
# Final Report

**Module:** CM0343

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**Project Title:** The Impact of Potential Changes to the ICT Curriculum in British Schools

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# Abstract

The situation with ICT in schools at present is unsatisfactory; pupils are not interested in the content they are learning or stimulated by the manner in which it is being taught. It is clear the ICT curriculum is partly at fault. The government have made numerous attempts to improve the situation with the final attempt being the removal of set programmes of study for KS4 students.

In a radical movement the Government has recently confirmed that ICT taught in secondary schools in England at key stages 1-4 will be replaced with Computer Science programmes of study as of September 2014. This change alone will have a huge impact on both students and staff. Pupils will now have the opportunity to really enhance their learning in term of understanding how computer applications are built not just making use of them. Companies like Microsoft are even starting to recognise the benefits of teaching Computing in schools as they have noticed a "shortage of people with the right Computer Science expertise in the UK" [1] and are supporting the Government in the transition from ICT.

The move to teaching Computing from ICT really is vital in order to provide students with the knowledge and skills necessary to survive in the current business world. However as schools currently stand, I am unsure as to whether they could cope with this change.

In my report I intend to identify what factors are likely to limit this change and what impact it would have on all the parties involved. Do schools have the necessary resources to deal with the changeover? if the answer to this is no, what is going to be done to resolve this? From modelling the situation I hope to identify what policies could be considered to help schools cope with this transition period and whether implementing these actions would be in the school's best interest in order to provide a significant benefit.

# Acknowledgements

I would like to thank my project supervisor, Wendy Ivins for providing me with guidance and direction throughout. She offered constant encouragement and support. Without her help, I would not have been able to develop such a challenging project.

My appreciation must go to Catherine Teehan for educating me in the field of systems dynamics. Her willingness to help and provide guidance throughout the modelling process is greatly appreciated. Without the constructive criticism of my previous work, I would not have made the significant improvements that have enabled me to produce a project I am immensely proud of.

I would also like to give my thanks to Gary Morgan for participating in a second interview. He provided me with a great deal of information that enabled me to build a real life simulation model.

I would like to thank my family and friends for their ongoing patience and support throughout my study.

# Abbreviations

ICT- Information Communication Technology

COMSC- Computer Science

PGCE- Postgraduate Certificate in Education

SSM- Soft System Methodologies

TOGAF- The Open Group Architecture Framework

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# The Impact of Potential Changes to the ICT Curriculum in British Schools

## 1. Introduction

As identified in the interim report, there are a number of issues surrounding ICT as a GCSE examination subject. In summary the main areas of concern include the content of the curriculum being outdated as many schools are concerned with providing the skills necessary to use the typical Microsoft suite rather than allowing pupils to be more creative and develop their own applications. As a result often lessons aren't challenging enough leaving pupils disinterested in continuing with education in the subject. Additionally, there is a severe lack of qualified ICT teachers with many schools using cover teachers to supervise ICT lessons rather than actually delivering valuable content. Many senior managers believe anyone can teach IT as long as they are capable of working a computer. However this couldn't be more wrong. Despite the vast amounts of funding that the government has invested in the training of ICT teachers there is still a huge shortage and as result some of the current stock are unmotivated and lack passion for the subject.

Having identified the real need for changes in the ICT curriculum in schools, my intention was going to be to identify what possible changes could be made to the curriculum in order to drastically improve it. However, during my investigation the Government and Department of Education announced they intended to "scrap the ICT and replace with a flexible new computer science and programming curriculum" [2] and as a result it meant the focus of my project moved towards the impact this change would have on ICT in British Schools.

My Interim report satisfied four out of five of the project's aims, concluding with an influence diagram that identified all the impacting factors that currently affect school's decision making process. In this report, I will aim to achieve the final project aim which is:

1. Through the use of systems dynamics, run various incremental simulations using iThink. Based on these results, identify recommendation for a proposed system to support decision making in schools. Assess how schools can monitor information and exploit it in order to achieve maximum success.

The first section of this report will provide a general background and summary of what changes there have been to the situation with ICT in schools since my last report. It presents the main reasoning behind the changes made and outlines any possible obstacles that are likely to be faced.

The next part is an overview of the steps taken in the period between moving from development of the qualitative model in the interim report to building up the data and knowledge necessary to start modelling the quantitative aspect. There is a summary of what I learnt from producing my interim report and how this has been used in the preparation for completion of the overall project. This section is also where the design and implementation of the simulation will be detailed.

From the model, I will be able to:

- Determine the influences on the situation
- Identify what influences have the biggest impact

- Outline where a policy action is needed
- Apply the policy
- Evaluate the impact the policy would have on the situation

The next section of the report is the Evaluation. I will analyse each project aim and assess whether I have successfully achieved it. I will also look at my chosen method of approach and determine its effectiveness in this project. The next portion of this report will look into possible future work. I will identify if any aspects of the project could be further developed and distinguish if there are any improvements that could be made.

The penultimate sector of the final report will be a reflection on learning. In this part I will detail the process I went through over the past year, identifying any issues that arose and my overall experience throughout the development of this project.

I will then bring the report to a close with a conclusion of the entire project.

# 2. Background

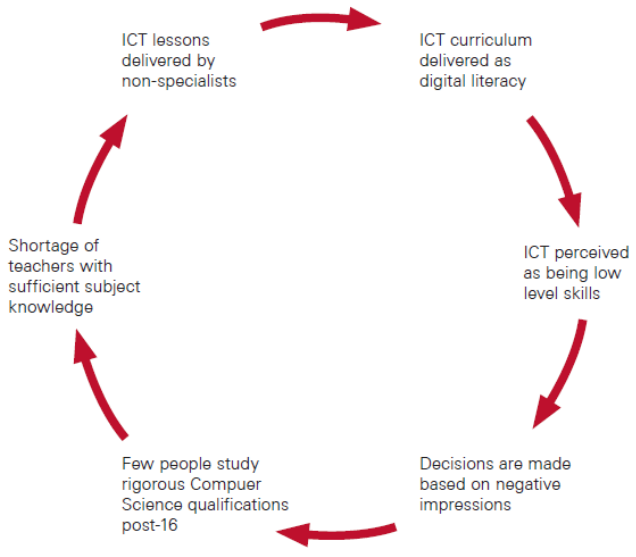
Despite the UK public's recent fixation with technology and the realisation that ICT underpins the vast majority of aspects of the modern world, [3] the number of pupils opting to study ICT at KS4 and above is continuing to decline. As a result, the Department of Education have taken a drastic approach of deciding to replace ICT in schools with a new Computer Science based curriculum. The intention of this movement is to reignite student's interest in technology and provide them with a skills set capable of more than word processing and data entry. Their aim is to encourage students to continue their study of the discipline at examination level and further, after exploring how useful the subject can be. Development of these skills will benefit both the individual and businesses as it will provide both entities with a competitive edge that is considered so vital in the current economic climate.

It is clear there is a need for such an extreme change. However, the Department of Education is so focused on how bad the current situation with the ICT curriculum is, referring to it as a "roadblock [3] in education", I am concerned they have not considered the feasibility of this transformation. Michael Gove has removed the problem of the poor ICT curriculum but has instantly created another, i.e. how are schools and teachers expected to be able to cope with this change? It appears that as one problem is resolved another arises.

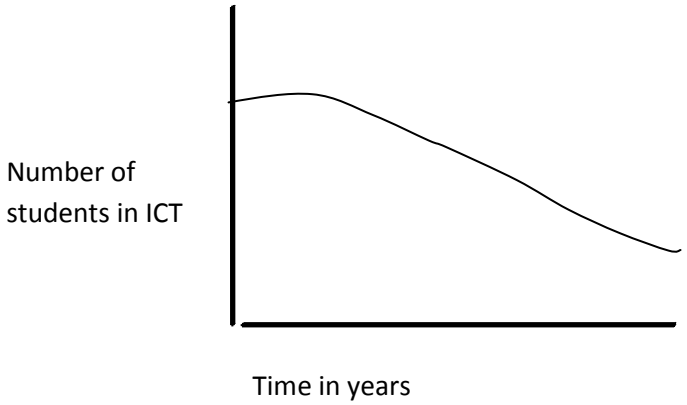
The biggest impacting factor on the level of student skills is the teaching they receive. The majority of subject teachers today are qualified in their field and some even considered experts. However, this is not the case with ICT. A contributing factor to this is those who have qualifications in ICT related degrees are more likely to work outside education where the financial rewards are far greater and have the opportunity to develop their skills further. It is difficult for the public sector to compete with the wages private firms offer, making it difficult to attract those skilled in ICT into teaching. Another reason for the shortage of qualified ICT teachers may be a result of lack of opportunities when they were studying. Over the past few decades there has been an IT revolution, transforming the way we live and work today. However, prior to this period there were not the same opportunities to specialise in ICT as there were available for English or Maths.

In the report published by The Royal Society, "Shut down or Restart" they have used a cycle to show inter related forces concerned with the current state of ICT in schools.

[3]



This model demonstrates the knock on effect that poor level of ICT being taught in school can have in the long term. The less students opting to study computer science post 16 will lead to fewer graduates in the discipline which will effectively lead to a shortage of teachers with sufficient knowledge. Each variable is having a positive impact on the next creating a process of continuous feedback. In the approach 'Systems Theory' these variables form a reinforcing loop. This is where the result of one action brings about more of the same action. In this case, a vicious cycle has been created as reinforcing the cycle brings about an undesirable action. As the structure will continue to decline exponentially, student's skills will continue to worsen and the number of students studying Computer Science will continue to fall.




These are the results I would expect to see from this reinforcing loop in behaviour over time graph. The downturn of ICT in schools will continue to the point of rock bottom until something is done in order to break the cycle.

The Departments of Education decision to move to a Computer Science based curriculum from ICT will break the negative reinforcing loop which should in time lead to significant improvements in the level of students skills and the number of students continuing to study Computer Science. However what the balancing loop doesn't show is whether schools will be able to cope with this change to create a virtuous cycle as powerful as the vicious cycle. [4]

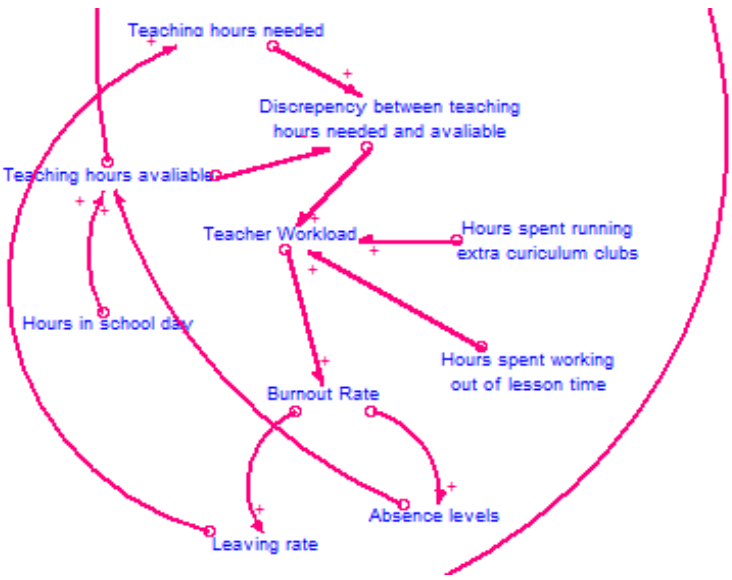
# 3. Transition to iThink modelling

## *3.1 Design of Qualitative Model*

The influence diagram in my Interim Report was produced with the intention to identify the wider influencing variables that would directly impact ICT in schools including the government's pressure, local authority's budget, available teacher training schemes and graduate scheme opportunities. However, after further analysis of the topic, I decided it would be more effective to approach the problem from an individual school's perspective and create a quantitative model that illustrated this. The reason behind the change of scope was by focusing on one school I could gather real facts and figures to input into the quantitative model. Using accurate data would produce a more reliable and effective simulation able to demonstrate the impact the movement from ICT to Computing would have on a school. As most schools operate in a similar format, the results obtained from the quantitative model could still be applied to other schools to help them individually in decision making.

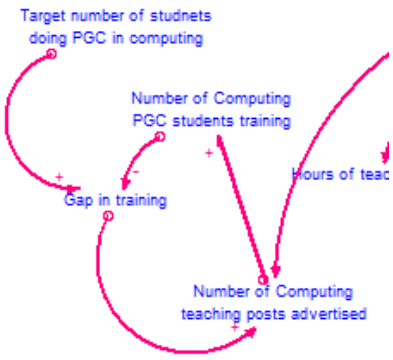
As a result, I created an additional influence diagram focused solely on one school. I worked incrementally and focused on small aspects at a time making the problem more manageable. I identified the areas that had the most significant impact on a student's skill level. These were teaching hours available, level of teaching quality, equipment available and existing funding and created four separate influence diagrams. There were clear interdependencies between the models which made combining them into a single influence diagram far more straight forward.

From the revised version of my influence diagram, I was able to identify some really interesting relationships. Looking at the teaching hours aspect of the diagram, there is the clear formation of a reinforcing loop. If more teaching hours are needed, there is likely to be an increase in the discrepancy between teaching hours needed and teaching hours available which will have a knock on affect of increasing teachers workload. If teachers are under too much pressure with an increased workload, there is a greater possibility of a higher burnout rate leading to staff having to take a prolonged medical leave or depart all together. The more teachers that leave work will lead to an increase in the number of teaching hours needed putting the remaining teachers under more stress and likely to cause the cycle to repeat again.



If I decided to model this aspect of the influence diagram in iThink, I would expect to see a constant rise in the discrepancy between teaching hours needed and those available until a policy action was put in place to control the situation. Another fascinating aspect of this particular section is the unintended consequences that have arisen as a result of the discrepancy of teaching hours. Staff absence level and leaving rates are both major issues schools would have to deal with as a direct result of not enough teaching hours.

The influence diagram also identifies the drastic need for teacher training. In order for schools to be able to make the switch from ICT to computing, the current teachers must have the necessary knowledge in order to teach the new curriculum at a satisfactory level. There are many things that are currently influencing teacher quality. This includes the amount of funding available in the school to improve the standard of teaching, along with the number of graduates that actually wish to pursue a teaching carrier in computing. However, what is ironic is the only way to encourage students to continue on after school to study computer science in university is a good experience of the subject at KS4 and KS5. At the moment, this is far from the case and as a result there is still a drastic need for changes to the schools ICT curriculum.




There is a currently a massive demand for Computer Science teachers in secondary schools, with the government offering bursaries of £9,000 to encourage graduates to pursue a career in teaching this subject. However, although it has been recognised that there is a deficiency in this particular area, it takes time in order to develop the skills necessary to become a successful teacher. [5] As a result there is likely to be a delay between those students in training and actually filling the teaching posts advertised. This can be seen in the influence diagram as providing there are still jobs available being advertised, there will be students in training to fill the posts. The more students studying for their PGCE will lead to a bigger gap in training. This constant reinforcing loop will continue until a limiting factor is introduced. Universities can only accommodate a certain number of students. Therefore this will constrain the number of PGCE places available. The government will only provide bursaries if the demand for Computer Science teachers still fails to reach its target. Without this bursary, skilled graduates may opt to take their skills into the private sector which is likely to be financially more rewarding rather than compete for the reduce number of Computer Science teaching posts now available. The revised influence diagram can be found in the appendix [A].

## *3.2 Development of Quantitative Model*

### *3.2.1 Source of information*

Now that I moved the scope of my project to an individual school, rather than generalising UK secondary schools, to gain the data necessary to quantify my model, I decided to interview Gary Morgan for a second time. As a retired secondary school COMSC teacher in Whitchurch High School he had vast amounts of experience in this area, having witnessed the initial move from Computing to ICT many years ago. After a brief interview with him, I was able to obtain the necessary data to quantify the variables. This was a very reliable source as throughout the interview he conferred with the Bursar of the school to ensure his figures were correct. Although it would be possible to make various assumptions and make use of research published online to obtain these results, it is likely they would be a collection of figures from numerous schools and averaged together. This would not have been as accurate or reliable.

### *3.2.2 Interview Results*

Whitchurch High School has recently become a Foundation category school, meaning they are still funded by the government but have far more control and freedom than community schools. The governors now have full responsibility for staff and pupil entry which is an enormous task as it is the biggest school in Wales. From the interview I discovered Whitchurch has around 2300 pupils split between two sites, upper and lower school. On average only one hundred students in a KS4 year group are choosing to continue their studies in examination ICT which has fallen over recent years from a peak of one hundred and forty students to as low as eighty or ninety. When asked for the possible reasons behind this, Gary stated that the main reason was due to falling interest, “In many cases, what was being taught in KS3 ICT is not stimulating pupils. Now technology has moved on, a lot of the students will have access to mobile devices, they want to utilise these pieces of hardware to learn new and exciting skills more relevant to their daily lives”. Another reason mentioned was the lack of space and equipment available in the school. Whitchurch could only accommodate a set number of students due to their limited supply of computers; they do not support sharing computers at examination level.

When asked if Whitchurch were to make the transition to teaching Computer Science, would the school completely replace ICT with the new subject or work it in incrementally, Gary felt the most likely approach would be a complete overhaul. He felt that introducing the curriculum at all levels at the same time would be far more efficient. If it was done a Key Stage at a time, it would take three years before the GCSE students would reap the benefits. This would allow all teachers to be trained at the same point, building their experience together. Gary emphasised that training would have to be done in the year prior to the curriculum change to ensure teachers are fully prepared, although the majority of learning comes with experience, the basic skills must be taught.

From the interview I was able fully understand how this transition period is likely to happen. I gained a far better understanding of how a school would operate in terms of distributing teachers and timetable slots. I was able to collect a vast amount of data that I have been able to use and input into my simulation. A full copy of the interview can be found in the appendix. [B]

### *3.2.3 Overview of iThink*

iThink is a software program created by iSee Systems used to model business processes. It is a very powerful modelling tool, far more useful than mathematical modelling as iThink enables you to focus on individual aspects whilst still looking at the whole picture. The software can be used to create models that capture all interdependencies of a situation as well as the individual processes and identify their consequential impact [6]. The beauty of this software is its dynamic nature; it can easily incorporate change which would be inevitable in process modelling. iThink uses stocks, flows, converters and modules in order to create a simulation model. In order to identify these pieces of information, all the variables affecting the system must be identified. (This was done using an influence diagram). A stock is used to represent an accumulation of assets that can be measured at any time. For example the figure for population of Wales will vary in size but if time stopped, the stock would still be present. A flow can be an input or an output to a stock and show change over a period of time. Being born and dying would be in-flows and out-flows of population as both these variable have an impact on the size of the population. By assigning values to stocks and flows, equations for relationships between variables can be formed creating a model capable of representing real life situations. [7]

One of the key advantages to using a modelling tool such as iThink is it allows human influences to be incorporated into the simulation as long as there is a method of providing a value or measure. This allows a far more complex problem to be simulated.

I decided to utilise iThink to formulate a model that would determine whether UK schools would have the resources to cope with this change and identify any unintended consequences that may develop as a result. iThink can reduce the risk of implementing a change as it can simulate the expected outcome. It creates what-if situations that would show the result of making a change. The move to Computer Science is only compulsory for English schools at the present time. Therefore, I hope to be able to use this model as an aid in the decision making process to determine whether or not Welsh schools should follow suite and adopt the same approach in the attempt to improve students' skill levels.

From the beginning of this project I had the intention of building the quantitative model incrementally. The reason for developing parts of the model individually is to ensure each section is running and generating the intended results before moving onto the next one. This step by step process makes the development process far simpler and reduces the likelihood of errors occurs in the final model as testing will have been performed throughout.

## *3.3 Simulating the Quantitative Model*

### *3.3.1 Design*

The premise of the model is to simulate the difference between a school offering ICT as an examination subject and COMSC and what impact it would have. From the revised influence diagram, I was able to identify the most significant problem schools would face in changing the curriculum would be the resources available. If the number of students were to increase with the transition, there are four key areas that would be primarily affected. :

- Number of ICT Rooms
- Amount of Equipment

- Number of Teachers
- Amount of funding

All of these resources stem from the decisions made in the core of the model. In order to represent this in the simulation, I created a decision process diamond which incorporates the primary variables that all other aspects of the model are dependent on. The simulation can be run where students study ICT or COMSC. I have incorporated a switch in the interface to control this, turning COMSC either on or off using the values of '1 and 0'. The variable 'attractiveness factor' is used to start the simulation based on which subject is being taught. (i.e whether the switch is up or down) Based on the literature review conducted I have made the assumption that if schools do move to teaching programming and computer science then far more students would be interested in studying COMSC. I have used a slider to represent the number of pupils taking the course as it enables me to run the simulation, changing the input each time. From a year group of 350 pupils, there are currently about 28% studying examination ICT at KS4. However, I have made the assumption this figure is likely to increase to around 40% based on the figures Gary Morgan provided. Using the total number of pupils and the likelihood of taking COMSC, I was able to form the equation for the number of pupils taking the course. After establishing previously there were 100 pupils enrolled for ICT divided between 4 experienced ICT teachers, I was able to calculate the average class size of 25. From this figure, I could incorporate the variable of how many students would not be accommodated if the number was to rise. As 25 is the maximum number of pupils allowed per class based on available machines and ensuring a high teacher standard is maintained, additional students would not be accommodated for. As a result there is the first lack of resources problem.

Policy 1 – ICT rooms

Each ICT room can only accommodate 25 pupils due to their specific layout, need for specialised desks and suitable chairs and necessity for extra power sockets. If the number of students wanting to study COMSC rises above 100, there will be insufficient space in these rooms. This is where the first policy action would kick in. To create the equation for the Policy, I used the theory if the discrepancy between the number of rooms needed and number of rooms available for pupils was greater than or equal to 1 then the Policy Action to reallocate rooms would take effect. The result of this policy would be for every additional 25 pupils over the original 100 taking the course, another room would be refurbished at the cost of £5,000. This was included in the simulation as 'gaining rooms'. In order to ensure a circular flow of the stock 'total number of rooms', I had to create an outflow. Once a room had been refurbished and allocated to a class of pupils that room became no longer available and therefore could be included in the losing rooms figure.

Policy 2- Equipment

Every pupil is required to have access to their own machine; sharing PC's in lessons will reduce performance, hinder attention and negatively impact examination results. Gary Morgan stated that when ICT was first introduced in schools, the demand was so popular they had to limit the number of places available on the course simply because they didn't support sharing machines. This is directly related to the issue of number of rooms to accommodate pupils. In order to work out the level of equipment needed figures from total classrooms available and students not accommodated are added to the total number of computer equipment currently available. This

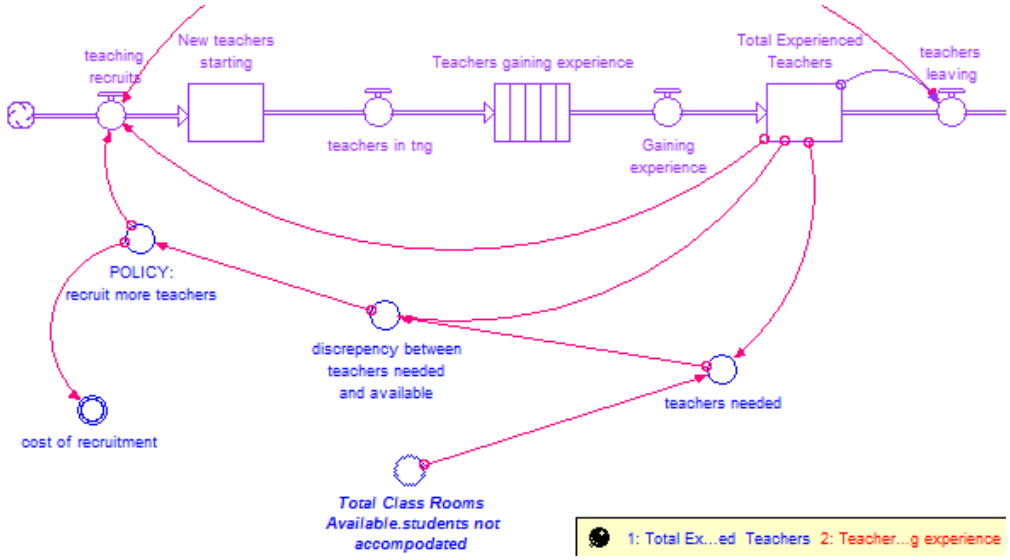
means it is possible to identify if there is a discrepancy between the equipment available and the equipment needed. If there is not enough equipment for each additional student over the base figure of 100 then a Policy Action to purchase more equipment is put into place. As more equipment is purchased the inflow of gaining equipment rises which will contribute to the total number of equipment available.

Policy 3- Teachers

From the literature review and interviews carried out, I concluded that ICT teachers are likely to be provided with the necessary training to teach COMSC during inset day prior to the changeover of curriculums. The school currently has 4 experienced teachers which can cope with teaching 25 pupils in a class for 5 hours a fortnight. As the school day is limited to 5 lessons a day, there is a limited number of teaching hours available and as a result most schools work at their capacity. If the number of pupils taking COMSC was to rise above 100 then there would not be enough teachers to cope with the increased number of teaching hours needed. This part of the simulation again stems from the decision process triangle and how many students are not accommodated for. If another class room is needed because there are more than 100 pupils, then another teacher is required to teach that class. Therefore the number of teachers needed is calculated using the equation:

(Total Class Rooms Available. Students not accommodated/25)+Total Experienced Teachers.

From this equation it is possible to work out if more teachers are needed than are currently available. If the discrepancy between these figures is equal to or greater than 1 then a Policy to recruit more teachers kicks in. Although a new teacher could start immediately, it is assumed that it takes a period of 2 years to practise before they can be classified as experienced. To incorporate this in the simulation, I have used a conveyor to illustrate completion of this period. These teachers can then be added to the stock of total experienced teachers.




Funding

Schools face a similar problem to the economy, “How do we satisfy unlimited wants with limited resources?”. [8] Head teachers in secondary schools are faced with the extremely difficult role of having to distribute the annual budget in the fairest and most appropriate way. There are often

influencing factors like government initiatives that affect how this money is allocated. From the interview with Gary Morgan I was able to obtain the necessary figures to simulate distribution of the budget.

| Budget % allocation | Area of spending |
|---|---|
| 30 | Recruitment |
| 20 | Equipment |
| 5 | Training |
| 10 | Building |

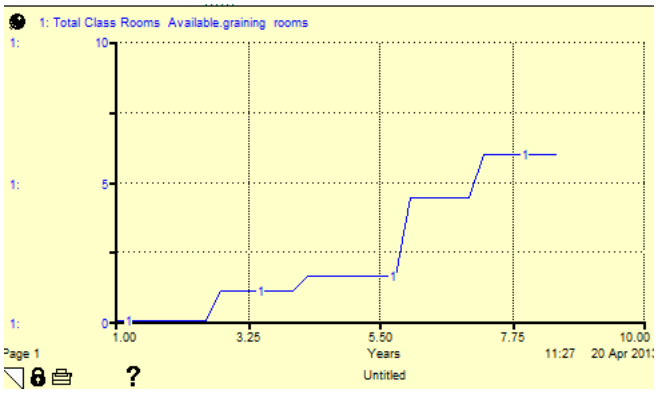
There are numerous variables adding to the total funds available. However there are also variables that upset this stock. Using a simple inflow, stock and outflow diagram I have been able to simulate how much funding will be available each year.

A full version of the simulation model can be sound in the appendix. [D]

### *3.3.2 Results*

*Policy 1*

| Policy Action | % of pupils taking course | Number of class room gained |
|---|---|---|
| No | 28 | 0 |
| Yes | 29 | 0 |
| Yes | 30 | 0 |
| Yes | 36 | 1 |
| Yes | 40 | 2 |
| Yes | 60 | 4 |
| Yes | 71 | 6 |

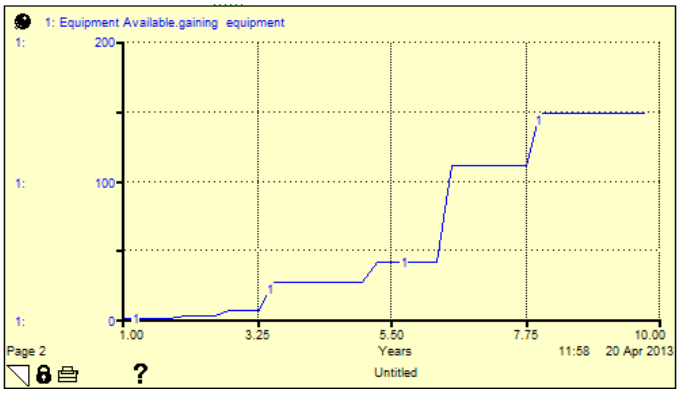



From the graph it is clear that as the more student wish to study COMSC, the school will have to increase the number of specialist ICT suites available in order to accommodate them. However, an issue arises only when the additional number of pupils falls between 0-25. Obviously if there are only 4 extra students, it is not worth reallocating an entire room. The school are then faced with the issue of either expanding their resources or turning those pupils away. After the huge push from the Department of Education about reigniting student interest

in computing, it hardly seems fitting to reject pupils who have an interest in studying the discipline because of insufficient resources.

*Policy 2*

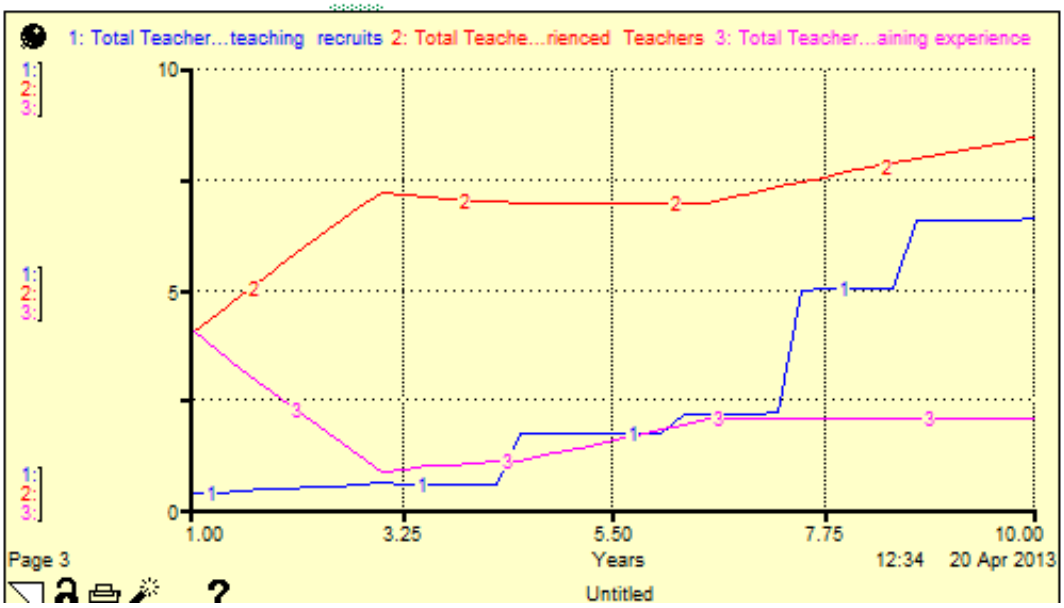
| Policy Action | % of pupils taking course | Number of equipment gained |
|---|---|---|
| No | 28 | 0 |
| Yes | 29 | 2 |
| Yes | 30 | 5 |
| Yes | 36 | 26 |
| Yes | 40 | 40 |
| Yes | 60 | 110 |
| Yes | 71 | 149 |




The graph shows the constant increase in number of pupils studying COMSC requires a similar increase in the amount of equipment. If the % increase moves from current 28% to likely 40% and the ration remains 1 pupil: 1 computer then a vast amounts of equipment are going to be needed to be purchased. However, due to equipment's direct link with class rooms, equipment is only useful if there is a room to house it. Therefore, if the model identified 5 more machines were required for the 5 additional pupils, there would be an issue of which room would these pupils be allocated to.

*Policy 3*

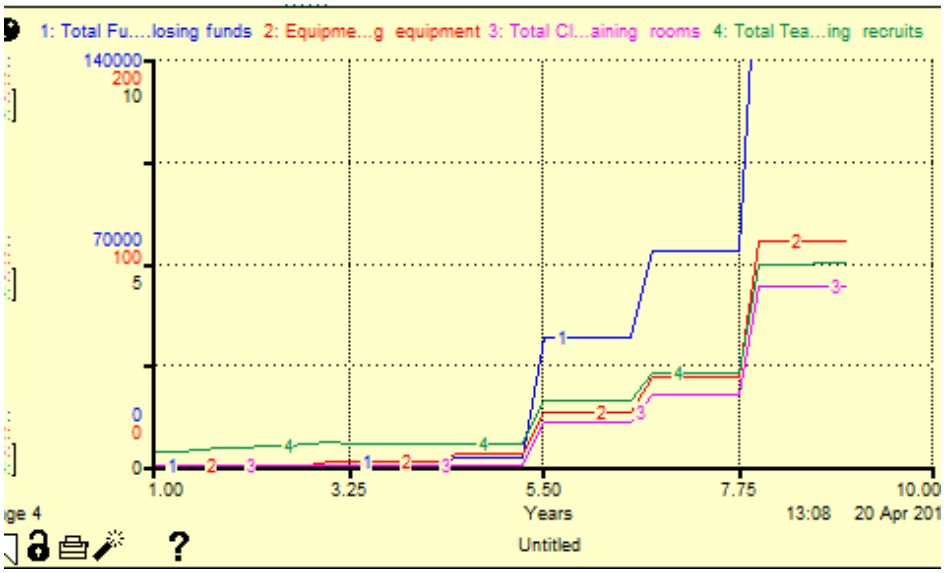
| Policy Action | % of pupils taking course | Number of teachers recruited | Number of Total Experienced teachers |
|---|---|---|---|
| No | 28 | 0 | 4 |
| Yes | 29 | 1 | 5 |
| Yes | 30 | 1 | 5 |
| Yes | 36 | 2 | 7 |
| Yes | 40 | 2 | 7 |
| Yes | 60 | 5 | 9 |
| Yes | 71 | 6 | 10 |




The policy action to recruit new teachers rises with the number of students as there would be more classes increasing the demand for teachers. The graph also shows teachers gaining experience. If an additional teacher is hired, they will need the necessary training. Therefore, in the period where no new recruits have been taken on, gaining experience is falling. This is because the 4 COMSC teachers currently teaching have been trained to an adequate standard or taught the subject for a period of more than two years to be classed as experience. Thus as the demand for new teachers rises, gaining experience does so similarly.

*Funding*

| **Policy Action** | **% of pupils taking course** | **Total losing funds** |
|---|---|---|
| No | 28 | 0 |
| Yes | 29 | 750 |
| Yes | 30 | 2500 |
| Yes | 36 | 44200 |
| Yes | 40 | 73950 |
| Yes | 60 | 140000 |
| Yes | 71 | / |



As expected, the graph shows that increasing equipment, teaching recruits and rooms all affect the total funds being lost. If more of the budget is spent, there will be less that is available. However as you can see from the graph once the % number of pupils studying COMSC reaches 60%, the entire budget would have been spent. This is obviously not feasible as it means one subject alone will have occupied the entire schools budget.

# 4. Evaluation

## *4.1 Evaluation of my Findings*

The simulation of the impact of the transition to Computer Science has been successful. It shows the attractiveness to study COMSC over ICT and as a result the increased likelihood of pupils wanting to study. This increase in demand calls for more resources as at the present time, schools are not far off their working capacity due to reducing teaching periods to maintain efficiency. From the model it is clear that increasing the number of resources will have a negative effect on the budget. If % of pupils taking the course rose to 71% the school would be in deficit. Based on this, it is clear something is wrong and a limiting factor must be identified in order to control the growth of the system.

| % of pupils taking course | Additional Classrooms needed | Additional Computers needed | Additional Teachers needed | Budget spent |
|---|---|---|---|---|
| 28 | 0 | 0 | 0 | 0 |
| 40 | 2 | 40 | 2 | 73950 |
| 71 | 6 | 149 | 6 | - |

Although the model has correctly simulated that an increase in pupils would result in an increase demand on resources and funding, there are some aspects that the model fails to incorporate. Firstly how would schools cope if 'students not accommodated' was not a significant figure to justify spending £5,000 refurbishing per room, £25,000 recruiting a new teacher and £12,500 on new computers? The school would have to decide on a minimum class size before allowing that class to run which means adopting a system where some pupils would be stopped from doing the subject. In situations to this previously, schools have created simple IQ tests to determine who will be accepted for the subject.

Secondly, the model could be considered flawed because of the issuing of timetabling. Reallocating a new room for every increment of 25 pupils may initially be proved to be correct but subsequently adding more rooms for every set of 25 would be incorrect as timetabling techniques would allow one new room to service far more than 25 pupils.

Another issue with the simulation is that if additional teaching hours are needed, rather than recruiting a new teacher and having to pay an additional wage, there may some redundancy in other departments. As a result a History teacher may be used to cover a small number of year 7 COMSC classes along with a Maths teacher teaching a few year 8 classes, freeing up a specialist ICT teacher for examination COMSC. This, however, may be detrimental to key stage 3 pupils and may have a negative impact on the success of the transition to COMSC. Unfortunately this scenario is often seen in secondary schools because Senior management believe ICT/Computing in KS3 can be taught by non specialists. They would be reluctant to apply this principle in any other subject. Hence, we have come full circle with a new curriculum supposedly generating fresh interest in the subject resulting in an increase in numbers, but on the other hand using non specialist teachers in KS3 may fail to ignite the interest that the government were so confident this change would have.

Although the simulation demonstrates a continuous rise in pupils interest in COMSC (to a point almost considered unrealistic at 70% of a year group), this interest is unlikely to remain constant. After the first few years where there is real enthusiasm for the subject, this number may decrease. As a result, the school would be left with surplus resources that they may have to allocate to other department.

### *4.2 Evaluation of Project Aims and Objectives*

This section is focused around identifying what I set out to achieve when starting this project and evaluating whether or not I was successful in doing so. I will discuss the reasons behind my triumphs and failures and how these have contributed to the formation of this project.

1. Identify what changes need to be made to the ICT curriculum currently in place in British schools.

In order to successfully achieve this project aim, I spent a great deal of time researching ICT in schools in general. I thought it was vital to learn how ICT initially started in schools; this enabled a comparison to be made between then and now. I focused on identifying the main problems with the ICT curriculum. I found the most significant issue to be the actual content being taught, a simple lack of programming skills. This was the core of the problem. However, it was apparent the teaching quality was also a huge influencing factor. Resources available and funding and budget allocated to ICT were also current problems schools faced. From this analysis, I was able to start to build a picture of what changes needed to be made in order to re produce the enthusiasm that surrounded the subject when it was first introduced.

2. Determine the reasoning behind the need for change and assess how successful previous changes have been.

Based on the problems and changes I identified, I went deeper into the matter to find out why and how these changes would impact the ICT curriculum. I made use of the interviews I conducted with professionals in education and additional research to gain a better understanding of the issues. I discovered the content of the current ICT curriculum is in desperate need of change because it does not challenge pupils. There isn't a significant jump between the skills taught in KS3 and those in KS4 ICT and as a result students skill levels are not vastly improving. The content is also considered out dated and uninteresting especially considering the recent advances in mobile technology.

The reason teaching was recognised as a problem in the current situation is due to the limited number of experts in the area. It became apparent that a significant amount of ICT teachers aren't necessarily specifically trained in the discipline, more commonly they were moved from another subject. Consequently, students are not receiving the same level of quality teaching as they would from English or Maths.

I learnt that in an attempt to improve the curriculum the government made the decision to remove the set programmes of study to allow ICT teachers freedom over what was taught. It was clear from the research published, this decision was widely accepted by those schools that had the teachers and resources to cope with this. However as for the schools with less experienced and confident ICT teachers, they continued to teach the same, old curriculum simply because they didn't have the subject knowledge to change it.

3. Identify possible alternatives to replace the present curriculum.

   I was unable to satisfy the third project aim as I feel it became redundant once the Government announced their decision to introduce a Computer Science curriculum as an alternative for the present ICT curriculum. This changed the approach of my project as I now had a real life situation to model rather than to evaluate any alternatives I invented. I focused on analysing the transition to Computer Science and the impact that would have on British schools.

4. Outline the key factors involved in order to produce a Causal Loop diagram and the significance they have.

I was unintentionally focused on achieving this project aim right from the beginning. Throughout conducting the literature review, I was noting down any obvious factors that played a part in ICT in schools. These became the basis for specifying all the variables involved in the situation. A key factor was the Government influence on the whole situation. The Government allocate funding for education which has a direct effect on the amount local authorities receive for education. This is then divided between local schools i.e. schools budgets and consequently split between subjects leaving you with ICT funding. Based on how much departmental money was available, the amount of training, number of computers and number of staff were influenced.

5. Through the use of systems dynamics, run various incremental simulations using iThink. Based on these results, identify recommendation for a proposed system to support decision making in schools. Assess how schools can monitor information and exploit it in order achieve maximum success.

I was able to satisfy this aim as I successfully simulated a model that tested whether a school would cope with the transition from ICT to Computing or whether certain policies would need to be implemented in order for this move to be successful. I was able to run the model with and without policies. From my model I was able prove that if the number of students studying COMSC was to increase then schools as they stand would not have the resources necessary to cope with the rise. The biggest problem is the budget would only be able to cope with the rising need for resources for a small period of time before the demand would exceed supply and schools would be in deficit. Based on the model I have been able to identify possible solutions which I have described further in 5. Future Work section.

### *4.3 Evaluation of Systems Dynamics Approach*

The influence diagram was very useful as it provided a method of summarising all the main aspects of the current situation with ICT in schools. The diagram provided a simple first step in the modelling process. Having read large amounts of research and published data, the influence diagram enabled me to summarise all the information into a basic and simple to understand model. By initially identifying the key areas, I was able to expand the diagram to a point where all the variables involved were recognised and polarity of relationships described, without having to provide figures or create mathematical equations; I was able to just focus on the problem situation. Using the influence diagram I could see which variables formed feedback loops, helping to identify the critical success factors needed to move to a stock and flow diagram. I think influence diagrams are one of the most valuable tools in decision making as so

many variables can be modelled including those that aren't necessarily quantifiable. It meant influences like teacher quality and teacher confidence could be included in the diagram without having to be concerned with providing data to measure them.

The quantitative model followed on from the influence diagram as it was used to add values to the key influences identified in order to run a simulation. The main advantage of creating a quantitative model was that I was able to vary the data inputted in order to see the different outcomes. Being able to easily manipulate the simulation meant I was able to assess the impact of introducing the policies and as a result help schools in the decision making process. iThink is unique in that it allows human influence to be modelled as long as it can be measurable. However, the difficulty comes when making assumptions about human influences and trying to quantify them. It would not be possible to include these issues in a standard mathematical model, therefore, systems dynamics can be considered more multidimensional. An issue i found with using iThink to model was its unusual representation, I feel if I was to demonstrate my simulation to schools who had no experience with the methodology of systems dynamics, they would struggle to understand the concept and would require an explanation of the principles behind it before being able to appreciate the workings of the model.

# 5. Future Work

If I was going to continue work on this project, I would look at monitoring whether the number of students choosing to study Computer Science continued to rise after the initial ten year period or whether the rate would steady. It would be interesting to see if the enthusiasm currently surrounding the subject and its principles continued in the years after the transition from ICT. Not only to see if student interest continued to rise but whether more teachers were entering the field. As an increase in COMSC students is likely to have a direct effect on COMSC graduates, I would expect the number of teaching recruits to rise significantly.

To investigate the issue further, I would interview people involved in University Computer Science and see how the change at school level has impacted their curriculum and teaching. I would expect lecturers would have to make dramatic changes as students would no longer require an easy introduction into basic programming as they would have had significant experience with programming languages previously. I am fascinated as to whether the degree content would become more advanced as a result of not having to waste time covering the fundamental principles. This may potentially have a knock on effect in the technology industry, based on an increase in expertise, skill level and innovation.

Another interesting area I would like to research further is the possible impact of introducing Raspberry Pi devices into schools. These single board machines are ideal to encourage and help students learn programming skills. The founder of the technology said these devices "could reverse the decline in students applying to study computing science at British universities, where applications have dropped by almost a quarter in the last decade" [9]. This is a bold statement to make and he has not provided any justification for believing this to be the case. I believe if I was to incorporate the introduction of Raspberry Pi's into my model, I could simulate what effect they would have on students skills and as a result the number of computer science applicants. I would hope to prove whether or not this statement is likely to hold true.

As a possible alternative to cope with rising number of students, I would suggest making use of laptop computers rather than refurbishing an entire room and dedicating it solely to Computing lessons. If regular classrooms were fitted with laptop cupboards capable of storing and charging enough devices for each pupil in the class, would reduce the amount spent on room refurbishment. I could incorporate this into my model to show what the advantages and disadvantages of this solution would be.

If I had more time available to work on the project I could focus on creating a more advanced simulation model. I would look back at the initial influence diagram I created of the general situation with ICT in schools and build a model that incorporated the wider factors, as opposed to limiting it to an individual school. For example, government spending, investments from technology firms, number of students studying Computer Science and other factors that influence ICT that was too complex to include in my first model. A real key area I identified in my influence diagram was the number of girls studying ICT. If I was to continue investigating this situation, I would look into whether the ratio of boys to girls would stay constant in the transition from ICT to COMSC or whether the number of girls would diminish as I would expect. It is clear from research carried out by Women's Media; girls are less interested in 'hands on' subjects than more academic ones. [10] In my model I have made the assumption that moving to

COMSC will increase the student's interest, this may not be the case for girls. There is the possibility they will be discouraged by the physical aspects of the subject meaning the increase in interest may not be as significant as I initially expected.

# 6. Reflection on Learning

I had little idea of the topic I wanted to tackle for my final year project. When it came to making a proposal, I knew very little about what the final year project was. I wanted a project based on a theme that really interested and stimulated me. I began by reading through the list of suggested titles published by the lecturing staff. The number of projects suitable for Information Systems students was significantly lower than those available for the Computer Science students which in a way made the whole decision process easier. From a limited list of project suggestions, one instantly caught my eye, a project suggested by Steve McIntosh based on improving the current ICT curriculum in schools with the introduction of Raspberry Pi devices. The reason I was attracted to this project was because I opted against studying ICT at KS4 purely because I found key stage 3 lesson so simple, repetitive and hence boring. Had changes to the curriculum been introduced beforehand, I most definitely would have continued studying the subject at examination level. As a result, I would have started my degree with a much broader knowledge and skill set as opposed to having to start from scratch in the first year.

After the first meeting with my supervisor, we agreed this was an appropriate project due to my keen interest in the topic but also vast amount of media coverage and negative press coverage that the area of ICT in schools was receiving. Having done a lot of research, it was clear there was a major issue at hand and this would be an optimum time to investigate this further. I decided the project title suggested by Steve was going to be the basis of my assignment but I felt focusing on the introduction of Raspberry Pi development boards may limit the scope of the project. As a result, I decided to gear my project to the whole situation of ICT in schools and how it could be improved, leading to finalising my project title as 'The impact of potential changes to the ICT curriculum in British Schools.

Although I had decided on a project title, I now needed a method to approach it. Having discussed possible alternatives with my supervisor, I came to the conclusion systems dynamics would be the best methodology. I knew it was the right choice as it is one of the most powerful modelling tools available and would add real value to my project. However, I only had a very brief encounter with the modelling tool previously and didn't really understand the principles behind it. I was very apprehensive basing my entire project around an approach I knew little about but I knew it was the most effective. It took a lot of research and learning but I eventually became more comfortable with it. It required comprehensive knowledge before I was able to write a detailed project plan.

When developing the project plan, I focused on breaking down the project title into small parts that would become my project aims. After referring back to my project aims, I do not feel they are detailed enough; I should have expanded further on what my intentions were. I feel my objectives were specific and accurate. However, I feel I could have further developed each point by describing in detail how each objective would be achieved. This would have added more value to the plan and given the project slightly more structure. I received 4/5 for my project plan and I believe this to be the reason for dropping a mark. The time plan was developed based completely on guess work. I have very little idea as to how long each task would take and as a result had to make approximate time calculations. Coincidentally, almost all

the estimates made were correct apart from completion of this report. I intended to work to the deadline set by the University. However, after receiving my examination dates, I decided to set my own deadline of two weeks prior to allow additional time for revision.

A skill I was able to develop from this project was the ability to research information and analyse the content and reliability of it. I knew a vast amount of the final year project was centred on a literature review but I didn't actually know what a literature review entailed. I decided not to study the module 'Information System research techniques' which covered this area because I thought having to produce two reviews at the same time may be too much work. This meant proactive learning was required and I taught myself how to critically analyse existing sources of information. I focused on looking for relevant information and data from various reliable sources that I could utilise to provide a thorough coverage of the situation. I made use of information published by professional bodies such as Computing at Schools, BSC The Chartered institute for IT and OfSted as well as reading blogs and statements written by teachers and students. I decided to make use of different sources of information to gain a much broader view not just read the facts and figures the Department of Education publish annually. At first, I was apprehensive as I feared I would be unable to identify all the issues involved. The reports published online related to this matter are very detailed and comprehensive and as a result I was concerned that I may find them too formal and struggle to grasp the fundamental problems underlying the topic. This was not the case as many of the published report files were accompanied by a summary report that was written in a manner far easier to understand. From this document I was able to identify the main issues at hand and retrieve any appropriate facts and figures.

Initially I had intended to create a questionnaire and then distribute them amongst KS3 school children. Questionnaires are a useful tool for data collection as vast amounts of information can be gathered relatively quickly. The answers are normally in the same format so the results are far easier to analyse. However I decided against distributing questionnaires for numerous reasons. Firstly, my target audience would be school pupils aged 12-15. I did not feel children of this age range would provide accurate answers. At an age where reputation is top of their priority list, if asked 'whether they enjoyed ICT in school?' the most likely answer is going to be 'no' regardless of their actual feelings. Another reason I decided against this was colleagues who had utilised questionnaires as a method of research warned me it was extremely difficult to encourage people to answer the form in their own free time. I came to the conclusion that if I wasn't able to get the results I needed from questionnaires, my time would be better spent elsewhere. Having reflected on the issue, I think a better approach would have been to get in contact with a school and use the questionnaires as part of the ICT scheme. The students could fill them in online on their mobile devices so answers would be private and completion would be compulsory homework.

I developed the qualitative influence diagram based on all the information I had collected previously. When I initially began to build the model, I started by making a list of all the variables affecting the delivery of ICT in schools and from this I identified the relationships between them. I was looking at the wider aspects relating to ICT in schools which was very useful to identify what knock on effects it has later on in life. In order to refresh my memory of what an influence diagram entailed, I referred back to a piece of coursework I completed in my second year of study. This was very useful as the justification behind the diagram explained how

I came to produce the model which meant I could follow the same line of thinking to produce this influence diagram.

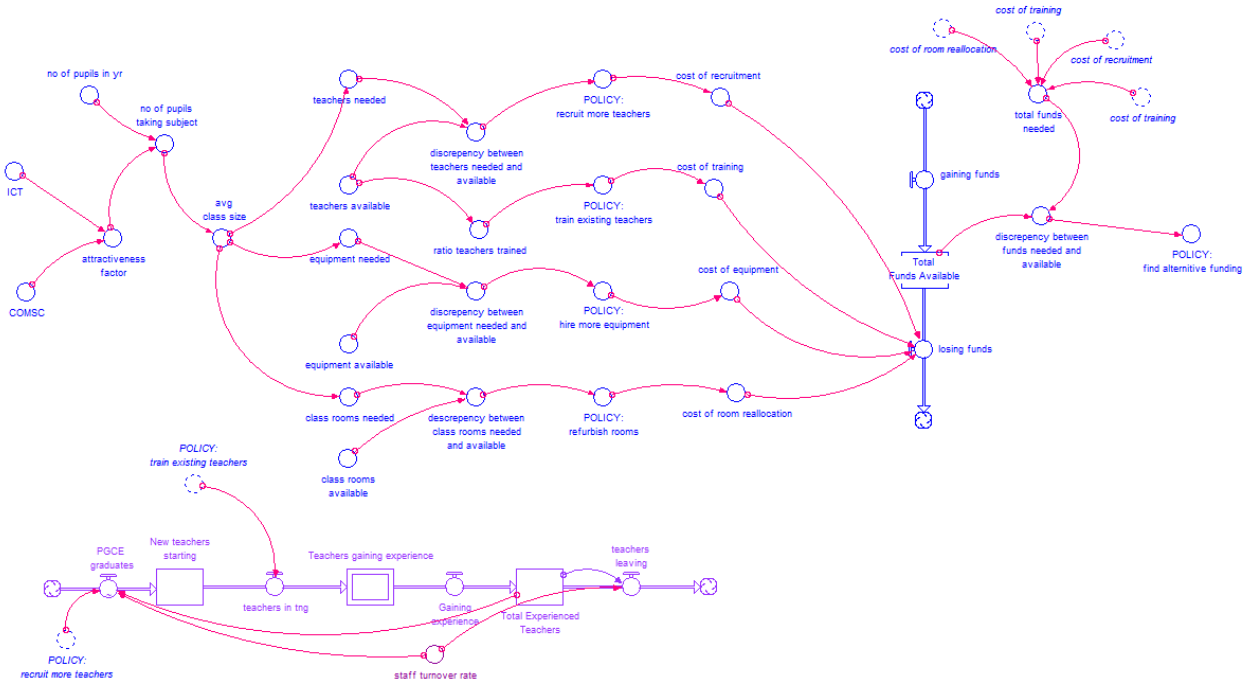
The influence diagram in my Interim Report was developed in Microsoft Word using text boxes and shape arrows. This became a very tedious task as it required constantly having to rearrange the positioning of variables. Having had more experience using the program iThink, I learnt it was possible to use the application to develop influence diagrams as well as stock and flow models. I was able to formulate the diagram using the module and convertor tools and include the polarities for each variable relationship. This was significantly easier and faster than using Word not only for the initial development of the diagram but it made making additions and alteration to the model far simpler as well.

During the process of developing my interim report, I hesitated as to whether or not to include the influence diagram in the interim or final report. The reasoning behind this was mainly due to the amount of work I had in other subjects. I found it very stressful having to meet five different coursework deadlines as well as produce my interim report. I decided I wanted to stick to my project plan and continue with developing the influence diagram. This worked out for the best as it turned out I ended up developing another influence diagram in my final report anyway. I received my interim report mark which I was extremely pleased with. I felt it reflected the amount of time and effort I had put in to produce this piece of work and it gave me the encouragement to start the next phase.

When it came to starting to develop the quantitative model, I encountered numerous problems. Firstly, I could not remember how to use the application iThink. I tried using previous models I had built, along with following tutorials found online but I still could not fathom how I could model the situation I had spent so long researching. I spent hours going through my influence diagram trying to identify what influences could be used as stocks and how to determine the relevant flows. After this period of uncertainty, I came to the conclusion I wanted to change the approach of my project and use a different method. I considered all other possibilities, including Soft Systems Methodologies and The Open Group Architecture Framework. At this point, I was very worried and was really struggling to see how I was going to be able to complete the project. I informed my supervisor of the issues I was having and she set up a meeting with a PHD student whose speciality was in systems theory. After discussing my concerns regarding the aspects that I should actually simulate, I was told to go back to the beginning, focus on the core of the project and what the overall aim was. I reviewed my initial plan and identified the main purpose of changing the current ICT curriculum was in order to improve student's skills. From this point, I forgot about creating a model in iThink and re focused my thinking. Using a pen and paper, I started with student skills and from there worked backwards identifying what would influence that. I effectively created a very simple influence diagram and from that, I was able to clearly identify the stocks I required in my model. Now that I knew what I wanted from the model and what to include, it was just a case of building it.

Writing the equations was without doubt the most difficult part of this project. I really struggled to determine which inputs needed to be included in the equation in order to produce the desired result. I discussed this with Catherine, the PHD student who had helped me previously and she advised me to think of it logically like a mathematically equation. After seeing examples, I began to better understand how to write my own.

After completing my first model, I was confident I was ready to start analysing the results and evaluating it to include in the report. However, when I look at it objectively, I realised I was not modelling the right problem, there were influences that were unnecessary and stocks not essential to the situation. This was a major setback, I had wasted almost three weeks learning how to create a model and successfully finishing it when I realised it was irrelevant. However, looking back at it now, this complication provided me with a new lease of life for the project. I now knew exactly what I needed to model, exactly what I wanted to test for and the results I was expecting. Although I had spent three weeks building the wrong model, I was then able to create the model I had intended much easier. This learning curve was surprisingly useful although at the time, frustrating.




The model above was the first completed model I created, which contained only three stocks. When trying to simulate this, each resource continued to rise beyond control. I could not understand why in the situation where 'need for teachers' decreased, the total number of teachers continued to increase. After periods of trial and error and running different figures through the simulation, I came to the conclusion that each resource needed to be represented as a stock in order to create a circular connection that would have inflows and outflows. I broke this model down into the four key areas and was able to use modules in iThink to effectively simulate each aspect. Modules create a hierarchical structure to the problem meaning the high level shows the focus of the problem and the lower level actually runs the simulation. This structure made the models overall appearance more aesthetically pleasing and simpler to understand. Using this application, I have learnt how effective it can be if used correctly. Its ability to incorporate issues into a model that other modelling tools would be unable to is remarkable.

The completion of this project has provided me with a wide variety of skills that will be transferable and extremely useful in later life. I have the ability to critically analyse a situation

and from this, identify key influences. I improved my problem solving skills, experiencing new applications and working through situations of difficulty. Having faced so many setbacks, I feel more confident about learning from mistakes and how valuable reflecting on these problems can be. Having completed this project, I am less apprehensive about entering the working world and being left to my own devices.

# 7. Conclusion

In conclusion, I believe moving from teaching ICT in secondary schools to Computer Science will be hugely beneficial. The working group 'Computing At Schools (CAS)' describes the discipline as: "Computer Science is particularly, but by no means exclusively, concerned with the study, design, and implementation of computer systems, and understanding the principles underlying these designs." [11] The content in the new proposed curriculum goes beyond just learning about hardware and software but teaching pupils to think in a more logical and computational manner and focus on providing them with the necessary problem solving skills that the technology industry demands. Through the use of programming languages and computational models, students will be stimulated and allowed to explore their creativity. If pupils are more interested in what they are learning, their attention levels will be heightened and targeted in the right direction. Students are far less likely to misbehave or distract others if they are genuinely enthralled in what is being taught. There will be less discipline issues as a result making teaching far easier and more enjoyable for the staff. If moving to Computer Science has the successful impact on student interest as intended then there will be a significant rise in the number of students sitting examinations. This will raise awareness of the subject and hopefully continue to encourage students to study it.

Based on a simulation of this situation I was able to identify the impact of introducing Computer Science into a school. In order to cope with the rise in pupils, the budget would have to be redistributed to cope with the increasing demand for resources. A policy to increase the number of classrooms allocated to the department would need to be implemented. As the subject requires specialist equipment, classrooms would need to be refurbished specifically to allow for sufficient number of power sockets, suitable layout of desks and specific chairs. Another policy action would need to be put into operation to cope with levels of equipment. A policy to purchase more computers would be necessary to maintain the 1:1 pupil to computer ratio that currently stands. The model also showed if the number of pupils in a class accelerated beyond more than what one teacher could cope with then a policy to employ or train additional staff would be required. This limited resource issue meant that all the policy actions in place would be funded from the school budget. It is clear the funds available for the school will continue to decrease at an exponential rate if student interest continues to rise until the school puts an upper level cap on the number of places available on the Computer Science course or finds additional funds to continue to support the demand for resources.

In conclusion, the main achievements of this project are having been able to recognize the drastic need for changes to the current ICT curriculum focusing specifically on the reasons behind these issues. I have been able to evaluate how successful previous attempts at change have been and take into account their failures when developing my alternative solution. Based on the Government's decision to move to Computer Science, I have been able to identify the impacting variables on the situation and create an influence diagram to demonstrate the relationships between factors. Through the use of systems dynamics and the program iThink, I was successfully able to simulate the transition from teaching ICT to Computer Science in secondary schools focusing on the key areas of teachers, equipment, room availability and funding. By monitoring and exploiting information within the

simulation, schools would now be able to predict how much additional resources they would require in order to cope with the new curriculum, helping to provide them with guidance amongst all the uncertainty.

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# Appendix