Does Team-Based Professional Development Make A Difference?
A Longitudinal Investigation of Teacher
Learning through Curriculum Design

Marie Afua Baah Bakah
Institute for Educational Planning and Administration,
University of Cape Coast,
Cape Coast

Abstract
While a growing body of literature documents teachers' involvement in curriculum design, this study further assesses curriculum design among teacher teams for instructional improvement and teacher development in some higher institutions in Ghana. Six teams of teachers were studied over a three year period as they redesigned their courses to commensurate contemporary workplace skill demands and improve instruction. Results from data collected through interviews, questionnaires, observation and field notes showed teacher professional development gains; especially due to shared knowledge and collective efforts to pursue up-to-date information from relevant sources to develop the curriculum. The classroom implementation of the redesigned courses revealed industry-relevant lesson experiences for students. It was concluded that participation in professional development focused curriculum design can impact teacher learning and practice. This study emphasizes the importance of teacher collaboration and marks a first step toward identifying how learning processes are encouraged and knowledge is constructed in design teams.

Introduction
Many schools carryout their reform efforts from a school-wide perspective and to achieve curricular coherence, they initiate reforms that concern the whole breadth of the curriculum in the school. This school-wide line of reasoning is more concentrated on strengthening reform by making it a shared practice across the school (Hord, 2004) and in doing so, realizing sustainable, significant, and coherent educational reform in schools and between the teachers. The proponents of the school-wide approach state that many innovation plans fail at an early stage, and when

an attempt does succeed, it is often an isolated effort of a few teachers embracing a reform. In the long run, most curriculum innovations and projects that rely on individual teachers' voluntary commitments do not last (Hargreaves, 2003). Therefore, there is a need to organize reform in a school-wide manner in which all teachers are somehow involved. An implication of the change in orientation (aiming at coherent and school-wide sustainable reform) is that there is a need for synergy and productive relationships between curriculum development at various levels (system, school, and classroom), professional development of teachers, and school development (Handeldalts, 2009). This synergy of processes is the key for sustainable reform (Fullan, 2001; Hopkins, 2001). Curriculum and curriculum reform can be seen as the central element of this trio as they touch directly on the learning of students, the daily work of teachers and their interaction with the students, and the way learning is organized in the school as a whole. The reform in Ghana's polytechnic education system is specifically aimed at changes in the curriculum. The interaction of curriculum reform and teacher development entailed the input of teachers who are at the forefront of curriculum improvement as they are central agents in all of these developments. As it is, teachers have a central role as curriculum makers of their school-based curriculum (Clandinin & Connelly, 1992, Skilbeck, 1998). Additionally, focusing on improving the curriculum is also intrinsically motiv-ating to teachers. Moreover, Skilbeck (1998) argues that teacher participa-tion in curriculum development potentially helps to improve the quality and relevance of what is taught and will strengthen teacher professionalism.

Ghana's Polytechnics

Polytechnics in Ghana were originally called technical institutes (at the secondary level) when they were established in 1951. In 1963, the technical institutes were re-designated as polytechnics but they continued to operate essentially as non-tertiary institutions which offered mostly advanced craft courses and a few technician programmes (Nsiah-Gyabaah, 2005). The polytechnics inherited the physical and academic facilities of the technical institutes that were converted to polytechnics. A Polytechnic Law, PNDCL 321, 1992 was promulgated to give legal backing to the upgrading of polytechnics. From 1993 onwards, the state-owned technical and vocational oriented polytechnics were upgraded to tertiary status to offer additional career-focused programmes in the sciences, techno-logy and business management leading to the award of Higher

National Diploma (HND) (NTCE, 2001). In 1994, the polytechnics commenced the running of HND programmes. In 2007 there was another step in the academic growth of the polytechnics in Ghana with the government directive (Ghana Government Polytechnic Law 745, September, 2007) to run bachelor degree programmes as part of strategies to improve on the capabilities and capacities of the polytechnics to meet the manpower needs of the nation. Thus Polytechnic Law (PNDCL 321 of 1992) has since 2007 been replaced by the Polytechnics Law (Act 745). This gives a clear mandate to the Polytechnics as embedded in their aims and objectives as follows:

    a. Provide tertiary education through full time courses in the field of manufacturing, commerce, science, techno-logy, applied social sciences, applied arts and such other areas as may be determined by authority for the time being responsible for higher education;

    b. Encourage study in technical subjects at tertiary level; and

    c. Provide opportunity for development, research and publication of research findings.

The above objectives clearly indicate that the central focus of polytechnic education is its career-oriented nature. The career-oriented and craftsmanship programmes of the polytechnics are run albeit only after approval from and accreditation by the National Accreditation Board (NAB). The autonomy granted the polytechnics gives them the degree of self-governance necessary for effective decision making concerning the functioning of the institution with respect to their academic work, standards, management and other related activities that are in line with the system of public accountability (Aidoo-Taylor, 2009). Currently, there are 10 polytechnics in Ghana administered under the National Commission on Tertiary Education (NCTE) and the National Board for Professional and Technician Exam-ination (*NABPTEX*); these are Accra, Bolgatanga, Cape Coast, Ho, Koforidua, Kumasi, Sunyani, Takoradi, Tamale and Wa Polytec-hnics.

Polytechnic Reform

Polytechnics in Ghana are institu-tions that provide tertiary level education in applied sciences, applied arts and engineering. According to Mentz, Kotzé and Van der Merwe (2008), a polytechnic degree gives skills and know-how for the changing demands of working life. In response to a Ghana Government mandate to develop comprehensive vocational and technical education and training, stakeholders in polytechnic

education have questioned measures being put in by the polytechnics to ensure that existing human and material resources commensurate their new status as tertiary institutions (Nsiah-Gyabaah, 2005). A number of programmes and projects have been commissioned and are still being executed in the polytechnics as means of preparing and equipping the polytechnics' human and material resource base. Notable among these are the Dutch sponsored NUFFIC/NPT 045 Project which was aimed at Building the Managerial and Leadership Capacity of Polytechnics in Ghana (Honyenuga & Kouwenhoven, 2009; Maassen & Azigwe, 2009). In addition, the government constituted the Council for Technical and Vocational Education and Training (COTVET) to regulate and give direction for effective management and development of competency-based curricula for polytechnics and technical institutions. In spite of the structures, policies and projects in place, polytechnic education in Ghana has suffered major setbacks which could be linked to factors such as (1) weak linkages with industry in terms of curriculum development which have further led to a mismatch of supply and demand skills (Owusu-Agyeman & Van den Oosterkamp, 2009). Furthermore (2) as at the year 2006, the existing polytechnic curricula did not meet the United Nations Educational Scientific and

Cultural Organisation (UNESCO), and International Labour Organisation (ILO) criteria of providing scientific knowledge, technician versatility and a cluster of core competencies and generic skills required for rapid adaptation to new ideas and procedures for study career development (Effah, 2006). Thus, although the original curricula of the polytechnics have been designed to cater for the needs of industries, there is the need for continuous update and evaluation of content to meet the challenges of industrial growth and expansion, current labour market policies and national policies.

Challenges in Capacity Building for Polytechnic Teachers in Curriculum Reform

Teachers are the key players during curriculum reform in the polytechnics with regard to upgrading of HND programmes and designing Bachelor of Technology programmes. One of the major internal challenges faced by the polytechnics in meeting demands of relevant curriculum and quality teaching and learning was the need for a knowledge and skill update of teachers who had been caught up in institutional revival since curriculum design became their responsibility (Gervedink Nijhuis, Bakah, & Akomaning, 2009; Nsiah-Gyabaah, 2005; Nsiah-Gyabaah & Ankomah, 2009). Even though arrangements were in place for teachers' further

academic studies in terms of acquisition of master's and PhD degrees by academic staff, these were dependent on funding from government and donor agencies which were not readily available (Gervedink Nijhuis et al., 2009). Even if scholarship was available, it was only accessible by few people who took years to complete their studies and return to post. Studies have shown that the polytechnics' teachers need to improve their knowledge and skills as they continue to practice their career (Gervedink Nijhuis et al., 2009; Nsiah-Gyabaah, 2005) and get involved in the design of HND and B. Tech curriculum (Owusu-Agyeman & Van den Oosterkamp, 2009). The success of curriculum reforms, like the ones indicated here in the polytechnics, is dependent on teachers' knowledge and skills to facilitate their participation in the reform which is critical as content, instruction and curriculum development largely falls within their control (Borko, 2004; Fullan, 2007; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). The delivery of quality technical and vocational education is dependent on the competence of the teacher, a competence measured in terms of theoretical knowledge, technical and pedagogical skills as well as being abreast with new technologies in the workplace. Enhancement of the abilities of polytechnic teachers is also a major step in improving the quality of teaching and preparing polytechnic graduates to contribute meaningfully to national development. Ladd and Fiske (2008) contend that quality professional development programmes improve the quality of the existing teaching population. In addition, studies have found that professional development can improve teacher quality by changing teacher practices (Wenglinski, 2002). This study therefore aims to explore the factors available and inherent opportunities available in a team-based approach to curriculum design and implementation for teacher collaboration and professional development in Ghana's polytechnics.

Teacher Professional Development and Educational Reform
Since the late 1960s, theory and research on organizations have emphasized learning as a crucial factor in productivity and change (Argyris & Schon, 1978). Learning has been associated with effective planning, problem-solving, and experimentation (Weisbord, 1989). Similarly, teacher learning has become more pronounced in the education literature and associated with the implementation of planned change (Fullan, 2007). Arguments abound that changes in the nature of teachers' work, subject matter and student populations challenge prevailing beliefs and practices and require on-going development of

knowledge and skills (Hiebert, Gallimore. Stigler, & Smylie, 2002). The key to better education practices and desired educational outcomes is to have a motivated and superior teaching workforce. Without the teacher's know-how, educational change efforts really suffer (Van Driel, Beijaard, & Verloop, 2001).

It is necessary to continually engage teachers in the process of learning to become effective. 'Professional development is described as those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students' (Guskey, 2000, p. 16). Ingvarson, Meiers and Beavis (2005) stated that professional development of teachers is now recognised as a vital component of policies to enhance the quality of teaching and learning in educational institutions. Continued professional growth of teachers is widely accepted as an essential ingredient to any educational reform (Fullan, 2007). The case of Ghana's polytechnics is crucial in the wake of reforms in the provision of relevant higher technical and vocational education. There is broad consensus among teacher learning researchers that "reform oriented" professional development tends to be more effective than "traditional" course based profess-ional development (Loucks-Horsley, Hewson, Love, & Stiles, 1998;

Penuel et al., 2007; Putnam & Borko, 2000). Evidence from a wide range of studies of schools engaged in reform suggests that those that make extensive use of teacher collaboration are particularly successful in promoting implementation, in part because reforms have more authority when they are embraced by peers (Bryk & Schneider, 2002). Quality professional development for teachers has never been more important than it is today as the challenges they face intensify and the expectations for quality education increase.

The learning of teachers is intertwined with their on-going practice, making it likely that what they learn will indeed influence and support their teaching practice in meaningful ways (Correnti, 2007; Putnam & Borko, 2000). Desimone, Porter, Garet, Yoon and Birman (2002) indicate that given the size of investment in professional develop-ment, and the dependence of education reform on providing effective professional development, the knowledge base on what works must be strengthened. Thus, unders-tanding what makes professional development effective is critical to understanding the success or failure of many education reforms.

Teacher Collaboration in Curricular Reform

Insights from reform literature also support teacher collaboration in teams as a fruitful means for educational reform. Recent literature maintains that teacher collaboration in the form of, for example, 'professional learning communities' is a central element in achieving sustainable school reform (e.g. Hord, 2004; Lieberman & Miller, 2004; McLaughlin & Talbert, 2001; McLaughlin & Talbert, 2006). In fact, one of the problems of school reform is that most teachers teach alone in isolated classes without having (or taking) the opportunity to reflect together on their teaching practices, to introduce new perspectives, to discuss new ideas, to give each other feedback on improvement efforts, and to jointly develop new initiatives. Schools that aim at innovation need thus to organize teacher collaboration centred on the teaching practice (Little 1990).

Collaboration between teachers is expected to have an impact on practice. There is considerable research showing that collaborative teacher teams are beneficial for student learning, which is the bottom line of educational quality (McLaughlin & Talbert, 2006). Collaborative teams have the most impact on student achievement when the focus of the work shows a persistent link to student learning and the initiatives taken are directly related to curriculum and instruction (Sackney, Mitchell & Walker, 2005; Vescio, Ross & Adams, 2008). Grossman et al. (2001) suggest that teachers need common curriculum experience in their collaboration (either by teaching together or observing each other teaching) in order to achieve effective collaboration that influences students achievements.

Teachers' participation in development processes and in implementing the curricular products in practice can also be beneficial for teacher learning. When designing their future practice, teachers build on their current practice and adapt it in relation to their needs and wishes Handelzalts (2009). By piloting the design product and by reflecting on the experiences and results, teachers can become aware of the specific potentials and problems of the reform. Based on such systematic reflections, they will gain new insights for the design. This can lead to yet another cycle of design, evaluation, and reflection. This learning process is an important part of the curriculum reform and development process, because in many curriculum changes a shift in teacher beliefs, roles, and methods is essential (Fullan, 2001). Adding these arguments to the strength of the curriculum perspective in the school reform discussed in the previous

section, leads to a strong argument to concentrate teacher collaboration in schools on curriculum planning.

Collaborative Curriculum Design and Teacher Development

Collaborative curriculum design is gradually advancing in education as a means to create teacher ownership during curriculum innovation (Borko, 2004; Villegas-Reimers, 2003). Collaborative curriculum design processes have the potential to contribute to the professional development of the teachers involved as well (Borko, 2004; Deketelaere & Kelchterman, 1996; Jarvis, Holford & Griffin, 2003; Penuel et al., 2007). There is a growing consensus that professional development yields the best results when it is long-term, school-based, collaborative, focused on students' learning and linked to curricula (Darling-Hammond & Sykes, 1999; Garet, Porter, Desimone. Birman, & Yoon, 2001; Loucks-Horsley et al., 1998). Penuel, et al. (2007) reported from a large-scale survey that professional development which is specific and linked to the curriculum, influenced teachers' knowledge and practice and impacted implementation of curriculum reform.

In this study, collaborative curriculum design was assumed to be necessary for polytechnic teachers to update their syllabuses due to curriculum reform. Collaboration in

design teams, according to Handelzalts (2009) and Simmie (2007) contribute to enhanced teacher knowledge, skills and practices. The construct of "collective participation" in Garet et al.'s (2001) study refers to professional development in which teachers participate alongside colleagues from their school and district. Supporting the notion that this would be an effective strategy for teacher learning, a large body of theory and research is focused on the importance of teachers' professional teams (Desimone, 2002), and recently acknowledged by Desimone (2011). Others have proposed that efforts to improve teaching quality through collaboration build relational trust in a school building (Penuel et al., 2007). Such trust allows leaders and teachers more latitude and discretion in making difficult decisions, creates clearer understandings of role obligations, and sustains commitment to improving student outcomes (Frank, Zhao, & Borman, 2004, Penuel et al., 2007). Interactions among teachers constitute a resource to teachers in support of their implementation of reforms, which can be considered a form of social capital (Penuel, Frank, & Krause, 2006).

Educational reform processes focused on curriculum as a main driver of change in a school-wide context in which a large group of

teachers is actively involved seems to be the advisable move forward. Although these kinds of integral activities already take place in some schools on various levels, it is far from being a common phenomenon and only a few schools have experience with it (Handelzalts, 2009). In view of its promise and growing popularity, the team-based approach in the polytechnic curriculum reform practice forms the context in which this study has been conducted. The main question that guided the conduct of the entire study was: *What is the impact of collaborative curriculum design on teacher professional development and curriculum reform practices?*

Methodology
This study was designed to investigate teacher collaborative curriculum design in design teams and how it affects teacher profes-sional development and classroom practices as the polytechnics under-went curriculum innovation and progress in their evolution as tertiary institutions. Teachers' collaborative course update was facilitated through design teams during which they were supported through industry visits to strengthen their knowledge-base for effective contribution to a relevant curriculum. The study therefore focused on investigating teacher professional development during the collaborative course design process with the use of the multiple case

research method (Yin, 2003). Quantitative and qualitative data were collected during the study. Quantitative data was mainly composed of questionnaires with five point Likert scales for both teachers and their students. Qualitative data sources were structured and semi-structured interview guides (teachers and leadership), teacher-written reports and researcher logbook. The variety of data sources used in the study guaranteed *triangulation* to increase the quality of data. The collaborative curriculum design took place within the context of the polytechnics. The focus of collaborative curriculum design was on the design teams, visiting industries, redesigning common curriculum and teaching try-out of updated courses. During the entire study, six design teams were followed in two polytechnics. The results were analyzed on team and across team level within each polytechnic and finally on individual level, assessing personal teacher learning encounters and comparing individual profess-ional growth.

Teachers' questionnaire responses were analyzed using PASW Statistics to compute the means and standard deviations. Analysis of comparison of teachers' perceptions of design teams before and after the professional development programme employed the Wilcoxon non-parametric test (Corder & Foreman, 2009) on

assumption that the population cannot be assumed to be normally distributed. Effect size was calculated using Cohen's *d* (Cohen, 1988). Means and standard deviations were calculated for students' responses in their questionnaire. An independent sample T-test was computed to find out whether significant differences existed regarding the experiences of participants and non-participants in the teaching try-out. A one-way ANOVA test was conducted to evaluate the extent to which differences exist between the participants (Automobile, Production and Electrical HND students) perceptions of the lesson they had.

There were five categories of semi-structured interview data collected from each teacher to find out their experiences during the following design team activities: industry visits, course update, teaching try-outs, perceptions of design teams and teacher learning in design team. On average, each interview lasted 45 minutes and was audio taped. All interviews were transcribed and coded using codes generated from the study. The coding schemes (Bogdan & Biklen, 1992; Miles & Huberman, 1994) were labelled: *industrial attachment evaluation, course update evaluation, teaching try-out appraisal, perceptions of design teams and teacher learning in design teams.* Atlas-ti software version 6.2 was used for the coding of all the

interview data. Information recorded in the logbook was analysed qualitatively using data reduction technique. Major themes were identified and clustered (Miles & Huberman, 1994).

Findings
In this study teachers' professional development was supported during collaborative design of their courses in a curriculum reform context in polytechnics in Ghana. Teachers in the mechanical and electrical departments of the engineering faculty in two polytechnics received support through design team introductory workshops, teamwork in design team and industry visitations. The professional development of teachers took place in several forms during the collaborative course design process facilitated through design teams. Outcomes in this dissertation have shown that collaborative curriculum design in design teams did not only improve the relevance and quality of curriculum but was a valuable means of teacher professional development and had positive impact on their teaching.

During collaborative curriculum design, teachers' improved their knowledge-base when they visited industrial settings to obtain information on current technological advancements in industrial operations, machines and equipment. The teachers conducted teaching try-outs

of the updated courses which were subsequently evaluated by their students. Findings were that teachers successfully redesigned their courses in design teams which impacted positively on their knowledge and classroom practices. They acquired subject matter knowledge and skills, curriculum design skills and collaborated effectively to enhance subject matter dialogue and interaction. *Furthermore, design teams enabled active learning and dialogue on subject matter among teachers and were a useful means for the professional development process.* Collaborative curriculum design *enabled individuals' active learning as follows.*

Domain Knowledge
Teachers acquired subject matter knowledge during collaborative curriculum design activities in design teams. They discovered central concepts, facts and principles relating to their courses. Teachers had a broader and deeper understanding of certain topics in the courses they teach. Due to the importance of practical lessons teachers teach, they learnt about tools, the functioning of some equipment, the maintenance procedure for certain machines and certain production processes. (1) Teachers developed their know-ledge further through interacting with colleagues on subject matter. Both experienced and less experienced teachers within the teams learned

from each other's contributions on subject matter. (2) Delving into the syllabus to identify need areas for update and the process of reshaping content were learning grounds for teachers as they immersed themselves in their domains to ensure curriculum quality. (3) Teachers learned as individuals since they personally discovered certain information, knowledge and skills from others; (4) For the group, interactions on team assignments were pervasive. They also viewed their learning as a collective venture due to the continual interactions for a relevant curriculum. (5) In addition, teachers' industry visits strengthened their knowledge-base for effective contribution to a relevant curriculum. They discovered relevant knowledge at the industries concerning contemporary industrial operations, services and servicing, machines and equipment as well as procedures in production. This direct contact and interaction at the industries constituted firsthand knowledge acquisition in subject matter domains and was useful and handy for teacher professional development, course update and teaching. Apart from getting to know about relevant industrial trends, teachers individually handled equipment in brief training sessions to improve their hands-on experience. The personal handling of equipment through training at the industry boosted the practical skills of teachers and was a

relevant experience for their practical lessons in particular. In effect, teachers acquired domain knowledge during collaborative curriculum design of the syllabus in this study.

Curriculum Design Knowledge

During collaborative curriculum design, teachers shared experiences and learned from each other since the target for them was mutual growth and attainment of shared instructional and curricular goals. Their participation in curriculum design activities increased knowledge in curriculum design and content. They became more familiar with the structure of the syllabuses and stated objectives. Additionally, teachers' reflections on subject matter, delivery and outcomes in the teams enhanced interaction and knowledge sharing. (2) Involvement in collaborative curriculum design granted teachers the opportunity to reflect on realistic challenges they encountered with their courses both in theory and practical lessons. The examination of course structure and its update impacted positively on teachers' skills and competence for course redesign and teaching. Analysing the course structure, incorporating competencies that students need to possess, balancing technical and industry-specific skills and bridging the gap between the syllabus and industry competency standards were among the concrete practical tasks and learning experiences for teachers. (3) Through collaborative curriculum design, teachers learned to bridge the gap between the syllabus and industry competency standards, and they designed situational learning experiences based on the understanding of workplace contexts and changes. They embarked on their design tasks which called for documenting their newly acquired knowledge from industry for curriculum design purposes, a process which had phenomenal effects on their knowledge through the intensive brain work to restructure their syllabuses to reflect current needs of industries. (4) Teachers received pedagogical support from the team for the teaching of updated courses after the course redesign. Discussions on delivery were useful since teachers needed pedagogical support to present certain fresh industry information to students. (5) The teaching try-outs were based on the updated courses and were also a learning ground for teachers and enabled them to practice what they had learned from the industries. Teachers therefore gained knowledge in curriculum design during the collaborative curriculum design process in this study.

Knowledge through Collaboration

Teachers acquired knowledge through interacting with each other during collaborative curriculum design in design teams to improve their instruction. (1) Collaboration

among teachers in design teams enhanced their knowledge in content and curriculum design. It opened up the opportunity for dialogue on their subject matter, discussions on what should be taught, and brainstorming on relevant information from industry and brought teachers with varied experiences and ages to a level of thinking and cohesion. Their collaboration enabled them to converse knowledgably about the curriculum to achieve the objectives of the programmes. (2) Collaboration thus enabled teacher interdependency and interaction. Their participation in design teams for course design improved collaboration making them discover how to share knowledge and ideas, to communicate with others, be resourceful, broadminded and tolerant as well as to learn how to find information on subject matter. (3) There were consequences of design teams during the design process such as tolerance of diverse characters and behaviours, seeking ideas from colleagues, unearthing of research ideas, learning to communicate with others, uniting with others to achieve set targets and being open to criticisms. In this study therefore, teachers' collaboration in design teams during collaborative curriculum design resulted in knowledge acquired in diverse ways on content, designing the curriculum and teaching.

Usefulness of Design Teams

The foray into design teams helped to understand how teachers negotiated their environments in relation to their own learning. The design team concept in this study aimed at providing an environment for teachers to engage in collaborative curriculum design, and where teacher professional development can take place. (1) Teachers benefited from collaboration in design teams as it stimulated their learning from one another and from group initiatives. Individuals had the opportunity to expand their experiences; therefore teacher collaboration in design teams was particularly successful in promoting teacher learning. (2) Teacher learning and professional development was impressive during collaborative curriculum design in design teams. The approach changed teacher practices and beliefs with regard to improving their knowledge and skills and had important implications for teacher professional development in higher education. (3) Groups of teachers meeting to share and work together provided an opportunity to extend their profess-ional boundaries which they found very interesting. Their professional activities which included curriculum design embedded individuals' learning in the social environment of the design teams. (4) It became evident that in professional development, it is worthwhile to engage teachers in teamwork to

rigorously plan and implement their own learning and deliberate on the curriculum. Findings from this study provided evidence that design team approach in collaborative curriculum design can foster teacher professional development and collaboration. The study provided new insights for professional development activities which employ teamwork for teacher learning and change. Design teams in this intervention clearly appeared to be a worthwhile approach to team-work among polytechnic teachers for them to update their knowledge and skills, update their courses and improve teaching. It becomes evident from the implications of this study that it is useful to connect teachers through teamwork and allow their reflections on current practices and promote creativity. Given promising findings, it is worthwhile considering the application of this study in other polytechnics in Ghana and in sub-Saharan African due to its far reaching implications.

Conclusions

This research afforded teachers in Ghana's polytechnics the dual opportunity to improve their knowledge and skills in design teams and collaboratively design their courses in light of current technological advancements at the industrial sector. Design teams were not only helpful for updating teachers' knowledge and skills in their respective subject areas but also

offered them the opportunity to strengthen their curriculum design skills and improve collaboration among them. The already existing curricular reform situation in the polytechnics offered fertile grounds for collaborative design. Furthermore this research enhanced teacher professionalism and knowledge as polytechnics embark on boosting teachers' professional development to commensurate polytechnic academic standing in a curriculum reform situation. The teachers displayed significant joint work and used concrete and current information for their course update. *Coordination and* feedback from the researcher has effectively encouraged teachers to keep working in teams. It will be worthwhile to identify how learning processes are encouraged and knowledge is constructed in design teams.

References

Aidoo-Taylor, N. (2009). Developing advanced technical and vocat-ional skills through polytechnic education: Historical perspec-tives. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in Polytechnic Education in Ghana* (pp. 39–50). Amsterdam: Vrije Universiteit.

Argyris, C., & Schon, D. A. (1978). *Organizational learning*. San Francisco: Jossey-Bass.

Bogdan, R., & Biklen, R. C. (1992). *Qualitative research for education: An introduction to theory and methods.* Boston: Allyn–Bacon.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15.

Bryk, A. S., & Schneider, B. (2002). *Trust in schools: A core resource for improvement.* New York: Russell Sage.

Clandinin, D. J., & Connelly, F. M. (1990). Narrative, experience and the study of curriculum.
  Cambridge journal of education, 20(3), 241-253.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Corder, G. W., & Foreman, D. I. (2009). *Nonparametric statistics for non-statisticians: A step-by-step approach.* New Jersey: Wiley.

Correnti, R. (2007). An empirical investigation of professional development effects on literacy instruction using daily logs. *Educational Evaluation and Policy Analysis, 29(4), 262–295.*

Darling-Hammond, L., & Sykes, G. (1999). *Teaching as the learning profession.* San Francisco: Jossey-Bass.

Deketelaere, A., & Kelchtermans, G. (1996). Collaborative curriculum development: An encounter of different professional knowledge systems. *Teachers and Teaching: Theory and Practice, 2*(1), 71–85.

Desimone, L. M. (2002). How can comprehensive school models be successfully implemented? *Review of Educational Research, 72(3),* 433-479.

Desimone, L. M. (2011). R&D: A primer on effective professional development. *Phi Delta Kappan, 92*(6), 68-71.

Desimone, L., Porter, A., Garet, M., Yoon, K. S., & Birman B. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81–112.

Effah, P. (2006). *A decade of polytechnic education in Ghana: An assessment of achievements and failures.* Report submitted to National Council for Tertiary Education, Ghana.

Frank, K. A., Zhao, Y., & Borman, K. (2004). Social capital and the diffusion of innovations within organizations: Application to the implementation of computer technology in schools. *Sociology of Education, 77*(2), 148–171.

Fullan, M. G. (2001). *The new meaning of educational change* (3rd ed.). New York: Teachers College Press.

Fullan, M. (2007). *The new meaning of educational change.* New York: Teachers College Press.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

Gervedink Nijhuis, C., Bakah, M. A. B., & Akomaning, E. (2009). Leadership challenges involved in managing institutional and curriculum changes in polytechnics. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in polytechnic education in Ghana* (pp. 85–100). Amsterdam: Vrije Universiteit.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record, 103*(6), 942–1012.

Guskey, T. R. (2000). *Evaluating teacher professional development.* California: Sage Publications.

Handelzalts, A. (2009). *Collaborative curriculum development in teacher design teams.* Enschede: University of Twente.

Hargreaves, A., & Fink, D. (2000). The three dimensions of reform. *Educational Leadership, 57*(7), 30–34.

Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one. *Educational Researcher, 31*(5) 3–15.

Honyenuga, B., & Kouwenhoven, W. (2009). Reflections on the NPT project on building leadership and management capacity in Polytechnics. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in polytechnic education in Ghana* (pp. 5–19). Amsterdam: Vrije Universiteit.

Hopkins, D. (2001). *School improvement for real: Educational improvement for real.* London: Routledge Falmer.

Hord, S. (2004). *Learning together, leading together. Changing schools through professional learning communities.* New York: Teachers College Press.

Ingvarson, L., Meiers, M., & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes and efficacy. *Education Policy Analysis Archives, 13*(10), 1–28.

Jarvis, P., Holford, J., & Griffin, C. (2003). *The theory and practice of learning* (2nd ed.). London & New York: Routledge Falmer.

Ladd, H., & Fiske, E. B. (2008). *Handbook of research in education finance and policy.*

New York & London: Routledge Taylor & Francis Group.

Lieberman, A., & Miller, L. (2005). Teachers as leaders. *The Educational Forum, 153* (69) 151–262.

Little, J. W. (1990). The persistence of privacy: Autonomy and initiative in teachers' professional relations. *Teachers College record, 91*(4), 509-536.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Maassen, E. P. H. M., & Azigwe, J. B. (2009). Building managerial and leadership capacity in polytechnics in Ghana: Conclusions and reflections. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in polytechnic education in Ghana* (pp. 67–84). Amsterdam: Vrije Universiteit.

McLaughlin, M. W., & Mitra, D. (2001). Theory-based change and change-based theory: Going deeper and going broader. *Journal of Educational Change, 2*(4), 301–323.

Miles, M. B., & Huberman, A. M. (1994). *An expanded source book: Qualitative data analysis* (2nd ed.). London: Sage Publications.

Nsiah-Gyabaah, K. (2005, May). *Polytechnic education in Ghana: The past, the present and the future.* Paper presented at the Kick-off Conference: NPT/UCC Project on Building Management and Leadership Capacity in Polytechnics.

Nsiah-Gyabaah, K., & Ankomah, Y. A. (2009). The role of research and development in polytechnic education in Ghana. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in polytechnic education in Ghana* (pp. 115–128). Amsterdam: Vrije Universiteit.

Owusu-Agyeman, Y., & Van den Oosterkamp, M. (2009). Challenges facing polytechnic education in Ghana: Anatomy of public perspectives. In W. Kouwenhoven, G. Oduro, & K. Nsiah-Gyabaah (Eds.), *Trends in polytechnic education in Ghana* (pp. 51– 66). Amsterdam: Vrije Universiteit.

Penuel, W. R., Frank, K. A., & Krause, A. (2006). The distribution of resources and expertise and the implementation of schoolwide reform initiatives. In S. A. Barab, K. E. Hay, & D. T. Hickey (Eds.), *Proceedings of the 7th International Conference of the Learning Sciences* (pp. 522–528). Mahwah, NJ: Lawrence Erlbaum.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes

professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44(4), 921–958.*

Putnam, R., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4–15.

Sackney, L., Mitchell, C., & Walker, K. (2005). *Building capacity for learning communities: A case study of fifteen successful schools.* Paper presented at the American Eduational Research Association annual meeting.

Simmie, G. M. (2007). Teacher design teams (TDTs) – building capacity for innovation, learning and curriculum implementation in the continuing professional development of in-career teachers. *Irish Educational Studies, 26*(2), 163–176.

Skilbeck, M. (1998). School based curriculum development. In A. Hargreaves, A. Lieberman, M. G. Fullan, & D. Hopkins (Eds.), *International handbook of educational change* (pp. 121-144). Dordrecht: Kluwer Academic Publishers.

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching 38*(2) 137-158.

Villegas-Reimers, E. (2003). *Teacher professional development. An international review of the literature.* Paris: IIEP-UNESCO.

Weisbord, M. R. (1989). *Productive workplaces.* San Francisco: Jossey-Bass.

Wenglinsky, W. (2002). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis, 10*(12), 1–30.

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education, 24*(1), 80-91.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.