The PRIMAS project: Promoting inquiry-based learning (IBL) in mathematics and science education across Europe

Policy: contextualising the European policy space in support of inquiry-based learning in mathematics and science

This international policy briefing report was drafted within the PRIMAS project based on national context and policy analyses. The report and more generally the policy work within the PRIMS project aim to inform the development of policy in national and international settings in relation to the education of young people in mathematics and science in ways that supports the implementation of IBL practices in compulsory schooling.

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The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

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SEVENTH FRAMEWORK PROGRAMME

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Policy: contextualising the European policy space in support of inquiry-based learning in mathematics and science

Executive Summary

PRIMAS Background

The project PRIMAS brings together 14 partner institutions and their associated teams from 12 different nations: Germany (DE), Switzerland (CH), Netherlands (NL), United Kingdom (GB), Spain (ES), Slovakia (SK), Hungary (HU), Cyprus (CY), Malta (MA), Denmark (DK), Romania (RO) and Norway (NO). The project has the overall objectives of ensuring that a greater number of students develop more positive dispositions towards further study of these subjects and the desire to be employed in related fields as well as additionally ensuring that students develop competencies through an approach that will prepare them well for life as critical inquirers in scientific domains. In pursuit of these objectives the project is working to effect a change across Europe in the teaching and learning of mathematics and science with teachers supported to develop inquiry-based learning (IBL) pedagogies so that students gain experience of IBL approaches.

Aims and purpose of the PRIMAS policy work package

Within the work of the project Work Package 7 (wp7) aims to inform the development of policy in national and international settings in relation to the education of young people in mathematics and science in ways that supports the implementation of IBL practices in compulsory schooling. In the first phase of this work the consortium has analysed at a national level, recent and current, policy developments in relation to the project's overall aims. This work will inform the next phase of work in which the consortium will consider how nations can learn from each other how key-levers of policy might support the project's aims.

Methodology and key theoretical constructs

The initial analysis of policy reported here builds on the earlier report of Work Package 2[1] (wp2) (Dorier 2010) in which an analysis of context was carried out identifying across nations existing factors, structures, opportunities and obstacles that might help or hinder the widespread take up of inquiry-based pedagogies in each country. This, in September 2010, reported of the systemic and structural constraints and conditions in each country using a framework based on Chevallard's Anthropological Theory of Didactics (ATD) (see for example, Chevallard 1992). In particular the scale of levels of didactical determination were used to structure the analysis. The work reported here follows a similar structuring based on four principal levels: civilisation and society, school, pedagogy and discipline. We also take account of the findings of recent work carried out by the Eurydice Network which provides information, on and analyses of, European education systems and policies. In particular we took into account two thematic studies (EACEA/Eurydice, 2011a, 2011b) and the Eurypedia website[2] that aims to present an accurate picture of national education systems across Europe.

The work reported here provides an understanding of the European policy space (Dale and Robertson 2009) that is developing in response to the overall European objective of increasing positive dispositions towards the learning of mathematics and science through the widespread implementation of inquiry-based pedagogies in schools. This has been developed using a

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1 Download: http://www.primas-project.eu/servlet/supportBinaryFiles?referenceId=4&supportId=1247
2 https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/

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comprehensive framework used in each country to identify that has allowed insight into policy at a national level and allows us to identify:

(a) the priorities that policies give to mathematics and science education and the professional development of teachers and the values that underpin these priorities;

(b) how systems and structures mediate / manage the implementation of policies;

(c) the processes of providing data and evidence that informs policy decisions.

The completed framework allows understanding to be developed in a vertical sense within each PRIMAS consortium nation (national reports) as well as in a horizontal sense in detail within each of these important themes across nations. In the full report, here, it is this detailed reporting across nations that provides the basis of analysis.

Summary findings and conclusions

Across the PRIMAS consortium nations what is striking in relation to the many policy developments that are identified as having impact at a range of different levels on the potential implementation of Inquiry Based Learning (IBL) methodologies is the wide range of different policies being implemented and the amount of effort that is currently being expended to support changes in teaching and learning in mathematics and science. But perhaps what appears more significant in all nations is the apparent lack of strategic vision and coherence of policy development across the full range of potential areas of implementation. Given the strong rhetoric at a European level for the widespread use of IBL in schools and classrooms to support stronger student engagement with mathematics and science it seems that many policy opportunities are lost and that there is not joined-up policy implementation to assist the work of PRIMAS and other projects that seek to effect changes in pedagogies. For example, teaching methodologies promoted in Initial Teacher Education and in in-service Professional Development are not necessarily aligned.

Equally significant seems to be the role that assessment is currently playing in educational reform. The OECD's international comparative study PISA is particularly important in this regard. The international rankings that result from PISA have been the catalyst for much policy development and resulting work across the educational systems of almost all countries. The influence that this particular study has exerted has not only been due to headline rankings in mathematics and science, but also due to detailed aspects of the study that have identified the performance of within population samples such as the most able students. The energies that are expended in chasing improved PISA league table positions are potentially too focused on short term gains that are in fact detrimental to engaging young people effectively in mathematics and science in the long term.

Our analysis of policy in relation to school systems and structures at a national level suggests that:

1. although mathematics and science have an important role to play in the school curriculum (as evidenced by their inclusion in international comparative studies and national assessment structures) this is not always prioritised or supported by policy developments in relation to overall school systems and structures although within schools the reverse is often the case, that is in schools mathematics and science are given high priority
2. the study of mathematics and science may often be considered as being more suitable for the most able students and it is often considered that inquiry-based learning is not important for such learners
3. many projects have been developed to support teaching and learning of mathematics and science but their impact may be dissipated because of lack of overall strategic vision

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We find that the cultural and historical situativity of curriculum specification and its implementation, not unexpectedly, plays an important role in defining each nation's approach to epistemologies and classroom practices and in implementation these are difficult to change. Although policies have been reactive to influences from international studies such as PISA in attempting to improve student attainment in the assessment that these studies use, in general at a national level there has been little attempt to do this through targeted development of pedagogy. Even where curricula have been redesigned it seems common that other policy mechanisms are not always used effectively to ensure adequate support for teachers who are expected to re-shape their classroom practice.

There is a significant need for curriculum specification that is more sensitively designed than currently appears to be the case. This needs to take account of the ways in which the specification is likely to be implemented and implementation intentions need to be signalled to teachers. Curriculum specification that focuses only on learning outcomes (and mainly outcomes of achievement) without taking any account of teaching input cannot expect to effect much change from the status quo. Overall, there needs to be a clear vision of what the curriculum wants to achieve across an expanded range of outcomes and these need to be planned for, and supported by, careful planning and communication.

Almost without exception across the consortium partners report that assessment is not aligned in ways that support IBL practices in classrooms. In most cases the emphasis in assessment of mathematics and science is on timed-written assessment that is narrowly conceived and leads to 'teaching to the test' that focuses on procedural application of knowledge relying on rules and procedures. This is particularly problematic because of the high value placed on assessment of mathematics and science, although much more so in the case of mathematics. We find that assessment outcomes, whilst having important implications for the progression of individual students, are used extensively as measures of performance of the school system. In most cases knowledge of measurement outcomes are restricted to those charged with effective running of schools. However, in some cases results are made available more widely to the public. The pressure on teachers to ensure their students perform well in assessments is therefore particularly intense and leads to pedagogies that are well established, non-risk taking and therefore provide further obstacles to change.

In countries where inspection of teaching in practice, in classrooms, takes place there is usually some support for active teaching that supports IBL. However, we find that this is the exception rather than the rule and there is also evidence that in some instances inspection is more focused on management issues rather than quality in teaching and learning. Quality in teaching and learning is paramount if we are to effect a change in educational outcomes, such as increased numbers of students at all levels positively disposed to, and literate in, mathematics and the sciences at all levels. This needs to be prioritised by policy developments that are supportive to the needs of teachers and their students.

A worrying aspect of the preparation of new teachers in a number of countries is the lack of emphasis on teaching quality at the expense of a focus on theoretical underpinning related to pedagogy and didactics. Only in a very few instances is there a focus on classroom practice in the assessment of new entrants to the profession. A commonly reported issue is the low subject knowledge-base of generalist teachers in Primary schools: this problem is particularly acute in terms of developing IBL practices in Primary schools as teachers who are not secure in their own knowledge of mathematics and science are unlikely to be able to support students whilst working with inquiry methods.

A further policy issue in initial teacher education (ITE) is the lack of specification of a curriculum for courses which are mainly designed, implemented and assessed by Higher Education Institutions. This provides both opportunities and challenges for projects such as PRIMAS that

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aim to bring about change in teaching practices in that it may be possible to ensure that some such courses incorporate some of the approaches to teaching being advocated but it also means that dissemination to those in charge of such courses can be a time consuming venture.

Perhaps most worrying of all to a project such as PRIMAS is the lack of coherence in terms of the lifelong learning and professional development of the teaching workforce. Across the consortium it seems that teachers are expected to learn on the job and the devolution of control but funding for their professional development to schools means that it may be difficult for many to access even the type of professional support they desire or require. Although initial teacher education is mainly situated in, or at least controlled, by research informed university departments this is often not the case in in-service professional development.

Recommendations

At a European level thought should be given as to how the European policy discourse in relation to education in general, and to teacher professional development in particular, can be expanded in ways that brings questions of policy coherence and strategy to the fore. This is important in terms of supporting the work of projects such as PRIMAS that aim to effect changes in teaching practices. In relation to this it is important to consider how policy at a national level in the following key areas can be developed in ways that inform and support each other:

Assessment

The role and nature of assessment in science and, particularly in mathematics, as a measure of system outcomes should be reconsidered with some urgency. In current formulations which focus on knowledge recall and standard applications of rules and procedures such assessment is leading to a narrow curriculum experience for learners as teachers attempt to ensure that students obtain high marks.

At a national level much policy activity focuses on reactions to the outcomes of international studies such as PISA. Attempting to make short term gains in the rankings provided by such studies should be questioned and a more long term strategic response considered. In addition policy should recognise that focussing only on achievement in tests values only one outcome of education: thought should be given to other outcomes (and measures of these) such as dispositions towards further study of, and eventual employment in STEM disciplines. IBL approaches to teaching and learning can help improve such outcomes and can also lead to enhanced outcomes in inquiry and problem solving skills as well as ensuring that learners are better equipped with self-directing learning skills in addition to improving levels of interest in the subject matter.
Important in this regard is that focussing on international comparative studies and their achievement ranking, as is current practice, can lead to a narrowing of the curriculum in ways that can make it less appealing to those other than the highest achievers.

Curriculum specification and implementation

Curriculum specification presents a major design challenge and its implementation requires support, this is particularly important when curriculum change is desired. It is unlikely that curriculum change will occur, even if specifications are redesigned and clearly communicated. The next iteration of curriculum design at a national level should:

1. be informed by the learner experiences and teaching approaches that are desired
2. indicate clearly expectations in terms of learner experiences that might optimise learners' dispositions as well as outcomes in terms of attainment
3. consider the practicalities of implementation through professional development and other support

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4. indicate expectations in relation to learner experiences and teaching approaches to producers of text books and other resources

Policies that can stimulate curriculum innovation at a national level should be considered and also how schools operating within local contexts and structures can be supported when they wish to bring about curriculum innovation and change.

Professional practice

Within the national context thought should be given to how good practice in IBL pedagogies can be supported, for example, through inspection systems, and disseminated more widely. This needs to be planned for and strategically supported.

Professional development

Strategic support of teachers' professional development appears rare. This is an essential aspect of bringing about curriculum change and needs to be considered urgently in relation to aims, objectives and priorities in developing mathematics and science education.

Initial Teacher Education

At a national level consideration should be given to policies that can support widespread dissemination of curriculum development intentions to develop IBL methodologies throughout the system in ways that supports the initial teacher education of teachers.

Next steps

The consortium partners will use this report to explore at a national level, through a series of policy think-tank meetings, the implications for policy developments in their own countries and what they might learn from the approaches of other nations. This will inform potential policy directions at a national and strategic level and will also support and inform future work of the consortium towards producing a series of strategy briefings in the later stages of the project.

In the next phase, as part of the on-going work of the project, the policy work package will stimulate work supported by work packages focused on materials (wp3) and professional development (wp4) that explores innovation in assessment that might support IBL pedagogies more effectively. Partners will seek to exemplify how summative assessment might be designed that can ensure qualities that students develop when using IBL approaches are valued and explored. This will be carried out as part of the professional development programmes associated with the project. There will be additional exploration of how summative assessment can be used to support formative assessment practices in action in classrooms.

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2 Main Report

2.1. Introduction

European policy discourse and funding have prioritised the development of teaching approaches that may engage more students with positive dispositions towards, and aspirations to engage in careers in, science, technology and engineering and mathematics disciplines. Important in this regard and in setting the policy agenda at a European level have been the Maastricht Treaty (1992) and Lisbon Treaty (1999) that have placed education firmly on the European policy agenda.

"[t]he Community shall contribute to the development of quality education by encouraging co-operation between Member States and, if necessary, by supporting and supplementing their action, while fully respecting the responsibility of the Member States for the content of teaching and the organisation of education systems and their cultural and linguistic diversity.

Maastricht Treaty, 1992

The intention is to ensure that the European Union is well-positioned in what is termed the 'global knowledge economy'. This it is hoped can be achieved by Member States within their own national contexts by developing an agenda-setting European policy space and discourse.

Knowledge lies at the heart of the European Union's Lisbon Strategy to become the " most dynamic competitive knowledge-based economy in the world". The ' knowledge triangle' - research, education and innovation - is a core factor in European efforts to meet the ambitious Lisbon goals.

The main objectives of FP7: Specific programmes
http://cordis.europa.eu/fp7/understand_en.html

This Report is the first output of the policy work associated with the project PRIMAS (Promoting inquiry-based learning in mathematics and science education across Europe) which is funded under the Seventh Framework Programme (FP7) which "bundles all research-related EU initiatives together under a common roof playing a crucial role in reaching the goals of growth, competitiveness and employment; along with a new Competitiveness and Innovation Framework Programme (CIP), Education and Training programmes, and Structural and Cohesion Funds for regional convergence and competitiveness."

The main objectives of FP7: Specific programmes
http://cordis.europa.eu/fp7/understand_en.html

The broad objectives of FP7 are grouped in four categories: Cooperation, Ideas, People and Capacities. PRIMAS contributes to the latter of these under the auspices of the thematic priority, Science in Society. Central to the work of PRIMAS, therefore, is the (re-)engagement of young people in learning mathematics and science through pedagogies that support inquiry-based learning.

Active engagement in the learning of mathematics and science it is proposed by the Rocard Report (2007) is essential if more young people are to be better disposed than is currently the case to follow trajectories in studying and working in STEM areas.

"Improvements in science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools, actions for teachers training to IBSE, and the development of teachers' networks should be actively promoted and supported."

(Recommendation 2, Rocard 2007)

The work of PRIMAS, therefore, attempts to scale-up, from what in many instances is a low-base inquiry-based teacher pedagogies in schools across its twelve nation partnership: : Germany (DE), Switzerland (CH), Nederland (NL), England (En), Spain (ES), Slovakia (SK), Hungary (HU), Cyprus (CY), Malta (MA), Denmark (DK), Romania (RO) and Norway (NO). In pursuit of this the project is providing for pre- and in-service teachers at both Primary and Secondary levels professional development supported by high-quality materials for both professional development activities and for the use of teachers with their students in classrooms.

This report stems from work under the auspices of the policy work package of the project and seeks to understand current policy intentions and inform the development of future policy in national and international settings. This builds on the project's analysis of national contexts by focusing on, and developing a more thorough understanding of, policy issues in relation the project's overall objective.

A systematic analysis of three key issues in the policy field has been undertaken and is reported on here with the intention of building not only on the on-going work of the project but also on recent reports at a European level that give insights into national contexts and policies. Particularly important in this regard are the Eurydice reports on Mathematics and Science Education (EACEA/Eurydice, 2011a , 2011b) and the development of the Eurypedia[3] (the European Encyclopaedia on education systems).

In this report, therefore, we seek to provide evidence-informed analysis across the consortium of:

(a) the priorities that national policies give to mathematics and science education, the professional development of teachers of these subjects and the values that underpin these priorities;

(b) how systems and structures mediate / manage the implementation of policies;

(c) the processes of providing data and evidence that informs policy decisions.

[3] webgate.ec.europa.eu/fpfis/mwikis/Eurydice/

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2.2. Background

Much work has been completed recently in providing information of the national contextual settings in which mathematics and science education is being developed across Europe. Particularly important in this regard are the recent Eurydice reports on mathematics (Mathematics Education in Europe: Common Challenges and National Policies) (EACEA/Eurydice 2011a), and science (Science Education in Europe: National Policies, Practices and Research) (EACEA/Eurydice 2011b), the Eurypedia website and the PRIMAS project wp2 Report (Dorier 2010). These give an overview of the state of mathematics and science education across Europe (in the case of the PRIMAS report across the twelve consortium partnership nations) and in particular identify the support measures available to teachers and schools for boosting students' motivation and interest in science.

The situation as described by these reports reflects in many ways the findings of our own work. In science education although there is much activity that can be useful in achieving the aim of encouraging student engagement and achievement this does not seem strategically organized and consequently the outcomes are not necessarily effective. The Eurydice report on the state of science education identifies a number of key areas of concern:

- the lack of initiatives that focus on the gender imbalance in education (for example, the bias of females towards the biological sciences and away from the physical sciences)
- the lack of support for the most able students
- the lack of support for the least able students
- the support in curriculum specifications for active ‘hands-on’ classroom activity but the focus in classrooms on traditional teaching methods (and the consequent lack of engagement of students)
- traditional assessment and a lack of teacher facility with assessing science skills.

There is much activity in European nations in the area of science teacher education, often with the support of a national centre with the specific role of supporting teachers in developing their pedagogy. This contrasts with the focus of initial teacher education which is often more concerned with teacher knowledge in relation to the curriculum. However, in both pre- and in-service teacher education insufficient attention is paid to how teachers might best support the diversity of their students and in particular how they might help develop in students more positive dispositions towards science.

Equally the Eurydice Report concerning mathematics education provides much useful information of importance to the aims of the PRIMAS project. In summarising the recent flurry of activity that has taken place in many countries following the results of the PISA international comparative study the report states:

Mathematics curricula lay down all the essential learning aims and outcomes of mathematics education. In the past years, and especially since 2007, the great majority of European countries have revised their mathematics curricula, adopting an outcome-based approach whereby the focus lies on developing students’ competences and skills rather than on theoretical content. The amount of mathematics content in the curriculum has decreased while cross-curricular links, problem- solving and the application of knowledge has increased. This integral approach tends to be more comprehensive and flexible in responding to the needs of a diverse range of learners, as well as to their ability to understand the purpose of mathematics applications in the real world.

However, the report also reveals that central authorities are generally falling short on providing sufficient guidance to teachers for implementing the revised curriculum. Providing the necessary support to teachers while respecting their didactic autonomy remains therefore a challenge in Europe.

As in the case of science active teaching and learning is identified as being important in mathematics education as a means of engaging students who have a wide range of interests, dispositions and aspirations, The report identifies a particular concern about the engagement and the development of basic competences by low attainers. Important for the project PRIMAS is the identification of a particular concern that in almost all countries there is a lack of strategic intervention focused on student engagement.

The importance of mathematics for progression to a wide range of careers is highlighted and the report raises concerns about the lack of targets in relation to eradicating low achievement in mathematics. This provides a challenge in ensuring both engagement and achievement of low attainers in mathematics.

In general it appears that although initial teacher education programmes are comprehensive in addressing many of the issues of concern the survey suggests that there is still potential for strengthening these programmes in relation to "teaching mathematics to a diverse range of students and in a gender sensitive way are competences that need to be strengthened in future programmes". Additionally there is a need for programmes of professional development that address these issues and importantly the need for greater participation rates of in-service teachers in such programmes.

The PRIMAS analysis of national context mirrors these findings in relation to professional development:

"In-service teachers' training and professional development are usually very poor in most countries. Most of the time, the offer is limited to one-day sessions without much supervision. Beyond the question of motivation from teachers, in several countries, there is a real problem of accessibility to in-service training and professional development, including financial aspects."

This analysis points to the written specification of national curricula being generally supportive of Inquiry Based Learning, but also recognises the contradiction of implementation in relation to intentions. This, it is suggested, provides a particularly demanding challenge for the work of projects such as PRIMAS, as the societal expectations that are reflected in classroom practice are long-established in the culture and history of education and beyond. Changing such deeply situated activity requires work on many fronts: the intention in this report is to identify in greater detail the policies that at a national level act and interact to produce the system as it is so that we might better understand how to use potential levers and mechanisms to support systemic change. The framework, which we go on to describe in some detail here, provided the basis for the analysis of the policy context at a European level. In the next phase of our work all consortium partners will look in more detail and depth at their own national policy context and work with policy stakeholders to consider how the aims of PRIMAS might be achieved.

2.3. Some useful theoretical constructs

Dale (2009) draws our attention to two important terms: European Education Space and European Education Policy in discussion of policy in European and national contexts and is careful to explicate the differences between them. The work at the focus of the report presented here is intimately bound within the former, the European Education Space, and should not be confused with, but may be helpful in informing future iterations of the latter, European Education Policy. Fundamental to drawing this distinction is an understanding of the limitations to, and constraints under which European collaboration and policy direction might impact upon, national educational systems. As Dale, points out, European Education Policy must be conceptualised as very different to the education policy frames with which we are more familiar in our own national contexts. European policy in education does not operate in parallel to national policy but in a very different and European context: there is no parallel to national ministries with their range of services and offices of bureaucratic and professional support. Rather it aims at

1. developing the European dimension in education
2. encouraging the mobility of students and teachers
3. promoting co-operation between educational establishments
4. exchange of information and experiences
5. encouraging the development of distance education

(European Union, 2004, Article 149.2 quoted in Dale, 2009)

The work of projects such as PRIMAS clearly contribute to such aims through the networks of educators that it builds and through the collaboration it fosters across national boundaries. In doing this a *policy space* has been developed and supported which in turn, as the work of consortium partners here with its focus on policy priorities, explores how the objectives set out within the Rocard Report (2007) are being met, helps mould future iterations of European Education Policy. In this way the work of the project can be conceptualised as being generative of future policy direction.

At a more general level our works considers how systems, structures and most importantly people (teachers, educators, policy-makers) react differently to policy imperatives because of ‘local’ contexts resulting in what Robertson (1995) has termed glocalisation. In a first phase of work in this field PRIMAS, therefore, asks how do emergent globalising intentions interact with national contexts to result in localised outcomes? Although we note the important effects that catalysts such as the PISA comparative studies and the Rocard Report (2007) can have in giving a direction to European education policy it is the European Policy Space that can provide the essential feedback loop that ensures this reflects the realities of the education systems of member states and consequently policy that is realisable.

In our work we take a socio-cultural historical perspective of the development of education, and in particular at the grain size of the school and classroom, with teachers, curriculum managers and so on as key actors and stake-holders within these systems. Without making a complete Cultural-Historical Activity Theoretic (CHAT) (see for example Engestrom 2001) analysis we do consider as particularly important in the context of policy development and implementation that we gain an understanding of, and articulate how, policy is mediated by rules both implicit and explicit that encapsulate the intentions and values of the society in which the policy is situated. Important in this regard is the culturally and historically evolved setting and expectations of the community which policy informs of new directions. As our analysis shows it is often the well- and long-established expectations of the community that can prove difficult for policy intentions to be realised. For example, as Brousseau (1997) noted the didactic contract, that is the unwritten contract between teachers (and parents) about expectations regarding the learning, of say mathematics, in schools is strong and consequently many teachers find it difficult to innovate in changing their pedagogy. A change in formal rules, such as a development of the curriculum specification, may take a long time to bring about a change in activity by virtue of the very fact that the ‘old’ practices are well embedded in daily routines and provide stability. Our analysis will point to such natural ‘conservatism’ in education with practices being strongly routinised on a day-to-day basis, particularly in the classroom and in the practices of teachers’ and their students.

The analysis of policy implementation in the consortium nations also builds on the systemic theoretical approach taken and outlined in some considerable detail in the first deliverable of work package 2 (Dorier 2010). This used the work of Chevallard who developed the construct of

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Didactic Transposition (Chevallard 1985) which from a sociological perspective situates and considers the didactical system as part of society at large, interacting with and in various spheres, in particular the academic sphere of the discipline (that produces and controls the scholarly knowledge) and what Chevallard named the *Noosphere* (from the Greek *noos*, "the place where one thinks") the sphere where different actors select and adapt the knowledge to be taught. This knowledge is then transposed into taught knowledge, through a process of mediation that includes writing textbooks and materials for teachers, as well as individual preparation from teachers. Finally this knowledge is actualised in the classroom and studied by students, this becomes the learned available knowledge.

Chevallard developed this work further to model the educational system as a complex structure of different institutions in much the way that CHAT considers activity systems which bring together key actors and stakeholders. This *institutional approach* considers a hierarchy of *didactical organisations* that are co-determined through their mutual interaction. This is explained at a greater level of detail in the first report of work package 2 (PRIMAS Deliverable N° D 2.1) (Dorier 2010). Here it is sufficient to draw attention to how the framework used in the national policy analysis has, without making this explicit, been informed by how ATD considers institutions at different levels that are co-determined. This is implicit in the structuring of the framework under each of the themes (priorities, management and data/evidence) considered. Consequently the framework considers school structures at a system level, curriculum organisation at a system level, assessment/qualification structures, curriculum organisation / teaching at a school level, initial teacher education and teacher professional development.

2.4 Methodology

2.4.1. Analytical framework

In this initial phase of the policy work of PRIMAS our aim is to understand the **policy context** at a national level in which PRIMAS is working to increase the use of IBL pedagogies in mathematics and science classrooms across the partnership. That is, we wish to develop an understanding of the European policy space that is developing in response to the overall European objective of increasing positive dispositions towards the learning of mathematics and science through the widespread implementation of inquiry-based pedagogies in schools. Building on our work that developed an understanding of school systems across the partnership and the comprehensive work undertaken by the Education, Audiovisual and Culture Executive Agency recently reported we have developed an analysis that focuses on the identification of three key issues in relation to national policy.

We seek to provide evidence informed analysis at a national level, and in summary across the partnership, of:

(a) the **priorities** that policies give to mathematics and science education and the professional development and the values that underpin these priorities;

(b) how systems and structures mediate / **manage** the implementation of policies;

(c) the processes of providing **data** and evidence that informs policy decisions.

A framework was developed in an iterative cycle of improvement, and which each partner then completed with respect to their own nation. This required (i) responses to a series of questions that inform the key issues of priorities, management and data/evidence, (ii) references to the policy evidence base, and (iii) affordances and constraints in relation to the aims of PRIMAS. The framework has three important themes:

2.4.2. Theme 1: The priorities promoted by policy

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Rationale: At different times policies can reflect the different priorities that a society or government has: for example, in general, across the industrialized nations in recent years there has been policy rhetoric that there is a need to ensure better education of young people in science, technology, engineering and mathematics in pursuit of a well-prepared technology-focused workforce. These priorities at a strategic European level are expected to work through to a national level to inform detailed policy in relation to many aspects of education. In the light of the European strategic aim of developing more active and engaging learning in mathematics and science it is the aim of PRIMAS to shed light on how national policy priorities may afford or constrain the work of the project. Through the lifetime we therefore seek to gain a detailed understanding of current national priorities (and consequently values) in policies towards education and consider the potential implications for the work of PRIMAS.

We asked: In what ways are mathematics and science education **prioritized** (or not) by policy? In relation to
(i) the structures of the school system (for example; schools may specialize in technology, funding may be increased for students following particular courses, …)
(ii) curriculum organization at a system level? (for example, how more time may have to be allocated to mathematics than other subjects, curriculum support materials may be provided that promote science, certain topics in mathematics / science may be prioritized above others, …)
(iii) assessment / qualifications? (for example, it may be that students are required to have passes in mathematics examinations before being allowed to progress to the next phase of education, more points for university admittance may be awarded for qualifications in science than in other subjects…)
(iv) teaching? (for example, active or passive teaching methods may be supported by inspection systems …)
(v) initial teacher education? (for example those training to teach mathematics and the physical sciences may receive more funding, teacher training institutions may be given increased recruitment targets in mathematics …).
(vi) teacher professional development (for example, more funding may be made available for mathematics and science training …)

2.4.3. Theme 2: How systems and structures mediate / manage the implementation of policies

There are many different approaches towards achieving the same ends for any given policy or strategic direction. Although governments can attempt to make structural and systemic changes there are often deep-rooted cultures that have historically evolved and become part of how ‘things are’ and are often resistant to change. We seek to understand how systems and structures mediate the implementation of policies in relation to the priorities in key areas of education and the potential implications for the work of PRIMAS.

To identify and understand national mediation and management systems we asked the following questions:

(i) How is the curriculum specified and how independent can schools be in implementation of this, in general, and in relation to mathematics and science in particular?
(Overall, how is curriculum specification controlled by policy - in general and in relation to mathematics and science in particular? Are there regulations about what schools must teach?)

(ii) How similar and how different is curriculum implementation and teaching of mathematics and science allowed to be between school-types (for example, primary or secondary, vocational or academic, public or private) and between schools of the same type?
(Overall, how centrally controlled is the classroom practice of teachers? For example, do they have free choice in their selection of resources or is there a state controlled text book?)

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(iii) How is the assessment of mathematics and science managed at a national level? What impact does assessment have on teaching and learning of mathematics and science?
(How centrally controlled is assessment / qualifications? Do teachers contribute to assessment that lead to qualifications? What is the potential in the management of assessment for IBL?)

(iv) How is initial teacher education managed/controlled in general and in relation to mathematics and science teaching in particular?
(What are the policies if any about initial teacher preparation in pedagogy / didactics? Is this at the discretion of the initial teacher education provider or in some way controlled centrally?)

(v) How is teacher professional development managed/controlled in general and in relation to mathematics and science teaching in particular?

2.4.4. Theme 3: Data and evidence that informs policy decisions

Policy makers use a wide range of data as well as drawing on personal and collective philosophies and ideologies to inform their policy actions. PRIMAS seeks to understand across the partnership how key aspects of national education systems are measured and consequently what data and evidence is available to inform policy development. In pursuit of understanding of the evidence base we ask the following key questions:

(i) What data is collected about educational outcomes at a system level to inform policy in relation to mathematics and science education (eg participation, attainment in assessment etc.)?

(ii) How are outcomes of schools measured? How are these measures used? What particular role, if any, does mathematics and science education play in relation to these measures?

(iii) How are the outcomes of teaching and learning measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(iv) To what purposes are measures of pupil performance in assessment used at individual, school and systemic levels? In relation to this are there any particular issues in mathematics and science education?

(v) How are the outcomes of initial teacher education measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(vi) How are the outcomes of professional development measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(vii) What has been the impact of international studies such as PISA and TIMSS on educational policy in general and in relation to mathematics and science in particular?

The full framework is given in Appendix A.

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2.5. Results: Summary of consortium partner nation responses

2.5.1. Theme 1: The priorities promoted by policy

2.5.1.1. In what ways are mathematics and science education prioritised (or not) by policy? In relation to (i) the structures of the school system (for example; schools may specialize in technology, funding may be increased for students following particular courses, …)

Across the partnership there is evidence that the disciplines of mathematics and science are identified as having high importance within education. The concern is expressed at the highest political level with many partner nations reporting involvement at a parliamentary level. Resulting from this high level and strategic policy concern there are many instances of special projects that are promoting innovation in the teaching of these subjects. Notably, in many of the partnership nations there are bodies that have the express aim of supporting mathematics and science teaching and learning, in some cases these are national centres, often accompanied by outreach centres, that promote excellence in pedagogy through a range of cpd programmes. The structural mechanisms that support teacher involvement in such initiatives are varied. This has consequences for potential engagement. In Denmark, for example, a network initiative (Danish Science Gymnasiums) provides research informed project support to participating institutions that in return make specific commitments that prioritise mathematics and science development within their institutions.

There are other instances of specially designed programmes that are optional and run in out of school hours. This clearly requires motivated and energised teachers in addition to pupils with similar qualities.

In most cases, although there are a lot of project initiatives underway, it appears that these are not often strategically managed.

Other partners highlight the structural support that is being given by means of updating school facilities particularly providing new teaching and learning information and communication technologies, such as interactive whiteboards and data logging equipment.

A number of partner nations report the devolution of power in the school system that gives individual schools the responsibility for their own curriculum organisation (see 1.5.1.2 below), albeit within an often centrally determined (and rigid) structure. This leaves prioritisation of mathematics and science an issue that may need to be addressed at a 'local' level.

However, within schools there are often instances of mathematics and science having opportunities to be prioritised. In Hungary, for example, the most able students in these subjects may be in special classes with the aim of preparing them to the highest level in mathematics and science. In such instances inquiry-based learning is often seen as not being appropriate.

In general, in almost all cases, school systems are not structured in ways that might prioritise the learning of mathematics and science.

Our analysis of policy in relation to systems and structures suggests that

1. these often do not prioritise or support any enhanced importance of these subjects although within schools the reverse may be the case
2. the study of mathematics and science may often be considered as being most suitable for the most able students and that inquiry-based learning is not important for such learners

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3. many projects have been developed to support teaching and learning of mathematics and science but their impact may be dissipated because of lack of overall strategic vision

2.5.1.2. In what ways are mathematics and science education prioritised (or not) by policy?
In relation to (ii) curriculum organization at a system level? (for example, how more time may have to be allocated to mathematics than other subjects, curriculum support materials may be provided that promote science, certain topics in mathematics / science may be prioritized above others, …)

As might be expected across nations there is wide variation in relation to how some aspects of the curriculum are organised and prioritised and in terms of other aspects there is much less variability. We find that often outputs in terms of expectations of student learning are defined whereas inputs in terms of teaching are not. Although there are, in all cases, centrally defined curriculum expectations that reflect the cultural and historical evolution of individual state education systems there are instances of variation being possible if not actively encouraged. We note, for example, in Slovakia the newly implemented policy that individual schools are required to have a part of their curriculum developed at a local level. This provides a space in which mathematics and science may be prioritised, but of course there are many other potential demands on this curriculum space. There is a similar situation in Germany but here there has been a strengthening of the core curriculum due to relatively poor performance by German students in the OECD PISA international study. However, there is less flexibility in other countries where time allocations for subjects in the curriculum are fixed centrally and cannot be varied, for example, in Spain.

We have identified variation in approaches to interdisciplinarity in the curriculum which reflects historically well-developed epistemologies. There appears little room to embrace new and emerging disciplines and fields of study. Some nations report that the curriculum emphasises key competencies that provide a new vision of how knowledge development might be conceptualised in relation to society in the digital age but that this is not implemented in practice with traditional subjects and disciplines providing the organising schema for teaching and learning in schools.

In general mathematics and science have high priority in the overall curriculum provision across partner nations, with mathematics often having the highest priority in the curriculum alongside the home language. This is often reflected in the amount of time each subject is allocated, although in some partnership nations it is reported that the time allocation for science is considered insufficient.

There is variation in approach to science education across the partnership: in some countries the curriculum is organised in an integrated way, in others the three separate sciences of Physics, Biology and Chemistry are defined and taught separately. This to some extent reflects educational views and preferences in relation to content and process domains with the integrated sciences often attempt to develop notions of what it means to become a scientist. There are clearly implications for projects such as PRIMAS in the different epistemologies that are adopted. For example, in Malta, in the case of science education there is a newly articulated vision that seeks both internal subject integration as well as connections to other subjects. This provides opportunities for the development of IBL approaches as supported by PRIMAS.

Coupled with high stakes assessment of mathematics and science that lead to what may be seen as highly valued qualifications (because of the significance these subjects have in the overall curriculum) time is often seen as being at a premium to teachers when working with their students. It seems that new curriculum formulations are often unsuccessful in making an impact on teaching and learning and that traditional values in education that prioritise “the basics” and knowledge accumulation prevail.

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Curriculum organisation provides a difficult challenge for innovation in teaching. This is not surprising as the curriculum in practice is mediated by teachers who are steeped in a history and culture that reflects a long tradition that has emphasized strong subject boundaries and 'basic' knowledge acquisition. This does not reflect the new ways in which, in many fields, activity has changed because of the advent of digital information and communication technologies.

2.5.1.3. In what ways are mathematics and science education prioritised (or not) by policy? In relation to (iii) assessment / qualifications? (for example, it may be that students are required to have passes in mathematics examinations before being allowed to progress to the next phase of education, more points for university admittance may be awarded for qualifications in science than in other subjects…)

The priority given to mathematics and science in assessment varies considerably across the partnership nations: in some cases successful grades in these subjects are required for progression to the next phase, particularly for progression from Secondary to Higher Education. However, in other nations there is no priority given to having a mathematics or science grade or qualification above those for any other subject.

Assessment in practice has two main purposes: the first as a measure of outcomes at a system level, the second as a measure of individual student attainment. The former may have little significance for individual students and is not a feature of the system in each country whereas the latter is often of considerable importance to the individual as such assessment is often the gatekeeper to progression. Many, but by no means all, nations have developed, or are developing, system-wide measures of accountability in the education system in which the assessment of students often plays a key role. In some cases this can be quite frequent.

What is clear is that the format of assessment has important implications for the work of projects such as PRIMAS. It is inevitable that teachers 'teach to the test', either so that the measurement of their work through assessment that attempts to measure system performance is favourable to their school or themselves individually as teachers, or to ensure that their students are positioned favourably in the competition for progression. In most cases the assessment currently in place is reported to be unsupportive to PRIMAS as it does not value many of the skills and qualities that students will develop through inquiry learning. This is not to say that inquiry-focused learners will not be well prepared to answer knowledge-focused questions requiring a procedural approach, but rather it does not demand the wider skill set that they will develop through taking an inquiry focused approach in their learning.

On a more positive note in some nations assessment takes a form that is more helpful in promoting the values of IBL. For example, in Slovakia there is assessment of 15 year-olds that requires students to engage with problems that demand a more open approach. In Switzerland in the Geneva canton it is also reported that assessment is supportive of IBL approaches.

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Overall assessment plays an important role in helping define students' experiences of learning in mathematics and science and our analysis suggests two important issues that PRIMAS partners will explore further:

- the nature of assessment can be more or less supportive of inquiry-based approaches to learning. PRIMAS provides an opportunity to explore this further by analysing different modes of assessment across the partnership. This can be used to inform those charged with the design of assessment in partnership nations and raise awareness of how their work is important in influencing the experience of students in classrooms.
- the value associated with mathematics and science assessment and qualification needs to be made explicit so that policy makers may better understand the implications for improving student participation in mathematics and science.

2.5.1.4. In what ways are mathematics and science education prioritised (or not) by policy? In relation to (iv) teaching? (for example, active or passive teaching methods may be supported by inspection systems …)

Across partnership nations there is much centralised control of the curriculum whereas in relation to teaching methods this is almost without exception left to schools and teachers. Only where there is inspection of schools that includes judgment of teaching is there any potential influence on pedagogy and didactics. Even where inspection systems exist they may have little influence on actual teaching practice as in some cases the focus of the inspection is entirely on administrative matters and possibly student outcomes / performance. For example, in Romania it is reported that inspections focus on management of a school rather than on teaching and learning. On the other hand in England, inspections do focus on classroom activity and inspection reports tend to be critical of passive learning and supportive of IBL approaches. However, this does not necessarily result in more active learning, as the influence of other measures of performance in particular through assessment tends to dominate. Even teachers who during inspector visits may demonstrate IBL practices return to less 'risky' actions as they prepare students for assessment that does not require IBL skills.

Across the partnership it is reported that the didactical contract (Brousseau 1997) that is commonly in operation is one that does not support the work of PRIMAS. Given that in general we found little prescription in terms of teaching methodologies there is the potential for PRIMAS to provide high quality support in this area. One question that emerges is that because in general schools have autonomy in their development of teaching approaches is, "how do we inform curriculum leaders and managers at a school level of the need for changes in pedagogies towards a more inquiry oriented approach?"

2.5.1.5. In what ways are mathematics and science education prioritised (or not) by policy? In relation to (v) initial teacher education? (for example those training to teach mathematics and the physical sciences may receive more funding, teacher training institutions may be given increased recruitment targets in mathematics …).

Most partners refer to two major problems in the supply of new teachers of mathematics and science in both Primary and Secondary phases (although in the Primary phase teachers are usually generalists): (i) difficulty in recruiting sufficient numbers and (ii) the quality of new career entrants' qualifications in mathematics and science. This is not the case in all nations, particularly in smaller partner nations. However, overall these are common and important challenges for initial teacher education. In some ways, therefore, it is perhaps surprising that we found few if any attempts to prioritise recruitment of suitable new recruits to teaching in these important areas.

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Only in a few cases have attempts been made to provide incentives (in monetary terms through bursaries or scholarships) that might attract potential teachers of mathematics and science.

Across the partnership the recruitment to courses in preparation for teaching in Primary schools provides some difficulties in ensuring that entrants are suitably qualified in mathematics and science. At this level new career entrants may have insecure subject knowledge although their general pedagogic skills are likely to become well developed. Our analysis found no instances of policy addressing let alone solving this particular problem in a systematic and sustained way.

In parallel with issues of curriculum in relation to school there is little evidence across the partnership of demands being made of initial teacher education in terms of the curriculum of the courses that are developed. The content of these is in the main not defined although there may be expectations set at a national level of outcomes (this is a minority position).

Most partners report that although there is little in the way of prioritisation of mathematics and science within initial teacher education there is the potential for PRIMAS to make an impact in this important area. However, rather like in the case of schools, because of the autonomy that initial teacher education providers (in most cases universities) have in developing their courses, there is the potential to provide targeted resources and initiatives that might be influential in the long-run in preparing new career entrants,

2.5.1.6. In what ways are mathematics and science education prioritised (or not) by policy? In relation to (vi) teacher professional development (for example, more funding may be made available for mathematics and science training …)

Policy in relation to Professional Development (PD) is of fundamental importance to PRIMAS as providing and supporting professional development is a core activity of the project. Within all partnership nations it seems that professional development in general is not organised in any strategic way to meet identified priorities. In most instances the funding for participants in PD is devolved to their schools which decide on local priorities and in the main only those teachers who are proactive with respect to their own professional development are likely to be able to take part in activity organised around IBL such as that offered by PRIMAS.

In contrast to initial teacher education that is usually centred around academic input from university educators together with periods of mentored professional practice in schools, because of the lack of strategically targeted in-service professional learning there is in most nations little professional development that is designed to reflect the research evidence base which is particularly strong in mathematics and science education.

The ad-hoc nature of much professional development in the partnership nations provides potential opportunities for projects such as PRIMAS to make an impact possibly by playing to the strengths that research informed developments provide for teachers. This may be exploited more than is currently the case in the latter half of the project and partners might explore how in existing systems and structures teachers might gain maximum credit for any work they undertake in professional development activities in relation to PRIMAS. For example, in England the work of PRIMAS has been used to inform the development of a 30 credit unit towards a Masters degree in education.

2.5.2 Theme 2: How systems and structures mediate / manage the implementation of policies

2.5.2.1. To identify and understand national mediation and management systems we asked the following questions: (i) How is the curriculum specified and how independent can schools be in implementation of this, in general, and in relation to mathematics and science

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in particular?
(Overall, how is curriculum specification controlled by policy - in general and in relation to mathematics and science in particular? Are there regulations about what schools must teach?)
(ii) How similar and how different is curriculum implementation and teaching of mathematics and science allowed to be between school-types (for example, primary or secondary, vocational or academic, public or private) and between schools of the same type?

(Overall, how centrally controlled is the classroom practice of teachers? For example, do they have free choice in their selection of resources or is there a state controlled text book?)

The issue of how the curriculum intentions are implemented is of high importance to innovation in teaching and learning such as that intended by projects such as PRIMAS. Across the partnership, in relation to this we find, as with all areas of policy there is a range of levers and mechanisms used to manage the curriculum with varying degrees of freedom for schools and teachers in the ways that they are expected to operate with more or less autonomy in this regard. In the most extreme cases we find the curriculum specified in detail (albeit, that its development is well informed by a wide range of stakeholders, including teachers) with clear expectations of what is to be taught and with little freedom to deviate from this and with even the selection of suitable texts as teaching resources centrally controlled. Such tight management of curriculum implementation is the exception rather than the rule.

However, even where there is scope for teachers to demonstrate greater agency in developing their teaching this is not often taken up. In most partnership nations we find the intention that day-to-day management of the curriculum should be at the discretion of schools, with curriculum outcomes being defined at a general overall level rather than in terms of detail. In practice, however, cultural and historical expectations, coupled with expectations particularly in relation to assessment in the later years of secondary education lead to a lack of experimentation and adoption of innovative practices by many teachers.

In general we find that teachers use curriculum specification, guidance and text books as important indicators of what to teach and are not innovative in how to work with their students in their learning. Text books in particular are reported as important in mediating curriculum expectations and we note that in some partner nations the development of these has lagged behind changes in curricula. It may be that in such cases online access to resources, as being developed by PRIMAS, could be influential and certainly necessary in supporting teachers' pedagogic practices.

We find that in some nations the control of textbook provision is highly centralised whilst in other there is a free market. In the latter case the development of texts is often undertaken by classroom teachers in their spare time and there are indications that such texts pay more attention to content coverage and organisation rather than consideration to the development of student engagement through active pedagogies.

Partners report that expectations regarding curriculum implementation are deeply engrained at all levels of society with, for example, parental expectations being important. As educational theorising has pointed out we can expect curriculum implementation to result in common patterns of lessons within nations leading to what have been termed 'cultural scripts' (Wierzbicka 1999). Over time this leads to a didactical contract (Brousseau 1997) being established and this is hard to shift. We note that in general parents contribute significantly to the maintenance at an institutional level of this contract and particularly for higher achieving students there is an expectation and favouring of 'traditional' instructional and assessment methods and suspicion of innovation.

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The issue of management of curriculum implementation provides a major challenge for PRIMAS and other similar initiatives that seek to bring about innovation in teaching and learning. Overall, we note that systemic conservatism provides a barrier to such developments and this points to the need for policy makers to consider at a strategic level how they might, through a coherent and well-targeted series of policy developments, support teacher innovation. We recommend strongly that the intended outcome, that is the development of teacher agency toward innovation in pedagogy, should be achieved by policy development that supports rather than dictates this. All partner nations report that there are pockets of good practice and potential for further development: these need to be encouraged to grown and their influence to expand. A starting point in a number of nations might be consideration of how texts and other resources and materials might be more supportive of such developments.

It seems likely that work in this area, if it were to be undertaken, is likely to progress at a speed such that there will have been little progress made within the lifetime of PRIMAS. A possible development within the project itself that may be of short term assistance is at a national level for PRIMAS partners to articulate clearly, and at a detailed level, how IBL approaches can be adopted in ways that extended curriculum outcomes are attainable.

2.5.2.2. To identify and understand national mediation and management systems we asked the following questions:
(iii) How is the assessment of mathematics and science managed at a national level? What impact does assessment have on teaching and learning of mathematics and science?
(How centrally controlled is assessment / qualifications? Do teachers contribute to assessment that lead to qualifications? What is the potential in the management of assessment for IBL?)

"… there are many schools where teaching is reduced to solving examination problems"

"….real world problems appear in the examination, but actually these problems do not need IBL, because they can be easily reduced to a non-contextualised form."

These two quotations from the response of one of the partners to this question summarise the nature of the problem that assessment poses.

The influence of assessment, particularly that used to measure student outcomes at the end of compulsory schooling, on day-to-today teaching is of major significance. In general summative assessment is not supportive of a change in teachers' pedagogies towards developing inquiry-based learning. The likely outcome is the continuing prevalent situation where many young people do not find the study of mathematics and science enjoyable, motivating or engaging.

In many countries the control of assessment is centralised in some way. In some countries this is at the level of the development of the actual assessment items but in others at the level of providing an overall framework to which the development of assessment must comply. Again, in ways similar to those related to curriculum implementation, expectations are culturally and historically situated. There are strong traditions associated with assessment, and international studies such as TIMSS and PISA and these help embed certain assessment formulations strongly in national developments as countries look to ensure that they appear to be performing well, and for many, most importantly, that they are improving. Consequently, introducing assessment that is supportive of IBL approaches may prove difficult. However, allied to this we find that as well as there being a need for materials that support day-to-day classroom teaching that encompasses IBL methodologies there is equally a need to provide models of assessment that might support this.

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The pervasive influence of assessment is questioned from the teachers' perspective in the reports of some partners. The in-depth knowledge that teachers gain of their students' learning is not valued in systems where terminal assessment is carried out by timed-written examinations that, as we suggest above, are narrowly conceived. Of course, teacher assessment raises issues of reliability in assessment terms, but it may be that given new technologies that it is possible that some objections to such practices might be overcome if we explore new approaches to assessment. There may be some room for such experimentation in some partner nations where there is little or no central control of assessment (such cases are the exception rather than the rule). Some partners report that assessment, even at the end of compulsory schooling is the responsibility of individual teachers. However, in many cases these teachers resort to tried and trusted methodologies, perhaps because of lack of examples of alternative practices. Such instances provide particularly promising areas for potential development.

It is notable that it is the case that there is more assessment of mathematics that is nationally controlled (with various degrees of frequency across partner nations) than is the case with science. This suggests that it may be in the area of science that there is greater space for experimentation in assessment than in mathematics.

2.5.2.3. (iv) How is initial teacher education managed/controlled in general and in relation to mathematics and science teaching in particular? (What are the policies if any about initial teacher preparation in pedagogy / didactics? Is this at the discretion of the initial teacher education provider or in some way controlled centrally?)

Two main issues appear pertinent from our survey of the management of initial teacher education (ITE) across the partnership: on the one hand the positive potential that devolution of responsibility for initial teacher education to Higher Education Institutions provides and on the other the possible negative impact of ITE placements of trainee teachers in schools that do not promote IBL practices.

It is common practice for ITE to have some form of specification, possibly defined expectations of outcomes, but little in the way of detailed guidance, with course design being the responsibility of the provider. This suggests that innovation in pedagogy such as proposed by PRIMAS may find a welcome space in courses of preparation of new teachers. However, devolution of the design of such courses to providers, whilst opening up potential avenues of dissemination provides a challenge as each provider needs to be contacted and convinced separately. This clearly provides an obstacle to the work of PRIMAS and similar projects. In the short term the project should consider how it might actively pursue a course of action that supports dissemination in this area. In the longer term at a strategic policy level thought should be given to how innovation in professional development of pedagogy might be supported by ITE through the development of mechanisms designed with this purpose in mind.

The experience of trainee teachers in schools as part of OTE is an essential element of theor training. However, thois socialises them into current practice which may be in conflict with the new pedagogies as advocated by PRIMAS. It seems clear that this early experience of teaching is a crucial mechanism in developing and helping establish the new teacher firmly in the social setting of schooling with its firmly rooted existing didactical contract. This appears to be a key area in which policy makers might consider how they can stimulate / facilitate the expectation of a constantly evolving eco-system of educational development rather than as is currently the case which is one of little change from generation to generation.

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2.5.2.4. (v) How is teacher professional development managed/controlled in general and in relation to mathematics and science teaching in particular?

There is much variation in the management of professional development (PD) across the consortium. We notice three distinct types:

i. no management or strategic control with responsibility for involvement being devolved to the school and individual teacher,

ii. some ‘light touch’ control with an accreditation or ‘kite-marking’ system having a role to play in quality control of provision and with some obligation for teachers to take part in PD but with responsibility for involvement again being devolved

iii. a planned strategic programme of PD provision with a requirement for practising teachers to take part in credit awarding PD on a regular basis.

In the case where there is no strategic direction to professional development provision, which is commonly the position in the larger nations in the consortium, there is often a free market in PD provision and PRIMAS and similar projects have to work hard to establish a new ‘brand’ or seek ways of linking with and using existing ‘brands’ that consortium partners and/or others have previously worked hard to establish.

In what appear to be more well-developed and strategically managed systems, for example, in Malta, there are expectations that each year teachers attend at least one PD course and a number of these are held at the end of the school year or just before the new school year begins so that attendance is made convenient for participants.

In many instances the provision of PD as a mechanism for teacher change provides a challenge because of ‘free market’ aspects and particularly because of the devolution to schools and teachers of responsibility for involvement in PD. This means that not only does a project such as PRIMAS have to develop attractive PD provision but partners acting as key brokers have to spend considerable time and energy ensuring through a range of networks that the provision is attractive to strategic policy developments towards mathematics and science teaching a very local level. The energy and time that this requires should not be underestimated.

Further, the design of PD has also to be of high quality and flexible so that it can meet other current issues of importance in schools that have local and immediate relevance. This means that, although PRIMAS has aims that are subject specific, partners report that there is often a range of competing issues of a more general nature. In some cases these may have relevance to mathematics and science and may even have some important connections. However, at a local level this can require creative adaptability in the design of PRIMAS PD and marketing of the resulting programme of effective implementation.

Overall, in almost all cases, partners report that ensuring that PRIMAS PD can find a place in the professional life of serving teachers is proving a challenge because of systems and structures of the management of PD.

2.5.3. Theme 3: Data and evidence that informs policy decisions

Policy makers use a wide range of data as well as drawing on personal and collective philosophies and ideologies to inform their policy actions. PRIMAS seeks to understand across the partnership how key aspects of national education systems are measured and consequently what data and evidence is available to inform policy development. In pursuit of understanding of the evidence base we ask the following key questions:

2.5.3.1 (i) What data is collected about educational outcomes at a system level to inform policy in relation to mathematics and science education (eg participation,

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attainment in assessment etc.)?
(ii) How are outcomes of schools measured? How are these measures used? What particular role, if any, does mathematics and science education play in relation to these measures?

There is measurement of student performance in examinations at various stages of their progress through school in almost all consortium nations and in all cases some assessment of their attainment is measured at the end of compulsory schooling. This is used to inform at a systems level the achievement of the cohort, and in many cases the achievement of individual schools. In some instances this is used only at a system level to inform managers of the state of the system and progress over time. In other countries results of this data is made publically available and may lead to ranking of schools and to inform parental choice of schools for their children where this is made possible. This is highly developed in England for instance. Mathematics (alongside home language) appears to always be included in assessment of any age group, and in many cases, but not all, some assessment of science is also included.

Important in the use of such data to inform policy development is the assumption that the assessment used is an adequate measure of what is required of learning outcomes. A number of partners refer to the importance of the TIMSS and particularly the PISA international studies in setting the agenda in assessment developments. This is discussed in more detail below and the issue of assessment has been discussed in 1.5.1.3 and 1.5.2.2 above.

Other data that may be used in addition to assessment outcomes includes drop-out rates, attendance rates, teacher qualifications, extracurricular activities. In many cases bare numerical data is collected; in only a few cases schools make a more comprehensive statement of their work which may include for example their staff's involvement with professional and curriculum development such as that offered by PRIMAS. Even in partnership nations where quantitative assessment data is not made publically available it is often used by schools to extol the achievements of their students in documentation and contact with parents and the local community more widely.

The use of quantitative data of pupil performance is in some cases, and increasingly so, being used in conjunction with monitoring and inspection at a local level. Such data may be used to trigger interventions by external agencies within schools in attempts to ensure improvement in performance in teaching and learning.

2.5.3.2. (iii) How are the outcomes of teaching and learning measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

In general, outcomes of teaching and learning are in almost all consortium nations linked directly to students' assessment outcomes. As has been discussed in a number of places in this synthesis of responses to our analytical framework assessment of students, often at a number of points during their progression through school, provides a major influence on the functioning of the education systems within regions and nations.

There is much less in the way of direct measurement or judgment of teachers' classroom practice, although, in some countries inspection systems operate that include qualitative judgments being made in relation to teaching. This is in one of its most developed form in Cyprus where teachers are subject to regular inspection of their work in classrooms. After an initial probationary period of two years during which observations are carried out every six months, this reduces to observation once a year for two years, and then at least once every three years. After twenty-five years the regularity is reduced even further to an observation once every four years, and teachers can expect an evaluative observation prior to any promotion. Although this regime provides regular monitoring of performance outcomes are not directly linked to remuneration, but

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do inform decisions relating to promotion to positions of responsibility. Self-evaluation is included in the overall package of monitoring.

2.5.3.3.(iv) To what purposes are measures of pupil performance in assessment used at individual, school and systemic levels? In relation to this are there any particular issues in mathematics and science education?

As has been extensively explained here assessment of students plays an important role in describing the education systems and importantly in ways that are influential to the development of policy and identifying policy priorities. Of course, assessment outcomes also have significant implications for students in terms of use and exchange value. Here we draw attention to how grades and marks are important for progression (exchange value), particularly in most cases as students approach the end of Secondary education and are considering moving into the world of work or undertaking further study in Higher Education. Gaining high grades can be very important for ensuring satisfactory progression and clearly for progression into the STEM disciplines high grades in mathematics and science subjects are required. In this way, achievement in mathematics and science for such students not only has high exchange value but also importantly may also be considered to have high ‘use’ value, that is, potential application to solve problems that are important to the student (often in new (inter-) disciplinary subjects such as in the bio-sciences). In this way although mathematics and science may have at first sight no particular enhanced value it may be that for some students this is indeed the case as to meet their aspirations these subjects are of considerable importance. It also appears that mathematics has some additional importance as this is almost always included in system performance measures based on assessment (alongside home language).

2.5.3.4. (v) How are the outcomes of initial teacher education measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

In most consortium partner nations there is no measurement of the quality of the teaching practice of new entrants to the profession although in many instances there is measurement by written examination and in these cases the theoretical underpinning of teaching can provide a substantial of the period of teacher preparation. In one of the most developed instance of assessment of actual teaching of new teachers, in England, all potential teachers are graded regularly as part of their period of preparation, but this on the whole is only used to inform inspectors of ITE courses of the quality of the judgments made by course providers of the teaching of their trainees. In this particular national case there is little importance given to the theoretical underpinning of teaching.

2.5.3.5. (vi) How are the outcomes of professional development measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

Although the quality of professional development is often monitored outcomes are in the main not systematically or systemically evaluated. In the Andalucian Region of Spain there has recently been an evaluation of teachers’ perception of their involvement in professional development, but there seems to be little information regarding the outcomes of PD although partners report considerable PD activity in their nations.

A more general exception might be where professional development is part of an academic programme leading to official accreditation such as in Masters programmes. In this case as part of standard Higher Education procedures the achievement of individual teachers would be measured.

2.5.3.6.(vii) What has been the impact of international studies such as PISA and TIMSS on educational policy in general and in relation to mathematics and science in particular?

Most consortium partner nations report that international studies such as TIMSS and PISA have made a substantive impact on their education systems. Headline league table positions provide major levers for reform as well as results at a more detailed level also contributing to national debates and helping define policy priorities and the direction of curriculum change. The most recent results from the longitudinal PISA studies have been important in almost all countries, particularly where the press and other media have been very active in reporting national standings. Many of the consortium partners report developments in curriculum specifications in mathematics and science, although some suggest that changes in actual classroom teaching practices may be less easily implemented than the rewriting of documents.

PRIMAS IBL approaches are seen in quite a positive way by most partner nations in the role that they might take in supporting students develop problem solving capacities.

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3. Conclusions

The reports from individual nations of the consortium reflect the considerable diversity in the rich cultural and historical settings in which education is developing and the work of PRIMAS struggles to gain a foothold. The localisation of the policy intentions that are emerging as a result of European Education Policy exemplifies well how globally emerging trends are adapted to meet the requirements of different nations.

The analysis presented here takes a horizontal form at a detailed level within three themes: priorities, management mechanisms and data/evidence. Across each of these we see similarities emerging, but also many differences some of which are more or less supportive of IBL practices. However, we should not forget that in the vertical direction, that is within a single country, it is how these different aspects of educational policy and their implementation interact both within the education field and with society more generally that defines and shapes the system uniquely. The eventual outcome is considerably more complex than even a careful understanding of component factors might suggest. Thus the European educational policy space that has emerged in relation to mathematics and science learning in general, and in relation to the affective domain of pupils' engagement, has many different affordances and constraints across nations and these might only be fully understood by those immersed in the cultural and historical roots of a nation, or in some cases region. What does seem clear is that the aims of European policy in this particular area take a much wider view of the outcomes of teaching and learning than the narrowly focussed lens of the international studies that appear so influential in informing policy makers. The OECD PISA study has a particularly strong voice in the policy discourse. The rankings of nations that this provides in relation to achievement in mathematics and science, gives a quick snapshot, that has dangerously come to provide the headline measure of outcomes of the work of schools and teachers. This has much more impact than it warrants. We draw attention to three important issues that emerge because of what is being measured and valued by PISA and how this is being used to inform policy development:

(i) the assumption that PISA tests capture the essence of ability in mathematics;

(ii) how this can support inclusion in, and positive dispositions towards, mathematics and science education;

(iii) the tensions that emerge through the focus on quality at the expense of quantity

Across the PRIMAS consortium nations what is striking in relation to the many policy developments that are identified as having impact at a range of different levels on the potential implementation of Inquiry Based Learning (IBL) methodologies is the wide range of different policies being implemented and the amount of effort that is currently being expended to support changes in teaching and learning in mathematics and science. But perhaps what appears more significant in all nations is the apparent lack of strategic vision and coherence of policy development across the full range of potential areas of implementation. Given the strong rhetoric at a European level for the widespread use of IBL in schools and classrooms to support stronger student engagement with mathematics and science it seems that many policy opportunities are lost and that there is not joined-up policy implementation to assist the work of PRIMAS and other projects that seek to effect changes in pedagogies. For example, teaching methodologies promoted in Initial Teacher Education and in in-service Professional Development are not necessarily aligned.

Equally significant seems to be the role that assessment is currently playing in educational reform. The OECD's international comparative study PISA is particularly important in this regard. The international rankings that result from PISA have been the catalyst for much policy development and resulting work across the educational systems of almost all countries. The influence that this particular study has exerted has not only been due to headline rankings in mathematics and science, but also due to detailed aspects of the study that have identified the performance of within population samples such as the most able students. The energies that are expended in chasing improved PISA league table positions are potentially too focused on short term gains that are in fact detrimental to engaging young people effectively in mathematics and science in the long term.

Our analysis of policy in relation to school systems and structures at a national level suggests that:

1. although mathematics and science have an important role to play in the school curriculum (as evidenced by their inclusion in international comparative studies and national assessment structures) this is not always prioritised or supported by policy developments in relation to overall school systems and structures although within schools the reverse is often the case, that is in schools mathematics and science are given high priority
2. the study of mathematics and science may often be considered as being more suitable for the most able students and it is often considered that inquiry-based learning is not important for such learners
3. many projects have been developed to support teaching and learning of mathematics and science but their impact may be dissipated because of lack of overall strategic vision

We find that the cultural and historical situativity of curriculum specification and its implementation, not unexpectedly, plays an important role in defining each nation's approach to epistemologies and classroom practices and in implementation these are difficult to change. Although policies have been reactive to influences from international studies such as PISA in attempting to improve student attainment in the assessment that these studies use, in general at a national level there has been little attempt to do this through targeted development of pedagogy. Even where curricula have been redesigned it seems common that other policy mechanisms are not always used effectively to ensure adequate support for teachers who are expected to re-shape their classroom practice.

There is a significant need for curriculum specification that is more sensitively designed than currently appears to be the case. This needs to take account of the ways in which the specification is likely to be implemented and implementation intentions need to be signalled to teachers. Curriculum specification that focuses only on learning outcomes (and mainly outcomes of achievement) without taking any account of teaching input cannot expect to effect much change from the status quo. Overall, there needs to be a clear vision of what the curriculum wants to achieve across an expanded range of outcomes and these need to be planned for, and supported by, careful planning and communication.

Almost without exception across the consortium partners report that assessment is not aligned in ways that support IBL practices in classrooms. In most cases the emphasis in assessment of mathematics and science is on timed-written assessment that is narrowly conceived and leads to 'teaching to the test' that focuses on procedural application of knowledge relying on rules and procedures. This is particularly problematic because of the high value placed on assessment of mathematics and science, although much more so in the case of mathematics. We find that assessment outcomes, whilst having important implications for the progression of individual students, are used extensively as measures of performance of the school system. In most cases knowledge of measurement outcomes are restricted to those charged with effective running of schools. However, in some cases results are made available more widely to the public. The pressure on teachers to ensure their students perform well in assessments is therefore particularly intense and leads to pedagogies that are well established, non-risk taking and therefore provide further obstacles to change.

In countries where inspection of teaching in practice, in classrooms, takes place there is usually some support for active teaching that supports IBL. However, we find that this is the exception rather than the rule and there is also evidence that in some instances inspection is more focused on management issues rather than quality in teaching and learning. Quality in teaching and learning is paramount if we are to effect a change in educational outcomes, such as increased numbers of students at all levels positively disposed to, and literate in, mathematics and the sciences at all levels. This needs to be prioritised by policy developments that are supportive to the needs of teachers and their students.

A worrying aspect of the preparation of new teachers in a number of countries is the lack of emphasis on teaching quality at the expense of a focus on theoretical underpinning related to pedagogy and didactics. Only in a very few instances is there a focus on classroom practice in the assessment of new entrants to the profession. A commonly reported issue is the low subject knowledge-base of generalist teachers in Primary schools: this problem is particularly acute in terms of developing IBL practices in Primary schools as teachers who are not secure in their own knowledge of mathematics and science are unlikely to be able to support students whilst working with inquiry methods.

A further policy issue in initial teacher education (ITE) is the lack of specification of a curriculum for courses which are mainly designed, implemented and assessed by Higher Education Institutions. This provides both opportunities and challenges for projects such as PRIMAS that aim to bring about change in teaching practices in that it may be possible to ensure that some such courses incorporate some of the approaches to teaching being advocated but it also means that dissemination to those in charge of such courses can be a time consuming venture.

Perhaps most worrying of all to a project such as PRIMAS is the lack of coherence in terms of the lifelong learning and professional development of the teaching workforce. Across the consortium it seems that teachers are expected to learn on the job and the devolution of control but funding for their professional development to schools means that it may be difficult for many to access even the type of professional support they desire or require. Although initial teacher education is mainly situated in, or at least controlled, by research informed university departments this is often not the case in in-service professional development.

4. Recommendations

At a European level thought should be given as to how the European policy discourse in relation to education in general, and to teacher professional development in particular, can be expanded in ways that brings questions of policy coherence and strategy to the fore. This is important in terms of supporting the work of projects such as PRIMAS that aim to effect changes in teaching practices. In relation to this it is important to consider how policy at a national level in the following key areas can be developed in ways that inform and support each other:

4.1. Assessment

The role and nature of assessment in science and, particularly in mathematics, as a measure of system outcomes should be reconsidered with some urgency. In current formulations which focus on knowledge recall and standard applications of rules and procedures such assessment is leading to a narrow curriculum experience for learners as teachers attempt to ensure that students obtain high marks.

At a national level much policy activity focuses on reactions to the outcomes of international studies such as PISA. Attempting to make short term gains in the rankings provided by such studies should be questioned and a more long term strategic response considered. In addition policy should recognise that focussing only on achievement in tests values only one outcome of education: thought should be given to other outcomes (and measures of these) such as dispositions towards further study of, and eventual employment in STEM disciplines. IBL approaches to teaching and learning can help improve such outcomes and can also lead to enhanced outcomes in inquiry and problem solving skills as well as ensuring that learners are better equipped with self-directing learning skills in addition to improving levels of interest in the subject matter.
Important in this regard is that focussing on international comparative studies and their achievement ranking, as is current practice, can lead to a narrowing of the curriculum in ways that can make it less appealing to those other than the highest achievers.

4.2. Curriculum specification and implementation

Curriculum specification presents a major design challenge and its implementation requires support, this is particularly important when curriculum change is desired. It is unlikely that curriculum change will occur, even if specifications are redesigned and clearly communicated. The next iteration of curriculum design at a national level should:

1. be informed by the learner experiences and teaching approaches that are desired
2. indicate clearly expectations in terms of learner experiences that might optimise learners' dispositions as well as outcomes in terms of attainment
3. consider the practicalities of implementation through professional development and other support
4. indicate expectations in relation to learner experiences and teaching approaches to producers of text books and other resources

Policies that can stimulate curriculum innovation at a national level should be considered and also how schools operating within local contexts and structures can be supported when they wish to bring about curriculum innovation and change.

4.3. Professional practice

Within the national context thought should be given to how good practice in IBL pedagogies can be supported, for example, through inspection systems, and disseminated more widely. This needs to be planned for and strategically supported.

4.4. Professional development

Strategic support of teachers' professional development appears rare. This is an essential aspect of bringing about curriculum change and needs to be considered urgently in relation to aims, objectives and priorities in developing mathematics and science education.

4.5. Initial Teacher Education

At a national level consideration should be given to policies that can support widespread dissemination of curriculum development intentions to develop IBL methodologies throughout the system in ways that supports the initial teacher education of teachers.

4.6. Next steps

The consortium partners will use this report to explore at a national level, through a series of policy think-tank meetings, the implications for policy developments in their own countries and what they might learn from the approaches of other nations. This will inform potential policy directions at a national and strategic level and will also support and inform future work of the consortium towards producing a series of strategy briefings in the later stages of the project.

In the next phase, as part of the on-going work of the project, the policy work package will stimulate work supported by work packages focused on materials (wp3) and professional development (wp4) that explores innovation in assessment that might support IBL pedagogies more effectively. Partners will seek to exemplify how summative assessment might be designed that can ensure qualities that students develop when using IBL approaches are valued and explored. This will be carried out as part of the professional development programmes associated with the project. There will be additional exploration of how summative assessment can be used to support formative assessment practices in action in classrooms.

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6. Appendix: Analytical Framework

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PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

PRIMAS – Policy Work Package

Phase 1 Aims:
To understand the policy context at a national level in which PRIMAS is working to increase the use of IBL pedagogies in mathematics and science classrooms across the partnership. We seek to provide evidence informed analysis of:

(a) the priorities that policies give to mathematics and science education and the professional development and the values that underpin these priorities;

(b) how systems and structures mediate / manage the implementation of policies;

(c) the processes of providing data and evidence that informs policy decisions.

Potential affordances and constraints to the overall aims of PRIMAS will be identified.

Method
Each partner will provide (i) brief answers to a series of questions that inform the issues identified in the Phase 1 aims, (ii) indication of policy evidence, and (iii) affordances and constraints in relation to the aims of PRIMAS.

Theme 1: The priorities promoted by policy

Rationale: At different times policies can reflect the different priorities that a society or government has: for example, in general, across the industrialized nations in recent years there has been policy rhetoric that there is a need to ensure better education of young people in science, technology, engineering and mathematics in pursuit of a well-prepared technology-focused workforce. These priorities at a strategic level work through to inform policy at a more detailed level in relation to many aspects of education and have an impact on what is valued by policy makers and those that work in implementing policies. We seek to gain a detailed understanding of the current priorities (and consequently values) in national policies towards education and consider the potential implications for the work of PRIMAS.

In what ways are mathematics and science education prioritized (or not) by policy? In relation to
(i) the structures of the school system (for example; schools may specialize in technology, funding may be increased for students following particular courses, …)
(ii) curriculum organization at a system level? (for example, how more time may have to be allocated to mathematics than other subjects, curriculum support materials may be provided that promote science, certain topics in mathematics / science may be prioritized

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above others, …)
(iii) assessment / qualifications? (for example, it may be that students are required to have passes in mathematics examinations before being allowed to progress to the next phase of education, more points for university admittance may be awarded for qualifications in science than in other subjects…)
(iv) teaching? (for example, active or passive teaching methods may be supported by inspection systems …)
(v) initial teacher education? (for example those training to teach mathematics and the physical sciences may receive more funding, teacher training institutions may be given increased recruitment targets in mathematics …).
(vi) teacher professional development (for example, more funding may be made available for mathematics and science training …)

Theme 2: How systems and structures mediate / manage the implementation of policies

Rationale: There are many different approaches towards achieving the same ends for any given policy or strategic direction. Although governments can attempt to make structural and systemic changes there are often deep-rooted cultures that have historically evolved and become part of how 'things are' and are often resistant to change. We seek to understand how systems and structures mediate the implementation of policies in relation to the priorities in key areas of education and the potential implications for the work of PRIMAS.

(i) How is the curriculum specified and how independent can schools be in implementation of this, in general, and in relation to mathematics and science in particular?
(Overall, how is curriculum specification controlled by policy - in general and in relation to mathematics and science in particular? Are there regulations about what schools must teach?)

(ii) How similar and how different is curriculum implementation and teaching of mathematics and science allowed to be between school-types (for example, primary or secondary, vocational or academic, public or private) and between schools of the same type?
(Overall, how centrally controlled is the classroom practice of teachers? For example, do they have free choice in their selection of resources or is there a state controlled text book?)

(iii) How is the assessment of mathematics and science managed at a national level? What impact does assessment have on teaching and learning of mathematics and science?
(How centrally controlled is assessment / qualifications? Do teachers contribute to assessment that lead to qualifications? What is the potential in the management of assessment for IBL?)

(iv) How is initial teacher education managed/controlled in general and in relation to mathematics and science teaching in particular?
(What are the policies if any about initial teacher preparation in pedagogy / didactics? Is this at the discretion of the initial teacher education provider or in some way controlled centrally?)

(v) How is teacher professional development managed/controlled in general and in relation to mathematics and science teaching in particular?

Theme 3: Data and evidence that informs policy decisions

Rationale: Policy makers use a wide range of data as well as drawing on personal and collective philosophies and ideologies to inform their policy actions. PRIMAS seeks to understand across the partnership how key aspects of national education systems are measured and consequently what data is available.

(i) What data is collected about educational outcomes at a system level to inform policy in relation to mathematics and science education (eg participation, attainment in assessment etc.)?

(ii) How are outcomes of schools measured? How are these measures used? What particular role, if any, does mathematics and science education play in relation to these measures?

(iii) How are the outcomes of teaching and learning measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(iv) To what purposes are measures of pupil performance in assessment used at individual, school and systemic levels? In relation to this are there any particular issues in mathematics and science education?

(v) How are the outcomes of initial teacher education measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(vi) How are the outcomes of professional development measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?

(vii) What has been the impact of international studies such as PISA and TIMSS on educational policy in general and in relation to mathematics and science in particular?

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Theme 1: Policy priorities

(i) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **school structures** at a system level? (for example; schools may specialize in technology, funding may be increased for students following particular courses, …)
Policy references:
Potential affordances and constraints for PRIMAS

(ii) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **curriculum organisation** at a system level? (for example, how more time may have to be allocated to mathematics than other subjects, curriculum support materials may be provided that promote science, certain topics in mathematics / science may be prioritized above others, …)
Policy references:
Potential affordances and constraints for PRIMAS

(iii) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **assessment / qualification** structures? (for example, it may be that students are required to have passes in mathematics examinations before being allowed to progress to the next phase of education, more points for university admittance may be awarded for qualifications in science than in other subjects…)
Policy references:
Potential affordances and constraints for PRIMAS

(iv) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **curriculum organisation / teaching** at a school level? (for example, active or passive teaching methods may be supported by inspection systems …)
Policy references:
Potential affordances and constraints for PRIMAS

(v) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **initial teacher education**? (for example those training to teach mathematics and the physical sciences may receive more funding, teacher training institutions may be given increased recruitment targets in mathematics …)
Policy references:
Potential affordances and constraints for PRIMAS

(vi) In what ways are mathematics and science education **prioritised** (or not) by policy in relation to **teacher professional development**? (for example, more funding may be made available for mathematics and science training …)
Policy references:
Potential affordances and constraints for PRIMAS

Theme 2: How systems and structures mediate / manage the implementation of policies

(i) How is the curriculum specified and how independent can schools be in implementation of this, in general, and in relation to mathematics and science in particular? (Overall, how is curriculum specification controlled by policy - in general and in relation to mathematics and science in particular? Are there regulations about what schools must teach?)
Policy references:
Potential affordances and constraints for PRIMAS

(ii) How similar and how different is curriculum implementation and teaching of mathematics and science between school-types (for example, primary or secondary, vocational or academic, public or independent) and between schools of the same type? (Overall, how centrally controlled is the classroom practice of teachers? For example, do they have free choice in their selection of resources or is there a state controlled text book?)
Policy references:
Potential affordances and constraints for PRIMAS

(iii) How is the assessment of mathematics and science managed at a national level? What impact does assessment have on teaching and learning of mathematics and science? (How centrally controlled is assessment / qualifications? Do teachers contribute to assessment that lead to qualifications? What is the potential in the management of assessment for IBL?)
Policy references:
Potential affordances and constraints for PRIMAS

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(iv) How is initial teacher education managed/controlled in general and in relation to mathematics and science teaching in particular? (What are the policies if any about initial teacher preparation in pedagogy / didactics? Is this at the discretion of the initial teacher education provider or in some way controlled centrally?)
Policy references:
Potential affordances and constraints for PRIMAS

(v) How is teacher professional development managed/controlled in general and in relation to mathematics and science teaching in particular?
Policy references:
Potential affordances and constraints for PRIMAS

Theme 3: Data and evidence that informs policy decisions

(i) What data is collected about educational outcomes at a system level to inform policy in relation to mathematics and science education (eg participation, attainment in assessment etc.)
Policy references:
Potential affordances and constraints for PRIMAS

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(ii) How are outcomes of schools measured? How are these measures used? What particular role, if any, does mathematics and science education play in relation to these measures?
Policy references:
Potential affordances and constraints for PRIMAS

(iii) How are the outcomes of teaching and learning measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?
Policy references:
Potential affordances and constraints for PRIMAS

(iv) To what purposes are measures of pupil performance in assessment used at individual, school and systemic levels? In relation to this are there any particular issues in mathematics and science education?
Policy references:
Potential affordances and constraints for PRIMAS

(v) How are the outcomes of initial teacher education measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?
Policy references:
Potential affordances and constraints for PRIMAS

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(vi) How are the outcomes of professional development measured? How are these measures used? In relation to this are there any particular issues in mathematics and science education?
Policy references:
Potential affordances and constraints for PRIMAS

(vii) What has been the impact of international studies such as PISA and TIMSS on educational policy in general and in relation to mathematics and science in particular?
Policy references:
Potential affordances and constraints for PRIMAS

Additional comments

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Policy references:
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