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The Introduction and Development of GIS Curriculum in the UK Geography Education

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영국의 지리교육과정에서 GIS 커리큘럼의 도입과 개발에 관한 연구

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Abstract : Since the mid 1990s, in response to rapid changes in Geography subject, Geographic Information Systems (GIS) has been in central position in the UK geography curriculum. This paper discusses the roles of GIS for Geography subject curriculum and addresses main development within UK Geography curriculum since the 1990s, and investigates appropriate GIS curriculum that encourages teaching and learning of geography subject within the curriculum. To obtain these research purposes, this paper starts with the brief description of the Geography subject in the National Curriculum for England (1998) with the recent changes of Geography subject in the national exams (GSCE and A level) in the UK. This result represents a clear situation of Geography subject in the UK school education and also provides a new motivation that brings new challenges of information technology driven curriculum within the Geography subject. In turn, the interactive relationship of Geography and GIS within the current Geography curriculum is described by which the discussion of relevant GIS skills within Geography curriculum is followed. To propose the case studies that show the use of GIS for Geography education at school, Key Stages 2, 3, and 4 examples are discussed. Finally, this paper concludes with the issues that GIS benefits encourage geography teaching and learning and that potential applications can support not only the development of new teaching tools and learning strategies in geography education at schools, but also contribute to extend geographical skills and capabilities to collaborate with other subjects in school education in Korea.
Key words : Geography education, Geography curriculum, Geographic Information Systems(GIS), United Kingdom

요약 : 90년대 중반 이후 영국의 지리교육에서는 정보화 사회의 이해와 주변 환경과의 관계를 종합적으로 이해할 수 있는 능력을 향상하기 위한 노력의 일환으로써, 지리교과목 내에서의 지리정보체계의 도입에 대한 연구가 활발히 진행중이다. 본 논문의 목적은 영국 내 지리교과과정에서 진행되어 오고 있는 지리정보시스템(GIS)의 적용 및 교과 개발에 대한 현황을 파악하고 어떠한 내용들이 실제 연구 개발되어 오고 있는 지를 고찰하는 것이다. 먼저, 영국의 초중등과정(Key Stages 1, 2 및 3)내에서의 지리과목이 차지하는 위상과 현황을 살펴보고, 지리정보체계와 지리교과목과의 관계를 고찰한다. 이러한 관계를 바탕으로 각 과정내의 지리교과목의 교수와 학습을 위한 지리정보체계의 내용들을 살펴본다. 이에 대한 지리교과의 커리큘럼 개발에 대한 실제 사례 연구로써, 영국 내 학교 수업에 있어 실제 도입된 사례들을 살펴 보고 이를 통해 지리정보체계의 실제적인 수업 적용 사례와 이점들을 파악한다. 마지막으로, 정보화 사회에 부응하기 위한 영국 내 지리정보체계의 교과 개발 연구 및 지리교과와의 관계 설정에 대한 노력이 최근의 한국 지리교육의 문제를 이해하고 극복하는데 있어 가지는 함의를 제시한다.
주요어 : 지리교과과정, 지리교육, 지리정보체계(GIS), 영국 지리교육

1. Introduction

Geography subject has maintained a major position in the UK National Curriculum for several decades. However, Geography subject has experienced rapid changes in terms of subject popularity in the curriculum and national exams (e.g. GCSE and A-level). Since several new subjects have been introduced in the curriculum in the 1990s, wide range of subject selections has been able to take for pupils and this makes impacts for geography subject in the classroom. The recent results of the national exams (e.g. GCSE and A-level in the summer 2000 exams) also show some alarming news for geographers that candidate numbers taking

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geography has been declined significantly. Many reasons have been discussed with various approaches such as entry system changed, low teaching quality, lack of the subject specialists, shortage of teachers in the area, unsuitability of subject faculty inclusion (e.g. Humanities) (Mansell, 2000). These circumstances are analogue to current situation of Geography subject curriculum in Korea that has experienced the decline of teaching units in school curricular and of subject popularity compared with other rival social science subjects. As the plan of the 7th National Curriculum Standards has commenced, new environments will challenge to Geography subject at schools in Korea. Therefore, the experiences of the UK is important for geographers and education specialists in Korea to take into account of preparing new Geography curriculum and teaching strategies to meet the new standard plans.

Since the 1990s, UK education has undertaken many attempts to tackle those problems such that new curriculum strategies for learning and teaching have been implemented at school. One of the distinguished and widely accepted curriculum activities is the exploration of computers and information technology into school curriculum scheme. Under Education Reform Act established in 1988 (Education Reform Act, 1988), information technology and geography are among the subjects that are taught to all pupils from the ages five to sixteen years. The central aim within the Act is to use IT to enhance the quality of teaching and learning across the curriculum. It is probable that a geography teacher will be given responsibility for using IT as a medium for geography teaching in the classroom. This is a vital background of why GIS should be taught in Geography subject curriculum.

Since the 1990s, the application of computer and information technology has been widely spread into the classroom, in particular in higher education courses (e.g. Key Stage 4) (Green, 2001). The utilisation of computing techniques into Geography subject has been also led geography specialists and curriculum planning to explore relevant materials and curriculum schemes in school (Unwin, 1991, Coggins, 1990). To meet this demand, the identification of GIS roles are requested whether GIS curriculum can be integrated with existing geography learning strategies.

Therefore, this paper discusses the roles of GIS for Geography subject curriculum and addresses main development within UK Geography curriculum since the 1990s. In addition, this research investigates appropriate GIS curriculum that encourages teaching and learning of geography subject within the curriculum. To obtain these research purposes, this paper starts with the brief description of the Geography subject in the National Curriculum for England in order for readers in Korea to comprehend the subject curriculum structure. Then, the review of the recent changes of Geography subject is discussed with the candidate results of the summer 2000 UK national exams. This result represents a clear situation of Geography subject in the UK school education and also provides a new motivation that bring new challenges of information technology driven curriculum within the subject to meet the circumstance. Then, the interactive relationship of geography and GIS within Geography Curriculum of the UK will be described in the following section. To develop this discussion, this paper uses the Nation Curriculum for England which is a main background for the UK ones (National Curriculum for England, 1999). It will also discuss relevant GIS skills within the Geography curriculum. In turn, case studies of the use of GIS in Geography curriculum will be carried out to describe the success of the use of GIS skills into

Table 1. Structure of school geography in the National Curriculum for England

Curriculum Stages	Status in the curriculum	Main emphasis
Key Stage 1 (5 - 7 years)	Compulsory	Focuses on the description and identification of pupil's local, regional and UK's geographical features, environments using geographical skills and resources such as paper maps, photographs, and digital information prepared.
Key Stage 2 (7 - 11 years)	Compulsory	Focuses on the investigation of geographical comparison and variety in the UK and abroad by exploring relevant geographical and IT skills
Key Stage 3 (11 - 14 years)	Compulsory	Extends global context of geographical coverage to investigate human and physical environmental interaction on national, international, and global scales. During the stage, pupils should be taught relevant theories, methods, analytical skills of contemporary geographical and environmental issues in the world
Key Stage 4 (14 - 16 years)	Optional, but popular subject for GCSE national exam	
	Optional, but popular subject for A/AS exams at 18	

Scource : Rawling(2001).

geography education for which Key Stages 2, 3, and 4 examples are discussed. Finally, this paper will conclude with the issues that GIS benefits encourage geography teaching and learning and the potential applications of GIS can support the development of new teaching tools and learning strategies which can extend geographical skills into other subjects in school education in Korea.

2. National curriculum and Geography

The National Curriculum for England has been set out what should be taught and learned in each subject at four Key Stages, according to Key Stage 1 for infant level, Key Stage 2 for Junior level, Key Stage 3 for Secondary level, and Key stage 4 for GCSE. Figure 1 shows the school geography aged from 5 to 19 in England curriculum (Rawling, 2001). During the period, there are two public examinations to apply high education courses, GCSE and A-level.

3. Recent changes of Geography subject in national exams

This section reviews current situation of Geography subject in GSCE and A-level examination. Distinctive features and characteristics are investigated to identify recent changes of Geography subject in the exams. For this analysis, this section uses a document made by Royal Geographical Society (Mansell, 2000) that shows the number of candidates taken the GSCE and A level exams during last five years. This paper, thus, summarised the issues discussed in the report. The result of 2000 summer exams shows directly that Geography subject is on the edge, which has been

experienced a big gap of subject popularity between old league table and new coming subjects. Some alarming results are reported for geographers and Geography teachers. At first, it was dropped by 12 percent of the number of candidates, taking A-levels compared to the rates of previous years. At second, the ranking of Geography has been fallen from 5th popular subject for the previous years (1997~1999) to 9th place at A level exam in 2000. While at GCSE, it has retained its 7th position, the number of the candidate taking Geography was also down. Tables 2 and 3 show the detailed information of Geography subject in the national exams.

For GCSE results, they shows more worrying with a series of dropping since 1997 when 4.0 percent rate was dropped followed by -8.5 percent in 1998, -3.12 percent in 1999, and -2.21 percent in 2000. For more details, see Table 1. These figures shows the largest drop rates of any of others subjects in the Key Stage 3, national curriculum and in the major ten subjects in the exam (Science, Maths, English, English Literature, Technology and IT, French, History, Art/Design, and German). There has been a steady decline of the candidates in the last five years from a peak of 302,298 to 251,605 in 2000, which the greatest drop of 8.5 percent in 1998. In respect to the reasons of the exam, several reasons for this continuous decline could be addressed(Mandell, 2000). At first, subject entry system for pupils preference can be argued for the reason. Geography has a tiered entry system when History has a single entry system so that may influence to deter Geography subject choice for the exam. At second, mixed ability class situation may cause the difficulty of subject choice for the exam. Then, this idea brings earlier selection and is passed on to students in lower years. The lower teaching quality in Geography subject is also one of the main reasons for the decline of Geography subject. OfSTED(Office for Standards in Education) reports have supported that the quality of teaching in Geography at Key Stage 3 for GCSE is not good as other Humanities subjects such as History and English. This may affect the making decision of students as to which GCSE subjects to study. The reports pointed the reason of the poor teaching quality that teaching at Key Stage 3 is not always undertaken by geography specialists or teachers. The shortage of geography teachers from the recent recruitment of Geography field contributes to this situation. This may result in non-geography specialist teaching in the crucial years of choosing GCSE option subjects. Geography subject is often taught in the Humanity Faculty in maintained schools, which does not reflect the nature of geography subject that aims the combination of human and physical aspects of geographical phenomena over space.

For the A-level results, it has experienced dramatic dropping of the candidates from 42181 in 1999 to 37112 in 2000, dropped of 12.02 percent. This also reflects the drop in GCSE numbers of 8.5 percent in 1998, because the 2000 result was followed by their GCSE's. In addition, the subjects overtaken Geography in their ranking are Chemistry, History, Business studies, and Art and Design(for more details, see Table 3).

This dropping rate can be highlighted by comparing rival subjects overtaken in 2000 such as Chemistry, Biology, and English which experienced of dropping for the previous years (1998~1999). There are several reasons for this drop. Firstly, it has been general decrease of the total number of candidates for A-level exam subjects for over last ten years. The increase popularity of vocational subjects such as Business studies and Media studies has contributed to the down. This outbreak contributed to the position of Geography popularity in 2000 exam. The wide curriculum options taught in A-levels

Table 2. Results of GCSE exam

	Number of GCSE candidates (95-00) & change %											
Subject	1995	(94-95%)	1996	(95-96%)	1997	(96-97%)	1998	(97-98%)	1999	(98-99%)	2000	(99-00%)
Science	976642 (1)	25.62%	997442 (1)	2.1%	1007140 (1)	1.0%	1006151 (1))	-0.1%	1017480 (1)	1.2%	1040139 (1)	2.23%
Maths	667908 (2)	11.01%	691111 (2)	3.5%	681265 (2)	-1.0%	670141 (2)	-1.6%	672950 (2)	0.42%	673056 (2)	0.02%
English	646460 (3)	8.42%	663009 (3)	2.6%	649678 (3)	-1.0%	637748 (3)	-18.0%	638018 (3)	0.04%	647436 (3)	1.48%
English Lit.	475297 (4)	11.8%	491850 (4)	3.5%	492678 (4)	0.2%	490845 (4)	-0.4%	501951 (4)	2.26%	512572 (4)	2.12%
Tech/CDT	347904 (5)	143.26%	245132 (7)	-30%	235877 (7)	-3.9%	385057 (5)	63.2%	407348 (5)	5.79%	424468 (5)	4.2%
French	340155 (6)	17.33%	342751 (5)	0.8%	328299 (5)	-5.0%	335698 (6)	2.2%	335816 (6)	0.03%	341004 (6)	1.55%
Geography	**295229 (7)**	**11.73%**	**302298 (6)**	**2.4%**	**290201 (6)**	**-4.0%**	**265573 (7)**	**-8.5%**	**257294 (7)**	**-3.12%**	**251605 (7)**	**-2.21%**
History	239524 (8)	5.33%	226808 (9)	5.3%	227447 (8)	-2.0%	209789 (8)	-7.8%	210113 (8)	0.15%	213346 (8)	1.54%
Art/Design	212478 (9)	0.18%	228882 (8)	7.7%	221543 (9)	-3.2%	206781 (9)	-6.7%	199208 (9)	-3.66%	201296 (9)	1.05%
German	126848 (10)	14.77%	132212 (10)	4.2%	132615 (10)	-0.4%	133683 (10)	0.8%	135158 (10)	1.1%	133659 (10)	-1.11%
Religious Studies	106223 (11)	4.11%	116549 (11)	7.9%	118545 (11)	1.9%	113381 (11)	-4.4%	115679 (11)	2.03%	116234 (11)	0.48%
Bus. Studies	85516 (12)	-20.03%	114119 (12)	33.9%	115498 (12)	1.1%	103262 (12)	-10.6%	98787 (12)	-4.34%	100962 (12)	2.2%
Biology	53984	-28.25%	48276	5.9%	47743	-1.1%	47523	-0.5%	47957	-0.09%	48715	1.58%
Chemistry	43846	-15.95%	46885	6.9%	45797	-2.31%	46025	0.5%	46968	2.04%	46917	-0.12%
Physics	43784	-18.53%	46446	6.1%	44892	-3.37%	45319	0.9%	46685	3.01%	46627	-0.12%
Music	37606	3.11%	41801	11.2%	43430	3.1%	42069	-3.3%	43002	2.22%	45797	6.5%
Home Economics	54769 (13)	-47.58%	97340 (13)	77.79%	104863 (13)	7.6%	52855	-54.0%	48391	-8.43%	45093	-6.82%
Total GCSE candidate	465968	10.3%	505715	8.5%	5415190	7.8%	5353090	-1.2%	5489710	2.6%	5481920	-0.14%

(Adapted from Mandell, 2000, provided by Ian Gregg, Geographical Association)

Table 3. Results of A level exam

	Number of A level candidates (95-00) & change %											
Subject	1995	(94-95%)	1996	(95-96%)	1997	(96-97%)	1998	(97-98%)	1999	(98-99%)	2000	(99-00%)
Gen. Studies	57468 (3)	7.15%	63454 (3)	10.4%	69142 (3)	2.5%	80570 (2)	16.5%	85338 (2)	5.91%	89805 (1)	5.24%
English	86382 (1)	-1.72%	86627 (1)	0.3%	93546 (1)	7.98%	94099 (1)	0.6%	90340 (1)	-4.0%	86428 (2)	-4.33%
Maths	62188 (2)	0.75%	67442 (2)	8.4%	73114 (2)	15.2%	70554 (3)	-3.5%	69945 (3)	-0.87%	67036 (3)	-4.16%
Biology	51837 (4)	2.27%	51894 (4)	0.1%	58534 (4)	12.8%	58457 (4)	-0.1%	56036 (4)	-4.14%	54814 (4)	-2.18%
Chemistry	42271 (7)	2.53%	40455 (7)	-4.3%	42458 (7)	4.9%	43030 (6)	1.3%	41727 (6)	-3.03%	40856 (5)	-2.09%
History	42694 (6)	-4.67%	43355 (5)	1.5%	42547 (6)	-1.9%	40495 (7)	-4.8%	38482 (7)	-4.98%	38779 (6)	0.77%
Bus. Studies	26837 (12)	7.69%	29100 (10)	8.4%	33359 (10)	14.6%	37006 (9)	19.9%	37926 (9)	2.48%	38226 (7)	0.79%
Art&Design	33907 (9)	-0.61%	33782 (8)	-0.1%	35289 (8)	4.5%	37119 (8)	5.2%	37385 (8)	0.71%	37609 (8)	0.59%
Geography	**43426 (5)**	**-6.29%**	**42766 (6)**	**-1.5%**	**43641 (5)**	**1.89%**	**44881 (5)**	**2.8%**	**42181 (5)**	**-6.02%**	**37112 (9)**	**-12.02%**
Physics	34761 (8)	-3.33%	32801 (9)	-5.7%	33508 (9)	2.1%	34244 (10)	2.2%	33880 (10)	-1.07%	32059 (10)	-5.38%
Sco. Science	30371 (10)	-61.33%	27871 (11)	-8.24%	30139 (11)	8.1%	26242 (11)	-12.94%	24749 (11)	-5.69%	23901 (11)	-3.43%
French	27489 (11)	-5.53%	27490 (12)	0.0%	25916 (12)	-5.7%	23633 (12)	-9.0%	21072 (12)	-10.84%	18221 (12)	-13.53%
Economics	26584 (13)	-13.92%	24580 (13)	-7.6%	20873 (13)	-15.1%	18670 (13)	-10.6%	18377 (13)	-1.57%	17113 (13)	-6.88%
Total A level candidates	725100	-0.51%	752169	1.2%	776115	3.18%	794262	2.3%	783534	-1.35%	771809	-1.5%

(Adapted from Mandell, 2000, provided by Ian Gregg, Geographical Association)

of these subjects also adds its growing candidate numbers, which cause the loss of the candidates who might take Geography for the exam. From the reasons, it can be inferred that candidates who might have chosen Geography as their third option at A-level in the past years are now choosing these subjects.

To resolve these problems, several alternatives or solutions are proposed. At first, greater flexibility in Geography subject in the national curriculum, are required to ensure the high employability of geographers when the students left schools. As a vocational subject, Geography subject should be able to combine its curriculum with other subjects such as Information Technology or Business Studies. For this, GIS can be a good element for this integration. Recruiting high quality candidates for geography teachers can be another solution for which appropriate organisations (e.g. the Teachers Training Agency) need to be involved for introducing undergraduate students to the teaching Geography as a career. This aims that the combination of well-trained young teachers into the profession field will inspire students in schools to study Geography subject, which will at the end influence to select the subject for the exams.

4. GIS and school geography education

1) GIS contributions for school geography

Although GIS is proposed to teach in the National Curriculum, this topic has been introduced from recent years since the mid 1990s and designed only to teach the ablest 16 year olds in Geography class such as for group projects in Key Stage 4 or GCSE levels. However, many geographers, information specialists and educationalists contented that using GIS as a tool helps students interpret spatial information and gain more understanding of the world around them. GIS represent a powerful and versatile tool for geography studies seeking to understand the patterns and processes that shape our environment. GIS can be applied to a variety topics relating to both human and physical and natural environments. Even though GIS is an integrated computer system for particular purposes and not educational technology itself, GIS contains several important components for school geography in terms of teaching and pupil's learning (Green, 2001).

Firstly, pupils can extend their geographical skills with GIS that they are able to experience how geographical techniques, tools, and skills are used to collect, manipulate, analyse and map geographical data. This allows pupils to understand geographical concepts and theories when they manipulate geographical information and data such as geographical coordinates, spatially referenced data, projections, and etcetera. Secondly, GIS develops corporation learning with other National Curriculum studies such as mathematics and Information Studies. GIS allows pupils to make full use of knowledge and techniques from the subjects to learn geographical applications. Simple GIS software requires pupils to utilise computing and IT skills acquired in the school for the use in the context of geographical studies. This contribution also places GIS an important subject in relation to environmental education, which supports for pupils to explore human and environmental interactions between geographical and environmental systems that will be a key area in the future of geography education. These integrated collaborated learning and interaction could help pupils to increase logical though, question and answer processes, and problem solving abilities. Thirdly, the learning of spatial data and geographical concepts through GIS use from early stage (e.g. Key Stages 1 or 2) can help the pupils develop the progression in learning about the use of

spatial data in geography right in the way through to higher education, in particular for GCSE and A-level, or Key Stage 4. This benefit is important not only for educating pupils in the schools, but also for the geography educators in higher education courses. Fourthly, GIS can provide pupils with the understanding of geographical information and spatial data how they can be used for basic tools for planning and decision making. This is also useful to perceive geographical events and issues of their neighbourhood and local area. Finally, GIS databases would contribute to build a geographical education tool for an enquiry-based learning strategy in school education such that students can take their questioning attitude into the workspace in support of specific and transferable skills. In geography education, therefore, GIS can be an important part of curriculum subject, both for its own and in association with other subjects of the National Curriculum such as Information Technology and environmental studies.

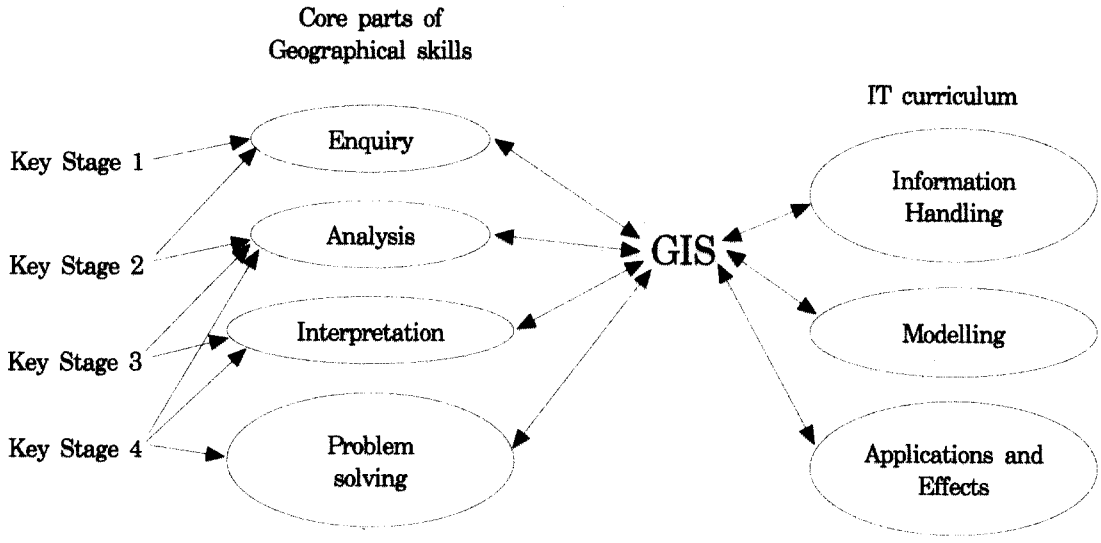
These advantages contribute to obtain for pupils to obtain geographical theories, mapping and cartographic knowledge, and to extend geographical perspective. New Geography and IT courses have ample opportunities for using GIS. Thus, the following section describes the interactive relationship between GIS and geography in school education with other IT course benefits. For this, AGI (Association for Geographical Information) has published a document to develop the discussion (Freeman, AGI, 1993) and this paper uses the discussions in the report.

2) Geographical skill, and GIS in the National curriculum,

As GIS is closely linked with IT and Geography subjects in the curriculum, the relationship should be investigated with these subjects' curricular. The Information Technology curriculum is divided into three sections or Attainment Targets (ATs). This is split into five sections, called "strands": 1) Communication' 2) Information Handling, 3) Modelling, 4) Measurement and Control, and 5) Applications and Effects. GIS is particular related closely with three strands of the curriculum, such as Information Handling, Modelling, and Applications and Effects. Geography curriculum has five ATs: 1) Geography Skills, 2) Knowledge and Understanding of Place, 3) Physical Geography, 4) Human Geography, and 5) Environment Geography (Freeman, AGI, 1993).

The aims of each stage in the Geography curriculum are that at Key Stages 1 and 2, geographical examples are focused on the studying of localities around pupils' geographies such as describing locality of UK, recognising differences between UK and other economically developing countries. At Key Stages 3 and 4, this extends to regions in the EC, USA, Japan, and CIS plus a specified economically developing countries. However, teaching methods encouraged at all levels within the programmes are an enquiry or problem solving approach to learning and collection, and the interpretation and analysis of data from a variety of primary and secondary sources. This relationship is summarised in Figure 2 that illustrates the interaction between the Key Stages, primary parts in Geography curriculum and IT skills within the curriculum for integration with GIS skills.

Geographical skills are not existed along without interaction with GIS and IT skills, and should be incorporated into the other ATs. For example, map interpretation and creating skills may be learned while doing fieldwork on Human Geography, and opportunities to use relevant IT (e.g. CD-ROMs, Internet, photographs) may arise when processing fieldwork information. In addition, GIS underpins both the geography and



Source : Freeman (1993).

Figure 1. Interactive relationship of Geography Key Stages and IT for GIS education within the National Curriculum

Table 4. Geographical Skills, IT and GIS skills for Key Stage 1

Geography curriculum	Geographical Skills relevant to GIS education	IT and GIS skills
Geographical enquiry and skills - Observation and idntification of their localities - Learning basic geographical vocabulary and skills Knowledge and understanding of places - Understanding their locality and contrasting with other areas Knowledge and understanding of patterns and processes - Recognition of local features and their changes Knowledge and understanding of environmental change and sustainable development - Recognise local environment and importance of sustainable environment	Follow directions: North, South, East, West Make representation of actual and imaginary places Extract information from and add it to pictorial maps (e.g. CD ROMs, Pictures, Photographs) Follow a route (e.g. shortest path to schools from pupil's home and compare with others)	Prepare a database in advance Select and retrieve geographical information on pupil's local area Practice storing, selecting, and analysing information using a mapping software Use a programmable toy to learn following a route practice Use digital camera to record places, people and events observed outside the classroom, or around local area Use CD ROM prepared or Internet to investigate a contrasting locality

Scources : Freeman(1993), the National Curriculum for England(1999)

Table 5. Geographical Skills, IT and GIS skills for Key Stage 2

Geography curriculum	Geographical Skills relevant to GIS education	IT and GIS skills
Geographical enquiry and skills - Explore their locality - Identify local issues and topics - Develop communication skills - Use appropriate tools, techniques, and IT methods Knowledge and understanding of places - Identify and describe geographical processes in local area Knowledge and understanding of patterns and processes - Recognise individual patterns and processes between human and physical features in local areas Knowledge and understanding of environmental change and sustainable development - Recognise interaction between human and environment - Recognise process of sustainable development	Interpretation of cartographic symbols to identify geographica features (e.g. Atlas and/or Ordnance Survey map symbols) Measuring distance at a range of different scales Developing geographical skills to describe geographical locations Developing geographical investigation (e.g. similarities and dissimilarities between UK and other countries)	Using IT for investigations requiring geographical data (e.g. use a database to sort, query, and present geographical information about different European countries - human and physical geographical data) Use a computer model to detect patterns and relationship between UK and EC, or other countries in Europe Use a software to create a database from the above practices so that geographical data can be captured, sorted and retrieved Use internet, CD ROMs, Satellite images to access comparative studies (e.g. comparing weather information about different locations in the UK, countries in the Europe)

Sources : Freeman(1993), the National Curriculum for England(1999).

IT curriculum and forms a strong link between them. It provides a vehicle for the main methods of teaching and learning that are set out in the Geography Programmes of Study such as investigation, enquiry, map interpretation, and data analysis (Geography in National Curriculum, 1999). GIS is, from this approach, an application where the IT strands of Information Handling, Modelling and Application and Effects may be all be found. To identify the benefits of these interactive relationship for Geography subject education, Tables 4 to 6 indicate where GIS links IT and Geographical Skills at Key Stages 1, 2 and 3 in the National Curriculum for Technology and Geography. The tabular information uses the report and review documents of the National Curriculum for England (1999) and Associate of Geographical Information (Freeman, AGI, 1993).

Table 6. Geographical Skills, IT and GIS skills for Key Stage 3

Geography curriculum	Geographical Skills relevant to GIS education	IT and GIS skills
Geographical enquiry and skills - Investigate various scales of geographies - Analyse and evaluate the conclusions - Develop communication skills in various ways - Develop field work skills - Study IT based sources - Develop communication and decision making skills using IT Knowledge and understanding of places - Explore geographical interaction on national, international, and global contexts Knowledge and understanding of patterns and processes - Identify human and physical features in global scales - Identify the geographical patterns between physical and human processes, and impact on geographical environments Knowledge and understanding of environmental change and sustainable development - Investigate environmental changes and management methods - Explore sustainable development and its implications for global environment	Using relevant techniques, interpret physical geographic phenomena (e.g. relief maps, topographic features) and those showing distribution patterns Using maps of different scales for appropriate purposes Using maps as an aid to choosing suitable locations for an enterprise model (e.g. to plot distribution of shops and service facilities in a town centre)	Select a software or mapping system Identify advantages and limitations of data handling programmes and graphic software Recognise solution for a geographical problems using a mapping/GIS software Investigate and assess the consequences of data variation and analytical methods/rules within a simple mapping and GIS models (e.g. chropleth mapping and graphic functions)

Scources : Freeman(1993), the National Curriculum for England(1999).

5. Case studies of GIS in Geography Curriculum

This section introduces the case studies that GIS skills have been successfully implemented for geography teaching and learning. The first case study undertaken in Rothwell junior school in Kettering Northamptonshire in England shows the use of digital mapping and software application for Key Stages 2 and 3 (Mapping news, 2001). The next study describes the application of the GIS for Key Stage 4 for geography teaching in Northern Ireland (Galloway, 1997).

1) Making use of digital map data at Key Stages 2 and 3

Local studies Software has developed for the use of the pupils in Year five (nine years old). The purposes of this software to the school educations are at first, to help pupils to evaluate the changes in their local area in some details. For example, Year three (seven years old) pupils explore their own locality using this software in their class. At second, this software helps pupils to address in a creative way such as many of the geographical enquiry skills and the knowledge and understanding of places of curriculum 2000. Using the software enables pupils to represent their town, street, and local features, and develop their understanding of the place around their homes and schools. These aims also include the development of their investigation to extend geographical view to compare other localities with their abilities.

For mapping practice in Year five Geography class, for example, the software requires the pupils to use drawing, icons, Ordnance Survey's NTF tiles of Rothwell areas (1 : 15000 scale). The purposes of this practice is to illustrate the geographical features in the local area, and compare other land use types and properties for the local town such that the pupils are expected to learn the locations and the differences of new roads, houses, farms, and school sites from their home and local areas. They are taught to link attribute information of the new building in their mapping practice, such as building names, and property name. The expected contribution of Local Studies software to Year three and Year five Geography learning and curriculum is that pupils can develop their geographical ideas and understanding of events and features happened around their local geographies, and that enjoy modifying and evaluating their own works.

As an example for the use of Local Studies software in the Geography practice, at first, the map of pupil's local area (e.g. Rothwell) is prepared for which Ordnance Survey 1 : 15000 scaled NTF tiles are converted into Local Studies software to show the area. Then, the pupils are asked to find the school (Rothwell school) and a pupil's home, and draw simple journey route to the school by using mouse. The software shows the walking distance with line. At this stage, Geography teacher asks the pupils to compare different routes and the distance with other pupil's results. This practice helps the pupils to ascertain how far places on the map are from each other and find the shortest route to the school, and their potential safe routes. This is identical to the the National Curriculum purposes for the Key Stage that aims to bring geographical distance and relationship of geographical features (See Table 5 for more details).

Map Importer software is used to import Ordnance Survey tiles to Local Studies software and information of the tiles such as attribution information. This software consists of mainly three functions, map display, zoom in and out, and saving and retrieving. Display map section is to create layers of all information that add some spatial information on digital map. For

example, the pupils can remove all homes, roads, and add other spatial information and view the remaining information. This practice is to develop spatial comparison and search abilities of geographical features through which the pupils can learn the geographical systems in their local areas. Using this software for their geographic enquiries enables them to experience various aspects of the local places in question, develop and devise hypothetical changes as part of their perspective. Zoom in and out functions also contribute the pupils to enlarge the map so that individual spatial features (e.g. buildings, streets, shops, schools) are visible or invisible. This practice helps to increase spatial scale concepts and visual contact of geographical features. Saving and retrieving functions can save pupil's work and import their results into other mapping software systems (e.g. Local Studies) for further work.

In summary, at first, Rothwell school's case shows that the usefulness and effectiveness of appropriate mapping software for teaching Geography subject for Key Stages 2 and 3 have been contributed to the pupil's Geography learning and teaching in the subject. The benefit also supports that the flexibility of user interface of the software systems allows a wide range of teaching strategies for tutors who deliver geography curriculum into the class. At second, initially the software systems have been developed for supporting teachers and yet providing the development challenges for pupils own practices in their class as they develop their skills. However, the functionality benefits of the software systems for geography teachers and pupils learning are apparent through the Rothwell case. Therefore, this lesson and outcomes can be also used for developing appropriate mapping software or systems of Geography subject in the geography subject development in Korea.

2) Putting GIS on the curriculum: a case study of Northern Ireland

From September 1996, GIS has became a part of Key Stage 4 GCSE Geography curriculum in Northern Ireland, which will lead the development of the subject into A-level later, because GCSE will result of cohort of the next A-level exam (Galloway, 2001). This is not only aimed to target within Key Stage 3 of the Geography curriculum in Northern Ireland, but it also provides useful revision materials for students in Key Stage 4. This section, therefore, addresses the contents of the GIS tools used in the curriculum and investigates the expected advantages for GIS educations in Korea.

Ordnance Survey of Northern Ireland (OSNI) and Northern Ireland Education Support Unit (NIESU) are main data suppliers for the success of GIS subject running in Geography teaching. They supply teaching and learning materials for the geography curriculum (Ordnance Survey in of Northern Ireland). A PC-based interactive multi media CD-ROM has been developed to bring GIS into geography classroom for which OSNI provides the PC-based GIS tool and NIESU provides guidance on the product content to ensure that it meets curriculum needs (Ordnance Survey in of Northern Ireland). The CD-ROM as a GIS tool has been developed for the pupils of the ages of 14 and 18 and many geography teachers who had no previous experience of the subject. The functionality of the CD-ROM includes tools, data entry, and data storage parts, and as GIS applications, it supports data input and use of GIS for pupil learning for Key Stage 4. Several advantages of the use of the CD-ROM can be discussed. At first, the CD-ROM provides suitable teaching resources to support textbooks for starting mapping and GIS teaching in the class. Many of Geography subject teachers presented their

concern of the lack of appropriate materials to teach GIS curriculum to their pupils. With respect of supporting relevant teaching resources, the CD-ROM can provide a good resource for Geography subject teaching with GIS. At second, it provides an opportunity of the development of PC and Mac based opening learning technology using CD-ROM that has been rapidly gaining acceptance in education as an appropriable teaching and learning material. At third, therefore, this use in the classroom can be a suitable supplement tool which provides hands-on experience of GIS for Geography curriculum. In Key Stage 3, the GIS CD-ROM is intended for teachers to meet a range of teaching requirements such as teaching the use of maps in geography and teaching the application of digital mapping in GIS. In addition, the teachers provide relevant applications to the pupils in order to understand GIS concepts and use it for their learning (e.g. data input, manipulation, and analyse their own data).

The functionality of the CD-ROM consists of three parts: query function, combination of spatial data (Overlay), and databases, georeferencing and diagram for graph creation (Galloway, 1997). These functions provide a supplement for teachers such that 'notebook' button can provide guidance for teachers to set further work for pupils and ask pupils to discover more about particular topics. It also offers references to other resources of information for the pupils to extend their geography learning scopes. Therefore, the CD-ROM application for student learning can be developed as a part of GCSE geography project such as settlement and wards -level census unit studies. For example, student can input their own data with existing census data provide by OSNI and NIESU. Using these resources enables them to use GIS to query and analyse their local phenomena (e.g. population changes, land use pattern, and socio-economic quality comparisons). The result can be exported to other spreadsheets to produce graphs and statistical correlation to plot on a map or screen. As ancillary functions, four components are included in the CD-ROM: navigation aid, a guide map, a glossary of terms, and help menu. The CD-ROM includes several navigation aids to assist previous page visiting or next section searching. A guide map function is to show the layout of the CD, and the function of a glossary of terms support the access from any page. The 'help' menu and modern screen capture and recording functions provide the students with step by step access of how to use the GIS tools and functionality. On-screen tutorials also demonstrate how GIS tasks can be well performed.

To train teachers who has involved in the application of the CD, Northern Ireland Regional Training Unit (NIRTU) organised a summer school to introduce the CD-ROM to Geography teachers and NIOS provided one-day course for technical expertise. From the meeting, although they have agreed the importance of GIS teaching tool, they have also concerned the shortage of suitable materials on the subject that the teachers knew a little about GIS. For this, the CD-ROM specifically addresses their needs. The CD has produced an accessible explanation and a practical demonstration of the subject to secondary level education standards. Finally, by allowing pupils to input their own data, they can create links to statistics, perform thematic mapping and explore other spheres of geography. Therefore, the application experiences of the CD-ROM has been demonstrated the strengths of GIS into Geography curriculum that how GIS can not only be integrated into the geography curriculum, but also helps to make geography more exciting and relevant human life and physical environments.

6. Discussions and Conclusion

It is indisputable fact that there has been a decline in the number of teaching units in Geography teaching at school levels in the last few years in Korea. As the 7th National Curriculum Standards plan in Korea aims to reform current teaching and learning strategies, the position of Geography subject and curriculum structure are requested to meet the curriculum framework (Educational Reform Initiatives, Ministry of Education and Human Resource Development, 2002). As a newer curriculum solution, this paper proposes the use of GIS for Geography education as an ICT (Information and Communication Technology) material that can adhere core skills for exploiting new geographical curriculum. For case studies, this paper addresses the UK experiences and examples of the application of GIS skills and techniques within the Geography subject curriculum.

GIS in schools in the UK is in an innovative phase. A number of developments are presently taking place that promise to raise the profile of GIS in primary and secondary school education and provide supports for teachers keen to exploit GIS in the delivery of Geography curriculum. As described above, Geography subject in the UK curriculum has experienced rapid changes. Many reasons are discussed not only within geography curriculum, but also from external education environments. However, it is necessary to take into account the main sources originated from geography curriculum and teaching strategies than investigating external factors. Geography subject curriculum explicitly requires GIS skills and relevant information technologies for the subject development. Several new specification documents and proposals have been prepared to encourage the greater use of GIS in geography teaching. The Dearing Review and the Qualifications and Curriculum Authority (QCA) Criteria for Geography issued by GCA (http://www.qca.org.uk/) make a number of points that encourage the use of competent information technology and other key skills in geography learning and teaching. These enhanced and newer supports indeed promise to provide a greater opportunity for teaching and learning with GIS in school education.

These environments require new IT based curriculum for geography teaching and learning in both UK and Korea. To response this circumstance, the UK education has explored computer driven IT or ICT subjects into school curriculum including GIS for Geography subject, which indeed reflect new demands and interests of pupils in the school education. This proposes a clear message to geography education in Korea that the use of IT based teaching plan and learning scheme is essential for Geography subject curriculum. Therefore, this paper discusses the experiences and lessons of the use of GIS in the UK cases to explore the Geography subject curriculum in Korea. However, several topics are still remained for the further research works. At first, appropriate curriculum structure and scheme plans of GIS and relevant IT curricular should be exploited to reflect the Geography subject education of the 7th National Curriculum Standards. At second, education programmes and plans for training and learning strategies should be explored to maximise the benefits of the GIS education within the Geography subject in Korea. At third, it is necessary to explore suitable geographic topics and issues that can appeal the active participation of pupils who want to learn computerised geography subject learning. Finally, these further research works should be collaborated with education specialists, schoolteachers as well as geographers.

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