quickly, and without the need for major funding and an expert software development team.

Project Design for ESCI

ESCI has both a narrower focus than StatPlay and a much more restricted range of possible representations and interactivity. There is no Sam and only a small set of interface components. But **CIjumping** took a few days to develop, whereas StatPlay's Sampling Playground took more than a year of expert software developer work-plus the effort needed to raise the funding, develop the specification, and manage the project.

The PD for ESCI is modest: Build simulations to illustrate concepts and techniques described in journal papers, and to provide calculation facilities. Distribute the software via the site of an e-commerce company and credit any income to a university account to support further development and research. IP issues are straightforward.

I intend to publish further papers on the use and interpretation of CIs, and these will be supported by further components of ESCI. I also plan to develop ESCI as the basis of a new introductory statistics course for psychology students based on visual representations, with few formulas and an emphasis on issues and techniques that reformers advocate. If successful this may lead to a published workbook or textbook.

ESCI's goals are limited, but the beauty of the ESCI PD is its modesty and scalability. The extent to which it is taken up will depend not only on its perceived usefulness, but on whether I can publish the planned papers, and the prominence of the journals in which they appear. Additional publicity via email discussion groups, conference papers and workshops may assist. ESCI would contribute directly to the reform of statistical practices if it is taken up and used by researchers and teachers. It may also contribute indirectly if it prompts other authors and software developers to adopt its techniques and representations.

Conclusions

Software Tools for Development

The choice of software development environment is as crucial now as it was for StatPlay in 1993. One major choice is between a full programming language (Visual C++ or Java) plus an overlaying set of developer's tools, or Excel plus some use of macros and Visual Basic. The latter represents an 80-20 solution: Specialised programming expertise is not required, much functionality is given by Excel itself, and development is very fast, but there are many limitations on what can be built.

These two major options may converge, with improved overlaying tools for Java allowing faster development, but I suspect such advances may be limited and specialist programming expertise will still be required. I would prefer to see major advances in the power of Excel, without the need for full use of Visual Basic. That could bring even greater scope to Excel users, without higher-level programming skills being required.

The Development Team

Major educational software development requires a team with expertise in the subject domain, educational design, graphics and interface design, software development, and project management. However if specialised programming expertise is not required it is more likely that one or two academics can come close to providing this range of abilities. Having a small team—with at most one expert programmer—avoids the problem that a large team requires specification and development processes that are more formal and bureaucratic, and inevitably raises more complex issues of IP, funding, personnel, and management. Whether the team is large or small, however, it may also need to draw on a range of commercialisation skills, as required to implement the PD.

Policy to Encourage Commercialisation

If a university or funding body wishes to facilitate dissemination and ensure ongoing maintenance it needs to support commercialisation. Beside funding for educational and software development it would be highly valuable if it provided management support to take primary responsibility for most aspects of commercialisation. This is probably the single biggest lesson from StatPlay: If others with appropriate commercial skills had been available to undertake much of the work towards commercialisation, success would have been more likely. In addition we would have been able to achieve better and faster development of StatPlay itself.

Providing specialist support for commercialisation should surely be cost-effective, and would allow academics to use their expertise to develop wonderful educational materials, rather than be diverted for countless hours into bureaucratic and commercial activities. Had we foreseen the enormous drain these latter activities were to have on us we would not have commenced StatPlay, or would have restricted ourselves to a much more modest project. It would of course be appropriate for any provision of major help towards commercialisation to be reflected in the allocation of percentages of ownership and/or returns.

Project Design to the Fore

It is interesting to speculate on the PDs of StatPlay and ESCI. A full StatPlay may have had market success, not least because of the expense of developing a competitor. But a large investment may become vulnerable to products developed cheaply with improved tools. Competitors to ESCI could be easily developed, so ESCI may need to inhabit educational (and market) niches and move quickly. However the current position is that StatPlay did not reach the market, and ESCI is recent and, although the first parts are available to the world, it is largely unproven.

I am arguing that Educational Design must be extended to PD. Overcoming the obstacles to educational dissemination requires careful attention to all aspects of PD. Project proposals should specify a full PD-perhaps not at first, but early, after an initial proof-of-concept stage. Commercialisation is in most cases essential if software is to be taken up widely, and to be updated to remain contemporary in the fast-moving world that students inhabit. There are many models for commercialisation to be considered.

It is hardly original to say that commercial issues matter, but I am arguing that they need much more attention than they often receive, and they need this throughout the life of a project. Commercial issues are likely to influence, and be influenced by, many aspects of a project; they need to be integrated into a comprehensive PD. Developing then following a full and powerful PD may be essential steps in achieving worthwhile educational change.

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