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RESEARCH ARTICLE

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The effects of comprehensive competence-based training on competence development and performance improvement of smallholder farmers: An Ethiopian case study

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Abstract

Low yield/hectare gains, food insecurity and environmental unsustainability are challenges experienced by the agriculture sector in Ethiopia despite substantial government investment. Although there are many factors that contribute to the poor performance of the sector, smallholder farmer competence gaps are principal among them. This study aims to examine the effects of Comprehensive Competence-Based Training (CCBT) on the competence development and performance improvement of smallholder farmers using the authentic professional core task during maize planting as a problem context. We applied a 3-week randomized (control group pretest posttest) design and single-blind field experiment to test the impact of CCBT through provision of a training to two comparable farmer groups using conventional 'Low-CBT' and innovative 'High-CBT' implementation levels. The samples included 'High-CBT' ($N = 220$) and 'Low-CBT' ($N = 220$) groups of smallholder farmers in the West Gojjam Zone in

Ethiopia. Data on competence development and performance improvement of farmers were collected from themselves, trainer Development Agents and Trained Assessors. The yield in quintal/hectare gains for each smallholder farmer was collected twice (before and after the intervention). Repeated (pretest, posttest) MANOVA and ANOVA measurements were used to analyze the data. The results revealed that the development of smallholder farmer competence in 'High-CBT' was higher than in 'Low-CBT' training. Comparisons of performance in both the authentic job situation and in terms of yield in quintal/hectare gains in the two groups revealed a better performance of both groups. However, the 'High-CBT' group performed better than the 'Low-CBT' group in both the authentic job situation and in terms of yield in quintal/hectare gains. We obtained 31 and 41 quintal/hectares of maize for the 'Low-CBT' and 'High-CBT' groups, respectively, which are better than the baseline average 22 quintal/hectare for both groups. These findings underscore the relevance of CCBT, especially when the design principles of CBE are integrated well in the training programme (which was called 'High-CBT level'), for improving performance, in this case gain in yield per hectare of smallholder farmers, which potentially results in the increase of household food security.

INTRODUCTION

Agriculture is the principal sector for the well-being of smallholder farmers in Ethiopia. Currently, this sector is challenged by impacts of climate change, population pressure, land shortages, declining average farm sizes and soil degradation (De Pinto et al., 2016; Graeub et al., 2016; Herrero et al., 2017; Lowder et al., 2016; Turner et al., 2016) which again exacerbate poverty, food and nutrition insecurity. To react to these emerging forces, strengthening the capacity of the extension system and developing a policy environment that supports it is significant (Davis et al., 2020). More attention should be given to agricultural policy and research so as to improve the agricultural productivity of smallholder farmers in low-income countries (Pinstrup-Andersen & Pandya-Lorch, 1997; Deneke & Gulti, 2016; Belay & Dawit, 2016). There is also a great deal of expectation from the agriculture sector that the sector will contribute to multiple development objectives which include gender equality (Anderson & Sriram, 2019), health and nutrition (Byerlee & Fanzo, 2019), poverty reduction

(Christiaensen & Martin, 2018) and environmental sustainability (Hansen et al., 2019). The sector is expected to help achieve the objectives that are declared in several of the Sustainable Development Goals of the United Nations 2030 Agenda for Sustainable Development.

However, achieving such objectives depends on transforming agricultural extension and advisory services with new training approaches that can provide smallholder farmers with high-quality information and knowledge sharing and competence development related to farm productivity (Davis et al., 2020) and environmental sustainability (Hansen et al., 2019). In the Ethiopian context, agricultural policies are formulated and research activities are implemented with the objectives of increasing productivity (yield/hectare gains) and environmental sustainability, thereby ensuring food security for smallholder farmers. The formulation of Growth and Transformation Plan-I (FDRE, 2010) aimed to reach 14.6 million beneficiaries by 2014/2015 (GTP-I, 2010/11–2014/15), while Growth and Transformation Plan-II (FDRE, 2016) was designed to reach beneficiaries to 18.237 million by 2019/2020 (GTP-II, 2015/16–2019/2020). However, smallholder farmer productivity is still low (Deneke & Gulti, 2016; Kassie et al., 2018), and the extension system is not oriented toward sustainability (Ministry of Agriculture and Natural Resources MoANR, 2017). Increasingly, unsustainable use of natural resources prevails in current agriculture practice (FAO, 2018). One of the factors for low agricultural productivity and environmental unsustainability is attributed to the limited capacity of smallholder farmers, which affects their job performance and yields/hectare gains. In other words, the competence gaps of smallholder farmers have impacted their application of labour (performance) per unit area and thus have affected yield gains (cf. Paul & wa Gīthīnji, 2018).

Specific competencies such as sustainability (Demssie et al., 2020), entrepreneurialism (Lans et al., 2010), problem solving and communication skills (Davis et al., 2010), ICT skill (Birke et al., 2019); skills relating to reviewing the quality of information (Spurk et al., 2019), decision-making skills (Dessart et al., 2019) and building engaged relationships (Mansfield, 1996; O'Reilly & Cunningham, 2017), among others, are not possessed by smallholder farmers. Generally, they are accustomed to receiving training with the proper focus on the technical aspects of extension (Davis et al., 2010; Ragasa et al., 2016). The current state of extension training in Ethiopia does not adequately address the diversity of skills, knowledge and attitudes needed for the role which smallholder farmers play (cf. Landini et al., 2017; Ragasa et al., 2016). However, recent research findings emphasize the importance of integrating knowledge, skills and attitude components in extension training (Landini & Brites, 2018; Tarekegne et al., 2017). This emphasis has strengthened the necessity of applying Comprehensive Competence-Based Training (CCBT) that consists of *cognitive, functional, social* and *meta-competence* domains (Le Deist & Winterton, 2005; Winterton, 2009) in extension. The importance of CCBT is supported by previous studies (Misbah et al., 2018) and is found valuable to the Ethiopian context to reform the extension training services, which are largely limited to rendering limited technical skills to farmers (Davis et al., 2010, 2020) as well as to theoretical rather than hands-on practical activities (Deneke & Gulti, 2016; Tarekegne et al., 2022).

The present experiment, therefore, focuses on testing the impact of integrating knowledge, skills and attitudes on the competence development and performance improvement of smallholder farmers in an authentic job situation (during maize planting) and in terms of yield in quintal/hectare gains using the CCBT model (Sturing et al., 2011; Wesselink, 2010). The competences that are related to understanding agro-ecological farming practices, extension management, programme planning and objective preparation, communication, relation-building and ethics took a central position in the training which belonged to all domains (*cognitive, functional, social* and *meta-competence*) (also, *refer to Competence-based training in extension below*). Although

smallholder farmers may have multiple priorities (Isakson, 2009), in this experimental study, conventional 'Low-CBT/L-CBT' and innovative 'High-CBT/H-CBT' levels of CCBT model were compared to assess the competence development of smallholder farmers, their performances during maize planting and yield in quintal/hectare gains.

THEORETICAL FRAMEWORK

Theoretical perspectives on agricultural innovation have broadened over time (Klerkx et al., 2012). The transfer of technology, which is recognized as the diffusion of innovation, is the first perspective (Rogers, 1995). From this perspective, extension is seen as the transfer and dissemination of ready-made knowledge from research to farmers. However, this kind of top–down approach has been criticized for: (i) excluding client farmers and their socio-cultural history and economic interests in the innovation process (Agwu et al., 2008); (ii) paying little attention to farmers who are resource poor and (iii) absence of meaningful dialogue and knowledge sharing among researchers, extension workers, farmers and stakeholders (Moschitz et al., 2015; Röling, 2009). The second perspective in extension theory is the transfer of technology in a two-communication mode (Pretty & Chambers, 1993). In this view, farmers are seen as sources of information and technology design, and knowledge is created in cooperation with farmers and transferred to them. This view also perceives the agro-ecological and farm economic context in an integrated way, to achieve the intended outcome of the fit of the farming system (Klerkx et al., 2012). The third perspective in extension theory is agricultural knowledge and information systems-AKIS (Klerkx et al., 2012). In this view, farmers are supposed to contribute their indigenous knowledge and play the role of experimenter, which is mainly characterized by participatory research and extension, joint production of knowledge and technology, demand-pull from farmers and interdisciplinary research by sociologists and farming experts. However, the second and third perspectives of extension are criticized for having a particular focus on the knowledge system in the public sector and lack of considering the diversity of actors in the agriculture sector, including that of the private sector (Hall et al., 2007). The fourth stage in extension theory is the Agricultural Innovation Systems-AIS (Klerkx et al., 2012) perspective. At this stage, farmers are supposed to play entrepreneur, innovator and partner roles, and institutional change is considered very significant for innovation. This theoretical perspective is characterized by a trans-disciplinary, holistic systems perspective and multiple-actor involvement, with the intended outcomes of capacities to innovate, learn and change. To solve farmer problems through the improvement of successful innovation, this view includes the existence of shared vision, coordinated links, information flows among various actors, incentive mechanisms, sufficient market opportunities, legislative and policy environments and well-developed human capital (Spielman et al., 2008). The importance of the AIS perspective has received substantial recognition (Schut et al., 2015). However, the fundamental question raised in relation to this perspective is about *how to operationalize* and *embed* it in different contexts (Kamara et al., 2020) which resulted in limited use of it in developing countries and widespread use of the linear model, despite its potential advantages (Klerkx et al., 2012). To provide support for trainee farmers and make them competent farmer professionals, learning in the school (farmer training centres, i.e., FTCs) and learning in authentic job situations (during maize planting) should be realized. This notion is further strengthened by the connectivity theory (Griffiths & Guile, 2003; Mulder, 2017a;

Wesselink et al., 2017). Therefore, to be able to connect learning in the FTCs with authentic job maize planting, CCBT in extension is proposed.

Competence-based training in extension

There is global consensus on the importance of competence, although there is a wide range of approaches to competence-based training. For instance, some approaches tried to prioritize the theoretical and conceptual foundations of it which is related to the world of education, while some others tried to link competence to the world of work to improve practice (Winterton, 2009). Similarly, Markowitsch and Plaimauer (2009) clearly explained the future use of competence ontologies. According to them, these ontologies are relevant to bridge the gap between the world of labour market and the world of education and training and to describe learning outcomes of education and training, among others. Three dominant approaches of competence were identified by Le Deist and Winter (2005). One approach is the behavioural US tradition, stressing job-related functional skills and underpinning knowledge. A second approach is the functional UK tradition, stressing adoption of a competence-based qualifications framework which later influenced European Qualification Framework developments (Markowitsch et al., 2008). This second framework was based on occupational standards of competence, grounded in functional analysis of occupations in a variety of contexts (Mansfield & Mitchell, 1996). Usually, the occupational standard identified key roles that are broken down into competence units which are again divided into competence elements called 'competencies'. Performance criteria with indicators formed the basis of assessment for each competence element (competency). It is argued that occupational standards are strongly attached to the authentic job situation (Mansfield, 1993). The third approach is a multidimensional and holistic one, which is applied in France, Germany, Austria and the Netherlands. This typology is composed of four competence domains that are necessary for a particular occupation (Le Deist & Minterton, 2005, p. 39): (a) cognitive competence domain (knowledge, comprehension and understanding); (b) functional competence domain (functional skills and operational effectiveness); (c) social competence domain (interpersonal relations and communication) and (d) meta-competence domain (reflection and learning to learn). There are also differences between *competence* and *competency*. Based on previous scientific reviews, a linguistic analysis and within the multidimensional holistic view, Mulder (2014, p. 14) defined *competence* as 'the generic, integrated, and internalized capability to deliver sustainable effective performance in a certain professional domain, job, role, organizational context, and task situation' and *competency* as 'a part of generic competence which is a coherent cluster of knowledge, skills, and attitudes which can be utilized in real performance contexts'. There are also different frameworks to assess the development of individual competencies (Dreyfus & Dreyfus, 1980; Miller, 1990; Sturing et al., 2011).

This advancement of competence-based training (Mulder, 2012; Mulder & Winteton, 2017) as a new educational innovation offers opportunities to design the agriculture extension services in a way that helps with managing the emerging challenges facing the sector. The need to introduce this method of training into the agriculture sector emanates from the importance to align the world of education (training) with the world of work and thus with different professional contexts (Mulder, 2014). There is a need to improve the connectivity between training approaches and learning in authentic job situations and to secure a balance between approaches and situations to realize successful CBT (Wesselink et al., 2017). In this study, the

multidimensional holistic competence view is used at least for four fundamental reasons: (i) it provides a chance to enhance alignment between the worlds of education (e.g., training in the FTCs) and work (e.g., during maize planting as in this study); (ii) it facilitates exploitation of the synergy between formal education and experiential learning to develop professional competence; (iii) it better reflects the unity of competence and the difficulty of separating *cognitive*, *functional, social* and *meta* dimensions in practice (Le Deist & Winterton, 2005) and (iv) it tries to distinguish between *competence* (plural: competences) and *competency* (plural: competencies) (Mulder, 2014).

Competencies should be directly derived from professional practice in relation to job-specific core tasks and should be used as a starting point for the development of the training curriculum (Biemans et al., 2004). According to the principle of 'constructive alignment' (Biggs, 1999), intended learning outcomes derived from competencies as specified by the curriculum should be aligned with teaching and learning activities and assessment tasks. However, Biggs's (1999) model is proposed to be revised for two reasons: (a) it does not elaborate on how intended learning outcomes are developed, which can be done by considering the different inputs against the educational philosophy and (b) it is deterministic which used to state the content of intended learning outcomes and assessments. However, the competence framework model involves deliberation among concerned stakeholders about the training programmes, student learning and assessing achievement. Besides, this model includes dynamic interactions or alignment between curriculum, instruction and assessment (CIA) on the one hand and the emerging state of the world of work, leading to innovation and transformation, on the other (Mulder, 2017a).

This framework acknowledges the necessity of an educational philosophy that deals with the *nature of learning* and *knowing* around which the CIA functions are organized (cf. Pellegrino, 2004; cf. Mulder, 2017a). This necessity urged experts to favour internal alignment between learning activities and assessment and linkages between curriculum and the world of work (Figure 1). The use of CBT is advocated, as it is rooted in social constructivist philosophy and according to which learners construct their own knowledge through interaction with others (Simons et al., 2000). This educational philosophy serves as a unifying paradigm so that the three functions are directed toward the same ends and reinforce each other

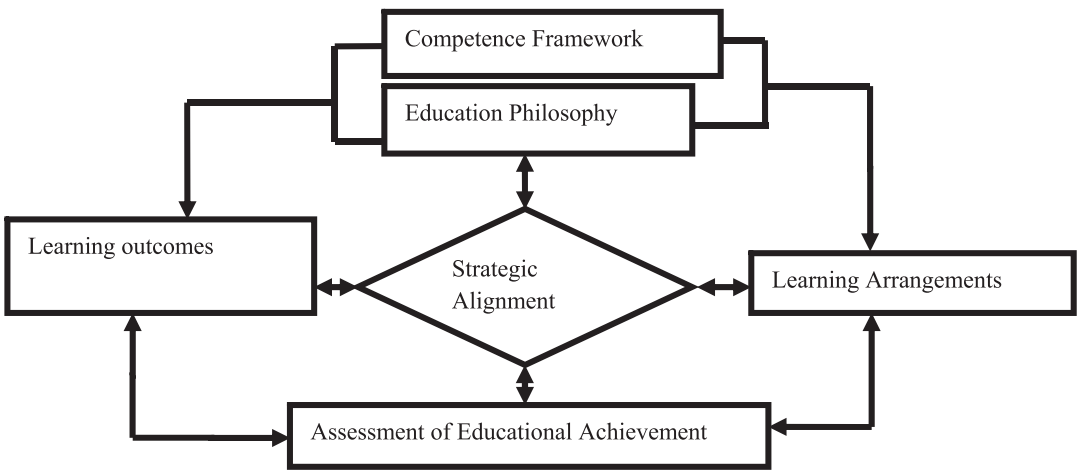

FIGURE 1 Model of strategic alignment of competence-based training components (Mulder, 2017a).

(cf. Pellegrino, 2004). According to Loyens and Gijbels (2008), characteristics of constructivist learning arrangements include knowledge construction, cooperative learning, self-regulated learning and engaging trainees in meaningful and authentic problem contexts, among others. Essentially, learning requires self-regulation and the building of conceptual structures through reflection and abstraction (Von Glasersfeld, 1995). Learning should include double-loop learning, which is an educational concept and process that involves teaching people to think more deeply about their own assumptions and beliefs through questioning the assumptions of a given objective, discovering and inventing new alternatives, objectives and perceptions and approaching problems (Argyris, 1993).

Extension training and support programmes provided by Development Agents (DAs) to smallholder farmers are expected to be based on these theoretical notions, since they have the potential to enhance alignment between the two worlds, which is, delivery of training provided in the FTCs and those provided during maize planting. However, in Ethiopia, DAs persist in delivering conventional instructional and assessment methods, and the expectation that they could bridge the differences between the two worlds is not being realized. Conventional assessment methods, although supportive, are less suitable to competence-based curricula (Biemans et al., 2009). This is because competence is inferred from observable performance outcomes on a set of tasks (Shavelson, 2013). Appropriate assessment of professional competencies should incorporate actual observation of the trainee's performance in real professional practice (Biemans et al., 2009). This assessment should correspond to what is expected from trainees in the world of work (Gulikers et al., 2004). To comply with professional requirements, there is a need to develop and apply competence-based assessments (CBA) that are performance-based and require trainees to perform professional tasks in the workplace (Gulikers et al., 2006). The quality of the assessment should also be strengthened through inclusion of key stakeholders' perspectives and qualitative arguments (Gulikers et al., 2009). Based on the insights discussed above, Mulder (2017a) revised Biggs's (1999) model within the conceptualization of the CCBT model to enhance better alignment between the worlds of training and work, as illustrated below.

CCBT is defined as a type of training that focuses on the following (a) requirements of the work field; (b) competencies as integrated knowledge, skills and attitudes and (c) stimulating competence development in trainees (Mulder, 2001). Thus, competencies are clusters of knowledge, skills and attitudes that are necessary to perform core job tasks or solve core job problems in professional practice (Mulder, 2001).

It is also known that the foundational principles of the AIS perspective are capacities to innovate, learn and change. The concept of capability in the AIS perspective is similar to the CCBT model, which stresses capability, too. Consequently, to operationalize and embed the alignment of the CBT components (Figure 1) and the AIS approach, the CCBT model (Sturing et al., 2011; Wesselink, 2010) was used to design the intervention in the present study. This model was selected for the following reasons: (a) it uses content, job and task analysis as a starting point to make decisions regarding the training curriculum; (b) it combines information from the job and task analysis with content analysis based on the current state of disciplinary knowledge (Mulder, 2012) and (c) it uses the social constructivist philosophy of teaching and learning as a unifying paradigm (cf. Simons et al., 2000). Tarekegne et al. (2017) had already developed and validated a competence profile for DAs and identified seventeen competences, followed by identification of the core job problems in the farming context (Tarekegne et al., 2021).

The core job problem during maize planting which affects yield in quintal/hectare gains was selected primarily through multistage discussions held with concerned stakeholders. The core job problem consisted of four tasks: (a) applying innovative farming methods; (b) capturing the

complex and dynamic interactions among systems and subsystems; (c) implementing nature-friendly and sustainable farming practices and (d) managing human and nonhuman resources. These tasks were composed of 14 activities (e.g., recognizing the total plant population, 72,000/hectare; operating uniform planting using proper inter and intrarow spacing, 80 × 40 cm and applying proper soil depth during maize planting, 5–7cm) among others (refer also Tarekegne et al., 2022, pp. 7–12). Seven competences which were categorized under the four competence domains: *cognitive, functional, social* and *meta* (Le Deist & Winterton, 2005; Winterton, 2009) and supposed to solve the core job problem took a central position during the intervention. As part of the design of this study, smallholder farmers followed an *innovative* 'High-CBT' and *conventional* 'Low-CBT' training approaches that were founded on the 10 CCBT principles (Sturing et al., 2011). Also, we refer to Supporting Information: A.

RESEARCH QUESTIONS

This study aimed to examine competence development and performance improvement of smallholder farmers during maize planting and in yield in quintal/hectare gains in the 'High-CBT' and 'Low-CBT' training conditions as observed by smallholder farmers' self-assessment, DAs' perceptions toward smallholders, and trained assessors' (TAs) observations of smallholder's performance during maize planting. Both conditions are compared on smallholder farmers' yield in quintal/hectare gains improvement before and after intervention. Research questions were posed as follows:

(RQ1): *To what extent does level of competentiveness of training affect competence development of smallholder farmers?*

RQ1A: *as perceived by the smallholder farmers themselves* (*auto-assessment*)*?*

RQ1B: *as perceived by DAs* (*expert assessment*)*?*

(RQ2): *To what extent does level of competentiveness of training result in actual competence gain of smallholder farmers?*

(RQ3): *To what extent does level of competentiveness of training affect performance improvement of smallholder farmers during maize planting as perceived by TAs?*

(RQ4): *To what extent does level of competentiveness of training result in productivity, that is, yield in quintal/hectare gains of the smallholder farmers?*

METHODS AND CONTEXT

Context of the study

A representative district was selected from 13 districts (*Woredas*) in the West Gojjam Zone in close consultation with experts working in the zone's Department of Agriculture. This district largely fulfills four main characteristics that are also relevant for other districts in the West Gojjam Zone: (i) it is a

dominant maize producer; (ii) it has a dense population with a shortage of arable land; (iii) it urgently needs sustainable intensification of farming and competent human resources to produce more yield in quintal/hectare and (iv) farmers largely used to receive more theoretical than hands-on practical training. The district has 21 local administrations with 26,095 rural households (Bureau of Finance and Economic Development, 2013). In this particular district, there are 21 government-financed FTCs where DAs ($N = 65$) are providing extension training, advising and support services to smallholder farmers in the local administrations, called *Kebeles*. There are two to three alternative training centres in the *subkebeles*, called 'got' in Amharic, which are constructed by the community, although they are under-resourced and poorly organized.

Participants

In this study, 65 DAs (females = 22 and males = 43) who received training in the 'Low-CBT' ($N = 32$) and 'High-CBT' ($N = 33$) levels participated. 'High-CBT' and 'Low-CBT' groups of trainee DAs were again connected to 'High-CBT' ($N = 220$) and 'Low-CBT' ($N = 220$) group of trainee smallholder farmers. A total of 440 farmers (females = 39 and males = 401) participated voluntarily. Furthermore, TAs ($N = 42$) were selected to participate from three Agricultural Technical and Vocational Education and Training (ATVET) colleges, and these TAs had different educational backgrounds, such as agriculture extension, natural resources management and crop science. DAs who participated in the provision of training to smallholder farmers earned a diploma (10 + 3) from ATVET colleges, their ages ranging from 23 to 43 years (mean age = 28.5, standard deviation [SD] = 5.51) and work experiences ranging from 2 to 18 years (mean work experience = 6.3, SD = 4.43), with 34% of them being women. Smallholder farmers (mean age = 45.34 years; SD = 8.79; average family size = 5.29; SD = 1.7; level of education (illiterate = 22%; nonformal education = 26.4%; primary (grades 1–6) = 39.3%; middle school (grades 7–8) = 8.2%; high school (grades 9–12) = 4.1% took part.

Research design

The intervention was a field experiment with *randomized pretest posttest control group design* since it maximizes internal validity (Ross & Morrison, 2004). The condition with the 'H-CBT' and 'L-CBT' levels was defined as *independent variable* and 'competence development' explained by seven competences and 'performance improvement' of smallholder farmers in (a) authentic job situations during maize planting and (b) yield in quintal/hectare gain as *dependent variables*. To compare the yield in quintal/hectare gains before and after the intervention, a baseline study was conducted for all 440 smallholder farmers. Since farmers in the study context possessed lands ranging in size from 0.25 to 1 hectare, each farmer's yield gain was converted to quintal/hectare gain in both the baseline study and after the intervention.

Procedures

(a) Identification of core problem:

The selected problem-context of farmers was low yield (Belay & Dawit, 2016; Deneke & Gulti, 2016; Kassie et al., 2018). Maximizing yield in quintal/hectare gains requires initial

performance of tasks that address interactions among water, seed and soil-related factors (Fageria, 1992). From the six job fields identified for successful smallholder farmer's performance (Tarekegne et al., 2021), the job profile for the field of during planting crop management was chosen for this study since it addresses the interactions of those factors. Multistage discussions on the job profile with key stakeholder groups led to two training components for smallholder farmers: (1) a theoretical part in the FTCs and (2) a hands-on practical part on farmers' own farm (i.e., during maize planting, as the core job problem). This core job problem consisted of four tasks. For the list of tasks and typical example of activities, please refer to Section 2.1. For successful performance of the tasks, stakeholder groups selected seven competences through multistage discussions, deliberations and judgement of their relevance to solve the particular job problem by both DAs and smallholder farmers. As stated in the introductory part of this study, these competences took a central position in the training, advisory and support services provided to smallholder farmers.

(b) Content of the training:

Key stakeholder groups and participants (see Section Participants) participated during CCBT module development, since the integrated view of competence that implies socioconstructivist processes of learning and work (Engeström, 2015), communities of practice (Wenger, 1998) and deliberative discussion as an innovative teaching strategy (Goodin & Stein, 2008) are acknowledged. That is, the integrated view implies constructivist learning arrangements, for example, cooperative learning, engaging trainees in authentic job situations (Loyens & Gijbels, 2008), reflection and abstraction to build conceptual structures (Von Glasersfeld, 1995) and double-loop learning (Argyris, 1993), among others as stated in Section 2.1 above. Five modules were designed to develop the seven competencies.

Each module consists of its descriptions, target competences and competencies to be developed, learning outcomes, time and duration of the training module, pre-and postassessment of competencies as requirement, and instructional methods. Each module was also divided into subunits, including tasks that could be further practiced in authentic job situations by smallholder farmers on an individual basis. The training module developed in the English language was translated into Amharic to train smallholder farmers for 5 days. The duration of the training day was limited based on the working context. In general, the training provided to farmers by the DAs in the FTCs is not more than 5 working days. Thus, training was provided to farmers in a way that they completed one module per day, followed by advisory/support services during maize planting for 10 working days. To establish connectivity between the modules and advisory and support services during maize planting, trainee smallholder farmers were supported and advised by DAs who were also closely supported and advised by TAs to perform job tasks during maize planting. Competencies required for performing job tasks were used. District-level experts who are known as subject-matter specialists closely observed the TAs.

Module 1: Understanding agro-ecological farming practices

Module 2: Agricultural extension management competence

Module 3: Programme planning and objective preparation competence

Module 4: Realizing extension communication and relation-building processes

Module 5: Applying affective attributes, extension advisory-facilitative personal characteristics and acting ethically in a during-extension-advising context

(c) CCBE/T learning environment and instructional methods:

DAs are supposed to provide their training services based on the main characteristics of CCBT. They are provided with the same curriculum framework to train farmers in FTCs.

Local administrations called *Kebeles* ($N = 21$) were divided into 'Innovative' and 'Conventional' groups using the simple random sampling lottery method followed by randomly labelling the DAs into ('H-CBT'; $N = 33$) and ('L-CBT'; $N = 32$) implementers of extension services, respectively. The model developed by Sturing et al. (2011) was used to design the intervention. From the five levels the model had, the 'Not CBT' and 'Completely CBT' levels were adapted into 'L-CBT' and 'H-CBT' training programmes, respectively (see Supporting Information: A). Before the training programmes were organized, quality assurance (fidelity) strategies were set up (cf. Moncher & Prinz, 1991). That is, strategies to confirm the realization of the independent variable CCBT with its two levels 'L-CBT' and 'H-CBT') were designed. In addition, an instrument was developed to measure fidelity and to confirm manipulation of CCBT and its two levels as independent variables (cf. Moncher & Prinz, 1991). Applying fidelity criteria in randomized field experiment can assure that the experimental treatment (e.g., 'H-CBT') is really absent in the control condition (e.g., 'L-CBT') (Mills & Ragan, 2000). To ensure the quality delivery of CCBT, Wesselink et al. (2017, p. 547) in Mulder (2017) (ed.) explained five basic features with 22 corresponding variables. These variables were made 33 indicators (i.e., items) to be measured using scales and defined with descriptors as follows: (a) 1 = Very low = the training *is not* fulfilling basic CCBT features in this regard; (b) 2 = Low = the training *rarely* has basic CCBT features in this regard; (c) 3 = Moderate = the training *moderately* has basic CCBT features in this regard; (d) 4 = High = the training *largely* has basic CCBT features in this regard and (e) 5 = Very high = the training *completely* has basic CCBT features in this regard. For the design aspect, *practice situation* and variable *complexity*, for example, an item was constructed as 'The practice situations are composed of tasks that are sufficiently complex'. Since the instrument was developed from a validated model, validity and reliability checks were not considered.

Three educational psychologists selected from a university were trained on the principles of CCBT, its levels and the descriptors (Sturing et al., 2011) in advance. Before they used indicators, the psychologists were involved in reflective discussions on the contents of the indicators to maximize clarity. The 33 indicators were used to evaluate the quality of the training programmes in two situations: training provided to DAs and performance of DAs in their support of farmers during maize planting. These psychologists were provided with opportunities to carefully examine their filled indicators to see whether there is any bias following comparison of the theoretical and practical sessions. The comparison was made to control *artificial deficiency* and *excess* in conventional (L-CBT) and innovative (H-CBT) groups, respectively. Just as an example, in theoretical or content assessment, the psychologists were instructed to check whether the competences defined in the module are addressed properly; in the practical assessment, they were instructed to check whether the competences addressed in the module are applied during maize planting, among others. So, the training provided by the researcher to trainee DAs was evaluated by these educational psychologists in both 'H-CBT' and 'L-CBT' conditions using the indicators developed for this purpose. The data collected from these three quality assessors were analyzed using Cronbach alpha, and interrater agreement was computed (cf. Crocker & Algina, 1986) for both conditions, that is, 'H-CBT' ($r = 0.81$) and 'L-CBT' ($r = 0.79$), which are acceptable (DeVellis, 2016). This analysis confirmed the realization of the independent variable CCBT and its two levels 'L-CBT' and 'H-CBT' with conditions of quality.

The operational guideline prepared for the FTCs (Ministry of Agriculture, 2009), recommended a period of training that ranges from 3 to 15 days, or sometimes up to 20 days,

for a short-term training and participation of 15–20 trainee farmers per round. However, the DA-to-farmer linkage (connection) was limited to training a minimum of six and a maximum of seven farmers in one training centre, since applying the 'L-CBT' and 'H-CBT' levels demanded more budget, time and human resources. Since the FTCs were limited in number (one per *Kebele*), we used alternative training centres situated in the *subkebeles*, called 'got' in Amharic, which were constructed by the community (see Table 1). Following completion of such arrangement, smallholder farmers took training for 5 days using 'H-CBT' and 'L-CBT' levels; each group separately. This was also followed by 10 working days advisory/support services during maize planting which were also 'H-CBT' and 'L-CBT' levels, respectively. This process was also closely supervised by ATVET teachers ($N = 42$) who served as TAs. This supervision is because the involvement of practitioners with different educational backgrounds was needed while developing and conducting competence assessments (Gulikers et al., 2009). Before they served as TAs, these ATVET teachers ($N = 42$) were provided with an advance training on the following: the 10 CCBT principles, levels and descriptors; selected competences and competencies; tasks/activities and performance indicators. This training was also designed to maximize quality delivery of the 'H-CBT' and 'L-CBT' levels through observing individual smallholder farmer performance in each group while being trained in the FTCs and alternative training centres and being advised and supported during maize planting by DAs.

The 10 CCBT principles (Sturing et al., 2011; Wesselink et al., 2010) were foundational principles to conduct the intervention. They served as guiding tools in the training programmes and can be enlisted as follows: (a) implementation of the training programme based on the core tasks, working processes and competencies needed to perform the core task; (b) implementation of the training programme within the centrality of complex core farming problems; (c) enhancing learning activities in different concrete and meaningful farming situations, (d) integration of knowledge, skills and attitudes in the instructional and assessment procedures; (e) regular assessment of trainee smallholder farmers; (f) challenging trainee smallholder farmers to reflect on their own learning; (g) structuring the training programme in a way in which the trainee smallholder farmers increasingly self-steer (direct) their learning; (h) making the training programme flexible based on the characteristics of smallholder farmers; (i) adjusting the guidance to the learning needs of the trainee smallholder farmers (trainee-centeredness) and (j) paying attention to reflection, learning to learn and career competences during delivery of the training (Sturing et al., 2011).

TABLE 1 Levels of CCBT, number of DAs/training centres and total trainee smallholder farmers.

CCBT levels	Number of DAs/ training centres	Number of trainee smallholders	Total trainee smallholders	Total trainee smallholders
'L-CBT' (conventional)	28	7	$28 \times 7 = 196$	220
	4	6	$4 \times 6 = 24$	
'H-CBT' (innovative)	22	7	$22 \times 7 = 154$	220
	11	6	$11 \times 6 = 66$	
Total trainee smallholder farmers in the 'L-CBT' and 'H-CBT' groups				440

Abbreviations: CCBT, comprehensive competence-based training; DAs, development agents; H-CBT, high competence-based training; L-CBT, low competence-based training.

(d) Measurement of dependent variables:

To measure the dependent variables of competence development and performance improvement, both quantitative and qualitative data were collected. To gather quantitative data, assessment activities were conducted on the level of 'competentiveness' of training and its effect on the following: (i) individual farmer competence development three times, right before and after training in 5 days' training in the FTCs and at the end of 10 working days performance during maize planting; (ii) actual competence gain of smallholder farmers in the 'H-CBT' and 'L-CBT' groups at the end of 10 working days placement during maize planting; (iii) performance improvement of smallholder farmers in each group during ten working days' parallel placement during maize planting and (iv) yield in quintal/hectare gains of each smallholder farmer. The researcher developed the questionnaires and tested their reliability. Cronbach's alpha coefficients were calculated for farmers at t_1, t_2 and t_3; for DAs at t_1, t_2 and t_3 and for TAs only once, which resulted in, respectively, $r = 0.94$, 0.93, 0.91; 0.72, 0.70, 0.78 and 0.71. These results range from respectable to very good (DeVellis, 1991, p. 85).

To gather qualitative data, smallholder farmers were interviewed using Kirkpatrick's (1996) four-level model on previous and current training and support services and the status of farmer yield in terms of quintal/hectare gains performance. Additionally, reflective sessions were organized with TAs and district-level experts to access qualitative evidence on the performance improvement and problem solving capability of each individual farmer in each group. In particular, experts were further requested to evaluate TAs observations. Finally, field observations were made for three successive years to evaluate the sustainable practice of CCBT principles in the 'H-CBT' and 'L-CBT' groups of trainee smallholder farmers. The following summary illustrates the timeline of these activities (Table 2).

(e) Data analysis:

A mixed between-within subjects analysis of variance (mixed ANOVA) was used to examine the effects of competentiveness of training on competence development of smallholder farmers as perceived by them and DAs as expert assessors. Not only that, but also it was applied to assess the extent to which level of competentiveness ('L-CBT' method or 'H-CBT' method) of training results yield in quintal/hectare gains. A mixed multivariate analysis of variance (mixed MANOVA) was also used to examine the effect of competentiveness of training on actual competence gain of individual smallholder farmers. An independent samples *t* test was used to compare the extent of performance improvement of smallholder farmers in the 'L-CBT' and 'H-CBT' groups as measured by TAs while the farmers are planting maize. Finally, data collected using the interview method, reflective focus group sessions and successive field observations were analyzed using content analysis method.

FINDINGS

The following section presents the results of the intervention.

RQ1: *To what extent does level of competentiveness of training affect competence development of farmers?*

TABLE 2 Timeline to gather data, instruments, participants (sample size) and sampling method.

Date	Instruments to measure the dependent variable	Participants	Sampling method
June 2018 (10–14;18–22; 25–29)	Five-point Likert-type scale defined with descriptors: (1) =*very low* =does not have the competency to perform the tasks; (2) =*low* =rarely has the competency to perform the tasks; (3) =*moderate*=moderately has the competency to perform the tasks; (4) = *high*=largely has the competency to perform the tasks; (5) =very high=completely has the competency to perform the tasks.	DAs ($N = 65$) and Farmers ($N = 440$)	Cluster
June 2018 (28–29)		'H-CBT' ($N = 220$); \'L-CBT' ($N = 220$) group of smallholder farmers	Cluster and simple random (lottery)
June 2018 (18–22; 25–29)	Five-point Likert-type scale with descriptors: (1) =*never*=fails to perform the task at all; (2) =*rarely*=hardly performs the task; 3=*sometimes*=somewhat performs the task; 4=*very often*=largely performs the task; 5=*always*=completely performs the task.	TAs selected from three ATVET colleges ($N = 42$)	Cluster and simple random (lottery)
February 2018 (Baseline); February 2019 (after intervention)	Yield data (quintal/hectare of maize) was collected twice for each smallholder farmer: before and after intervention.	'H-CBT' ($N = 220$); 'L-CBT' ($N = 220$) group of smallholder farmers	Cluster and simple random (lottery)
July 2018 (2–6); July 2019 (2–6)	Interview using Kirkpatrick's (1996) four-level model.	One farmer per FTC ($N = 21$ farmers)	Random selection of trainee farmers
July 2018 (9–10)	Reflective sessions with each group of TAs and district (*Woreda*) level experts.	TAs ($N = 22$) in the 'H-CBT' group; TAs ($N = 20$) in the 'L-CBT' group; experts ($N = 10$) in the 'L-CBT' group; Experts ($N = 11$) in the 'H-CBT' group	Cluster
June 15–30/2019; 15–30/2020; 15 May–20 June/2021	Participant observation; semistructured interview.	The researcher	Random selection of trainee smallholder farmer performance during maize planting

Abbreviations: ATVET, Agricultural Technical and Vocational Education and Training; DAs, development agents; H-CBT, high competence-based training; L-CBT, low competence-based training; TAs, trained assessors.

RQ1A: *As perceived by the smallholder farmers themselves* (*auto-assessment*)

A mixed between-within-subjects analysis of variance was conducted to assess the extent to which competentiveness ('L-CBT' method or 'H-CBT' method) of training affects competence development of farmers as perceived by the farmers themselves. Their perceived competences development was measured across three time periods: (pretest [t_0]; posttest [t_1] immediately after 5 days of training in the FTCs and posttest [t_2] after 2 weeks) (10 working days) of performance in an authentic job situation, that is, during maize planting. Before the analysis, the following assumptions were tested: (a) independence of observations, (b) normality and (c) sphericity. The independence of observations and normality were met. The assumption of sphericity was violated. Thus, the Greenhouse–Geisser epsilon was used to correct degrees of freedom. The results indicated a statistically significant main effect for time, F (1.283, 562.155) = 914.297, $p < 0.0005$, partial $\eta^2 = 0.676$, with both groups of smallholder farmers showing an increase in the scores of perceived competences as measured by the farmers themselves across the three time periods (see Table 3). There was also a substantial main effect for the competentiveness of training methods (competentiveness: 'L-CBT' method or 'H-CBT' method of training), F (1, 438) = 30.825, $p < 0.0005$, partial $\eta^2 = 0.066$, suggesting there is a statistically significant difference in the effectiveness of competentiveness ('L-CBT' method or 'H-CBT' method) in favour of the 'H-CBT' method of training. The interaction between time and competentiveness ('L-CBT' method or 'H-CBT' method) of training was also statistically significant, F (1.283, 562.155) = 5.694, $p = 0.011$, partial $\eta^2 = 0.013$, indicating that smallholder farmers' perceived competence development over time was different for the two groups (competentiveness of training) which indicate perceived competence development over time was higher in the 'H-CBT' condition than in the 'L-CBT' condition.

The means, SDs and sample sizes for these groups are presented in Table 3. As the table shows, the means of the two groups ('L-CBT' and 'H-CBT') are close to each other in the pretest, but they have many mean differences in posttest 1 and posttest 2. This is also more evident in Figure 2.

Figure 2 shows that in the pretest (t_0), both groups have very close means, but in the posttests (t_1 and t_2), the means of the 'H-CBT' group increases substantially. It is important to note that there already seems to be a difference in the pretest, although it is not statistically significant.

RQ1B: *As perceived by DAs* (*expert assessment*)

TABLE 3 Farmers' perceived competence developments mean scores for the 'H-CBT' and the 'L-CBT' levels of training across three time periods as perceived by the farmers themselves.

	'L-CBT' method ($N = 220$)		'H-CBT' method (N = 220)	
Time period	**M**	**SD**	**M**	**SD**
Pretest (t_0)	85.94	15.13	91.37	21.18
Posttest 1 (t_1)	101.76	15.73	110.60	17.14
Posttest 2 (t_2)	110.74	15.68	120.14	14.99

Abbreviations: H-CBT, high competence-based training; L-CBT, low competence-based training; SD, standard deviation.

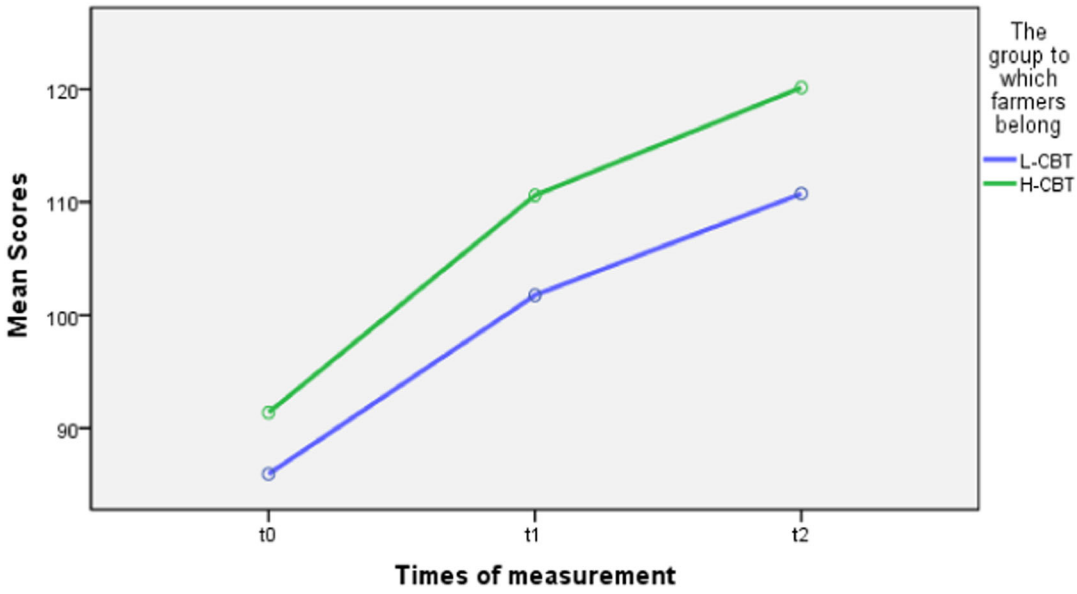

FIGURE 2 The effects of competentiveness of training on competence development of farmers as perceived by farmers themselves across three time periods. [Color figure can be viewed at wileyonlinelibrary.com]

A mixed between-within-subjects analysis of variance was conducted to assess the effects of competentiveness of training methods ('L-CBT' and 'H-CBT') on farmers' competence development as measured by DAs. DA perceptions about the competencies of farmers were measured in three time periods before the test (t_0), after the test immediately following training at the FTC (t_1), and after the test after ten working days of field support (t_2). Before the analysis, the following assumptions were tested: (a) independence of observations, (b) normality and (c) sphericity. Accordingly, the first two assumptions were met, while the third was violated. Thus, the Greenhouse–Geisser epsilon was used to correct degrees of freedom. The results of the analysis indicated that there was a statistically significant interaction between competentiveness of training and time, F (1.817, 114.457) = 7.355, p =.001, partial $\eta^2 = 0.105$ (large effect; Pallant, 2010, p. 210) showing that farmers' competence development as perceived by DAs over time was different for the two groups (competentiveness of training). There was a substantial main effect for time, F (1.817, 114.457) = 63.12, p < 0005, partial $\eta^2 = 0.501$ (large effect; Pallant, 2010, p. 210) with both groups of farmers showing an increase in the scores of competence development as perceived by DAs across the three time periods (see Table 4). The main effect on training competitiveness was also statistically significant, F (1, 63) = 17.568, p < 0005, partial $\eta^2 = 0.218$ (large effect; Pallant, 2010, p. 210), suggesting that there is a statistically significant difference in the effectiveness of the two training methods in favour of the 'H-CBT' training method. The means, SDs and sample sizes for these groups are presented in Table 4. As the table shows, the means of the two groups of farmers ('H-CBT' and 'L-CBT' training methods) as perceived by respective DAs are almost equal in the pretest (t_0) but they have many mean differences in the posttests (t_1 and t_2). Figure 3 makes this more visible.

Figure 3 shows that the means for the two groups are almost equal in the pretest (t_0), but in the posttests (t_1 and t_2), the means of the 'H-CBT' group increases substantially.

TABLE 4 Farmers' competence developments mean scores for the 'L-CBT' and the 'H-CBT' training methods across three time periods as perceived by DAs as expert assessors.

	'L-CBT' training method ($N = 32$)		'H-CBT' training method ($N = 33$)	
Time period	**M**	**SD**	**M**	**SD**
Pretest (t_0)	104.38	11.19	104.241	11.51
Posttest 1 (t_1)	106.03	10.40	112.55	9.45
Posttest 2 (t_2)	116.25	7.30	129.06	9.41

Abbreviations: DAs, development agents; H-CBT, high competence-based training; L-CBT, low competence-based training; SD, standard deviation.

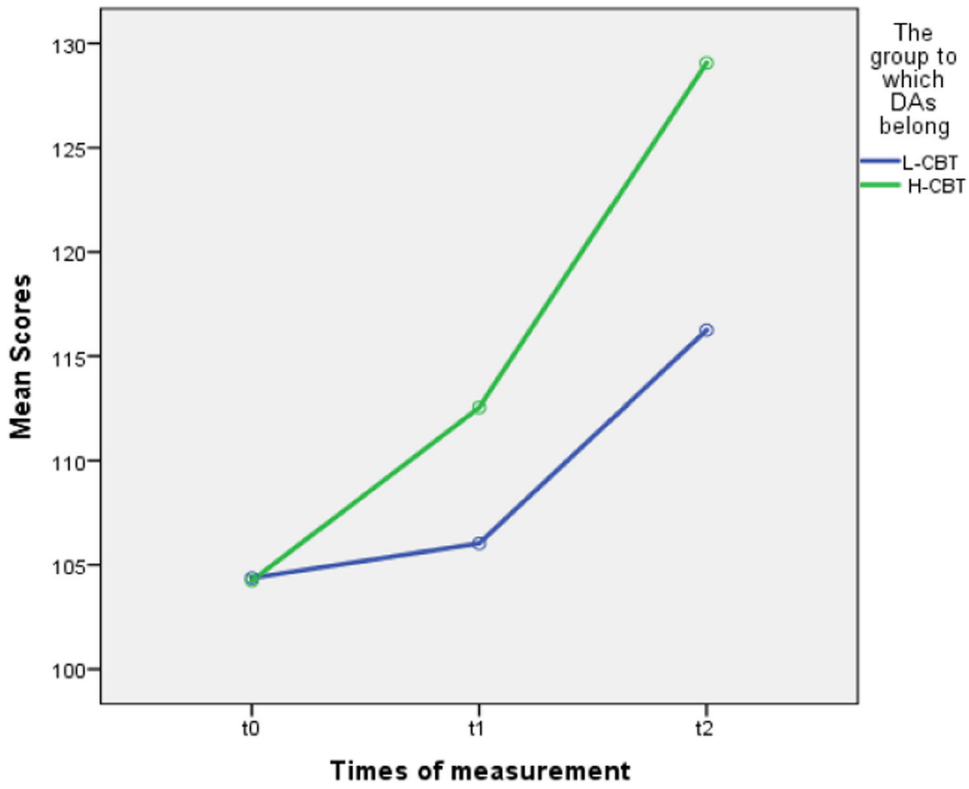

FIGURE 3 The effects of competentiveness of training on competence development of Farmers as perceived by development agents (experts). [Color figure can be viewed at wileyonlinelibrary.com]

RQ2: *To what extent does level of competentiveness of training result in actual competence gain of smallholder farmers?*

Mixed multivariate analysis of variance (mixed MANOVA) tests using SPSS version 23 for Windows was performed to assess the effects of competentiveness of training on famers' actual competence gain on the seven competences. Time was used as a within-subjects variable, whereas CCBT was used as a between-subjects variable. The sample sizes were approximately equal across the groups; therefore, the assumptions were considered to be met. A statistically

significant result was found for the interaction between group and time, F (2, 437) = 3.034, $p = .049$, partial $\eta^2 = 0.014$. The interaction effect indicates that the difference between the 'L-CBT' and 'H-CBT' training method groups on the linear combination of the seven dependent variables (competences) is different at the pretest as well as at the posttests (t_1 and t_2). Statistically significant multivariate results were also found for the main effect of the CCBT variable ('H-CBT' vs. 'L-CBT' training methods) F (1, 438) = 30.801, $p = .0005$, partial $\eta^2 = 0.066$ meaning that farmers in the groups 'L-CBT' and 'H-CBT' reported differences in the actual gain of their competences, particularly at t_1 and t_2 times. The main effect for time was also statistically significant, F (2, 437) = 757.516, $p < 0.0005$, partial $\eta^2 = 0.776$, indicating that farmers reported increase in competences across the three time periods. This increase refers to the differences in mean scores from t_0 to t_1 and t_2 between the CCBT levels. Table 5 presents the means and SDs for the seven variables (competences). Competence development (gain) here refers to the growth of competence levels as represented by mean scores of the seven competences from the first (t_0), second (t_1) and third (t_2) measurements.

Univariate tests presented in Table 5 show that mean scores for all the seven competences in the 'H-CBT' group were higher than in the 'L-CBT', indicating that smallholder framers in the 'H-CBT' group perceived themselves as more competent than smallholder farmers in the 'L-CBT' group for all the seven competences at t_0, t_1 and t_2 testing times. The differences are statistically significant for all seven competences (understanding agro-ecological farming practices and agricultural extension management competence; programme planning and objective preparation competence; realizing extension communication and relation-building processes competence; applying affective attributes during maize planting; applying extension advisory and facilitative personality characteristics competence and acting ethically competence) at t_1 and t_2 (see Table 5) for details. However, the difference of two competences (realizing extension communication and relation-building processes competence, applying affective attributes during maize planting) between the 'H-CBT' and 'L-CBT' groups is not statistically significant at t_0. The development patterns shown in Figure 4 help to make these findings more evident. Figure 4 shows the mean scores for the seven competences at the three time points, as well as the development patterns in the seven competences in the 'H-CBT' and 'L-CBT' groups of farmers. The scores on all competences have shown improvement over time, although it is largely in favour of the 'H-CBT' condition.

RQ3: *To what extent does level of competentiveness of training affect performance improvement of smallholder farmers during maize planting as perceived by TAs?*

Independent samples t-test was conducted to compare the extent of performance improvement of farmers in the 'L-CBT' and 'H-CBT' groups as measured by TAs while the farmers are planting maize. Before the analysis, the following assumptions were tested: (a) independence of observations, (b) normality and (c) equality of variances. Consequently, all these assumptions were met. There was statistically significant difference in the scores of performance improvement between the 'L-CBT' (M = 98.95, SD = 8.73, N = 20) and 'H-CBT' (M = 107.00, SD = 7.58, N = 22; t (40) = −3.197, $p = .003$, two-tailed) groups. The magnitude of the differences in the means (mean difference = −8.05, 95% CI: −13.139 to −2.961) was a large effect ($\eta^2 = 0.2$) (Pallant, 2010, p. 2010).

Kirkpatrick's (1996) four-level model (*Reaction*, *Learning*, *Behaviour* and *Results*) was also used to evaluate the training, advisory and support services provided by DAs to farmers. We

TABLE 5 Farmers' actual competence gain on the seven competences between the 'H-CBT' and 'L-CBT' groups across the three time periods.

Competences	Time 0			Time 1			Time 2		
	'L-CBT'	'H-CBT'		'L-CBT'	'H-CBT'		'L-CBT'	'H-CBT'	
***N* = 440 ('L-CBT' = 220, 'H-CBT' = 220)**	**M (SD)**	**M (SD)**	**F**	**M (SD)**	**M (SD)**	**F**	**M (SD)**	**M (SD)**	**F**
Understanding agro-ecological farming practices	9.97 (2.19)	10.53 (2.97)	4.97*	11.42 (1.99)	12.13 (2.38)	11.54*	12.22 (2.36)	13.00 (2.29)	12.31*
Agricultural extension management competence	12.58 (2.63)	13.15 (3.59)	10.17*	14.29 (2.63)	16.03 (3.29)	37.81*	15.20 (2.72)	16.79 (2.90)	35.00*
Programme planning and objective preparation competence	11.63 (2.57)	13.61 (4.02)	25.87*	13.45 (2.54)	15.7 (3.18)	39.74*	14.61 (2.62)	16.23 (2.92)	37.44*
Realizing extension communication and relation-building processes	22.13 (4.82)	22.19 (5.36)	0.013	25.55 (4.48)	26.63 (4.43)	6.38*	28.10 (4.60)	29.52 (4.12)	11.56*
Applying effective attributes during maize planting	7.01 (1.80)	7.42 (2.28)	3.28	8.38 (1.83)	8.85 (2.28)	5.75*	9.11 (1.92)	9.80 (1.90)	13.96*
Applying extension advisory and facilitative personality characteristics	14.89 (3.09)	16.18 (4.48)	12.29*	16.84 (3.23)	18.77 (3.62)	34.98*	18.38 (3.07)	20.61 (3.08)	57*
Acting ethically	10.19 (2.40)	11.08 (2.81)	12.80*	11.84 (2.23)	13.01 (2.52)	27.05*	13.11 (2.32)	14.19 (2.02)	27.25*

Note: 'H-CBT' = Innovative method; 'L-CBT' = conventionall method.

Abbreviations: H-CBT, high competence-based training; L-CBT, low competence-based training.

*Significant difference between the 'H-CBT' and the 'L-CBT' groups at $p < 0.05$.

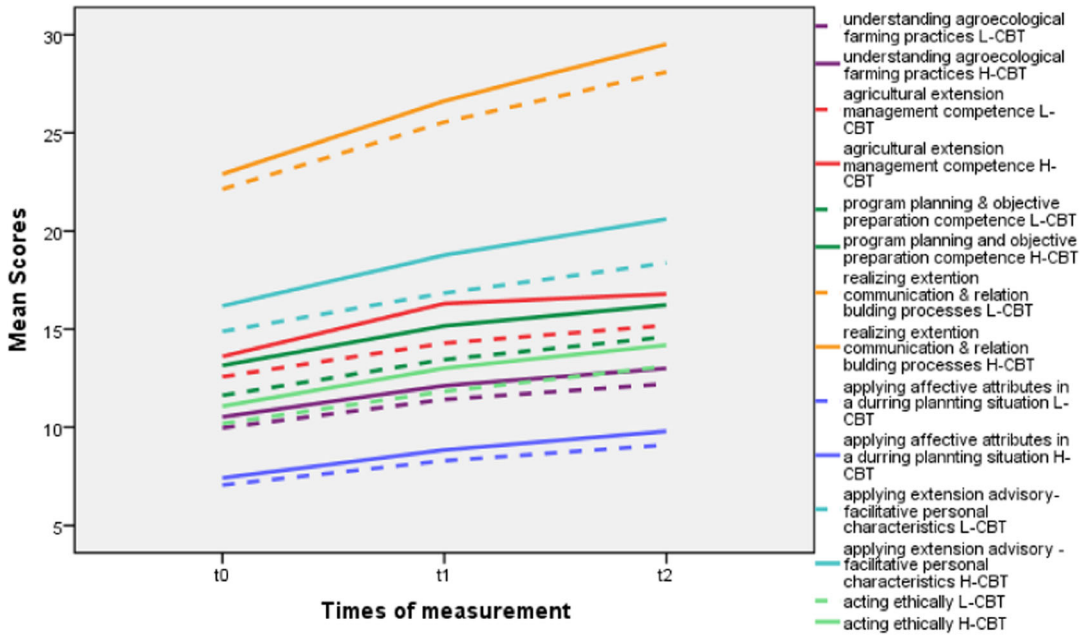

FIGURE 4 The effects of competentiveness of training on actual comptence gain of farmers across three time periods. [Color figure can be viewed at wileyonlinelibrary.com]

held interviews with both 'L-CBT' and 'H-CBT' trainee farmers. We organized 3-h sessions with each group of TAs and district-level experts. These sessions were to synthesize their observations as related to the performance of smallholder farmers during maize planting. The content analysis made for each level revealed similar result as had been discovered in a previous study. For example, in the *Results* level of the model, trainee farmers reported yield/hectare gain improvement of maize to 31 and 41 quintal/hectare in the 'L-CBT' and 'H-CBT' groups, respectively, which is comparable to the baseline 22 quintal/hectare for both groups (See also Tarekegne et al., 2022, p. 394, Table 3).

RQ4: *To what extent does level of competentiveness of training result in productivity, that is, increase in yield/hectare gains of smallholder farmers?*

A mixed between-within subjects analysis of variance was conducted to assess the extent to which level of competentiveness ('L-CBT' method or 'H-CBT' method) of training result in productivity gain, increase in yield/hectare. Yield/hectare gain was measured two times: (1) baseline (before intervention) and (2) after intervention. Before the analysis, the following assumptions were tested: (a) independence of observations, (b) normality and (c) sphericity. The independence of observations and normality were met. However, the assumption of sphericity was violated. Thus, the Greenhouse–Geisser epsilon was used to correct degrees of freedom. Results indicated a statistically significant main effect for time, $F(1, 438) = 2471.497$, $p < 0.0005$, partial $\eta^2 = 0.849$, with both groups of farmers showing an increase in yield/hectare gain across the two time periods (see Table 6). There was also a substantial main effect for the competentiveness of training methods (competentiveness: 'L-CBT' method or 'H-CBT' method of training), $F(1, 438) = 242.360$, $p < 0.0005$, partial $\eta^2 = 0.356$, suggesting there is a statistically

TABLE 6 Improvement of yield/hectare between the 'H-CBT' and the 'L-CBT' levels across two time periods: before intervention (t_0) and after intervention (t_1).

	'L-CBT' method			'H-CBT' method		
Time period	**N**	**M**	**SD**	**N**	**M**	**SD**
Average yield in (quintal/hectare gains) before intervention	220	22	3.99	220	22	3.99
Average yield in (quintal/hectare gains) after intervention	220	31	5.80	220	41	3.85

Abbreviations: H-CBT, high competence-based training; L-CBT, low competence-based training.

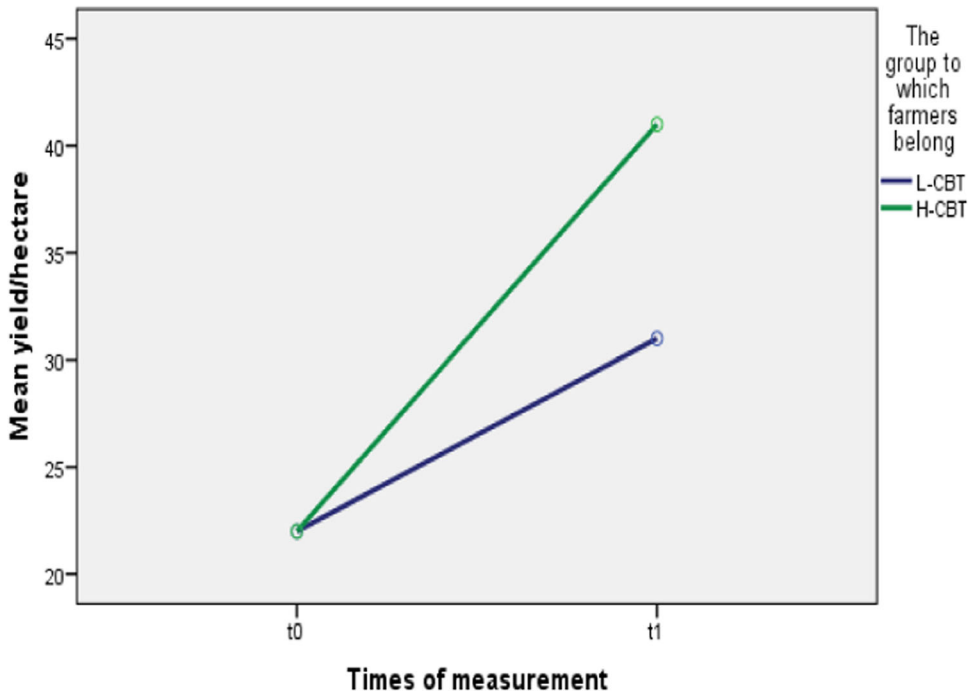

FIGURE 5 Improvment of yield/hectare between the L-CBT and H-CBT training methods before and after intervention. H-CBT, high competence-based training; L-CBT, low competence-based training. [Color figure can be viewed at wileyonlinelibrary.com]

significant difference in the effectiveness of competentiveness ('L-CBT' method or 'H-CBT' method) of training in improving yield in quintal/hectare gains in favour of the 'H-CBT' group. The interaction between time and competentiveness ('L-CBT' method or 'H-CBT' method) of training was also statistically significant, $F\ (1,\ 438) = 315.242$, $p < 0.0005$, partial $\eta^2 = 0.419$, indicating that the increase in yield in quintal/hectare gain over time was different for the two groups (competentiveness of training). The means, SDs and sample sizes for these groups are presented in Table 6. As the table shows, the means of the two groups ('L-CBT' and 'H-CBT') are close to each other in the baseline (before intervention); however, they have many mean differences in yield in quintal/hectare gain after intervention. Figure 5 also makes this distinction more illustrative.

CONCLUSIONS AND DISCUSSIONS

In this study, the revised theory of strategic alignment (Figure 1) and integrated conceptualization of competencies (Mulder, 2001) and AISs have been used as theoretical and conceptual frameworks. They were used to design the learning environment that enabled smallholder farmers to develop competencies and solve problems in the authentic job situation, during maize planting. They were also presented with their central features of innovation brokering, knowledge sharing and innovation capacities through the establishment of multistakeholder alliance (Klerkx et al., 2012). To operationalize and embed the components of the strategic alignment model (Figure 1) and the AIS perspective, the CCBT model (Sturing et al., 2011; Wesselink, 2010) was applied to organize the intervention. The DAs had already developed their individual ways of training, advising and supporting farmers before the intervention. We applied random assignment to minimize the influence of individual ways of training, advising and supporting on the 'L-CBT' and 'H-CBT' conditions. To guarantee the quality delivery of the levels of 'L-CBT' and 'H-CBT', according to the CCBT model, we checked fidelity using educational psychologists and ATVET teachers as quality assessors. The 'H-CBT' level demonstrated promising results in the smallholder farmer's competence development and performance improvement: (a) in the authentic job situation during maize planting and (b) yield in quintal/hectare gains. Understanding the effectiveness of CCBT and its potential to enhance competence development and performance improvement can be inferred from two sources. These are using (a) self-reports and (b) multiple assessors (Gulikers et al., 2009). Use of multiple assessors is advisable since making judgement from self-reports may lack validity and objectivity (cf. Ward et al., 2002).

We tried to obtain perceptions of trainer DAs as expert assessors, since perceptions of smallholder farmers and those of DAs on the competence development of smallholder farmers may be different. However, comparable results were found. Perceptions of DAs as expert assessors indicate the competence development of smallholder farmers in the 'L-CBT' and 'H-CBT' groups is almost equal in the pretest (t_0), but in the posttests (t_1 and t_2), the means of the 'H-CBT' group increases substantially (Figure 3). Smallholder farmers and expert assessors (DAs) who belonged to the 'H-CBT' group perceived more competence development of smallholder farmers than smallholder farmers and DAs who belonged to the 'L-CBT' group. These results could be due to the 'H-CBT' learning environments, as they: (a) give more emphasis to the core task, work process and target competences during training at all times; (b) organize the training around complex problems, and concrete meaningful farming situations; (c) focus on integration of knowledge, skills and attitudes to solve a job problem and (d) stimulate trainee smallholder farmers to largely self-regulate their own learning and practice critical self-reflection skills (Sturing et al., 2011; Wesselink, 2010), among others.

Competence development in this study refers to the growth of the competence levels targeted in this study. Smallholder farmers ($N = 440$) ratings were obtained on the targeted seven competences in both the 'H-CBT' ($N = 220$) and 'L-CBT' ($N = 220$) groups across three time periods. Smallholder farmers in the 'H-CBT' group perceived themselves as more competent than smallholder farmers in the 'L-CBT' group for all the targeted competences, particularly at t_0, t_1 and t_2 measurement times. The differences are statistically significant for all seven competences at t_1 and t_2. The difference of two competences (realizing extension communication and relation-building processes competence; applying affective attributes) between the 'H-CBT' and 'L-CBT' groups is not statistically significant at t_0 (Table 5 and Figure 4).

However, the difference in these two competences between the 'H-CBT' and 'L-CBT' groups is found to be statistically significant at the measurement times t_1 and t_2, which is in favour of the 'H-CBT' group (Table 5 and Figure 4). This finding is supportive to arrive at further conclusion on the debates between knowledge and competence development. The combinations of the strategic alignment with AIS frameworks and integrated conceptualization of competencies, followed by operationalizing them using the CCBT model, foster knowledge and competence development in balance. The finding refutes the deeply held conception that competence-based training undermines knowledge development. Rather, the finding establishes that competence-based education and the integrated view of it can enhance knowledge development. This conclusion underpins the importance of revising the conception that the conventional behaviouristic-functional view fosters knowledge development among learners or trainees (cf. Koopman et al., 2011). Moreover, TAs reported relatively better problem solving and resilience building capabilities in the 'H-CBT' groups in which the integrated view of competence is applied. They observed positive adaptation among smallholder farmers during exposures to complex problems during maize planting. The extent of performance improvement of smallholder farmers in the 'L-CBT' and 'H-CBT' groups as measured by perceptions of TAs, while the farmers were performing in authentic job situations, during maize planting was also compared. Statistically significant differences in performance improvement scores between the 'L-CBT' and 'H-CBT' groups were obtained. The magnitude of the differences in the means was a large effect ($\eta^2 = 0.2$) (Pallant, 2010, p. 2010). It is also known that CCBT should also incorporate quality CBA strategies (Gulikers et al., 2009). To maximize a valid and complete picture of the actual quality of the assessment; therefore, the perspectives of TAs were accessed through conducting successive discussions with themselves since they might have differences or agreements, which are indicators of quality issues of CBA (Birenbaum, 2007). It is observed that the addition of such qualitative argumentations improved the effectiveness of CCBT beyond the usual practice of examining the quality of the assessment instruments (e.g., checking validity of questionnaire). In relation with this, TAs observed better performance of the smallholder farmers in the 'H-CBT' group than in the 'L-CBT' group in many of the sampled tasks they performed in the authentic job situations (e.g., computing plant population/hectare, measuring inter and intrarow spacing and soil depth, checking moisture sensitivity, relationship-building with stakeholders, communication, problem solving, among others). The presence of TAs was welcomed by smallholder farmers. They appreciated the deliberative discussions made with TAs which were largely constructive and transformative. Smallholder farmers declared that the presence of such kind of experts (TAs) was unusual in maize planting situations in their locality.

Interviews were conducted with randomly selected trainee smallholder farmers in both groups to compare their previous and current training services. Smallholder farmers in both groups acknowledged the provision of better training, advising and support services. They enumerated the support services provided to them during maize planting, which they believed to be better than previous times in the following ways: (a) recognizing plant population per hectare (72,000/hectare); (b) applying proper row spacing (inter and intrarow spacing) (80×40 cm) and soil depth during planting maize (5–7cm) (using a stick provided by DAs/TAs); (c) checking fertilizer demand/hectare (Urea: 200 kg/ha and DAP: 200 kg/ha); (d) using quality seed variety (Hybrid, Limu), variety name (P3812W), release year (2012), and its requirement per hectare (25 kg/hectare), among others. Both groups appreciated the close follow-up of DAs, TAs, district-level experts and key stakeholder groups (e.g., seed, credit, fertilizer suppliers).

Compared to the baseline yield in quintal/hectare gains done by the researcher (average: 22 quintal/hectare) which is similar to Amhara Development Indicator (Bureau of Finance and Economic Development, 2013), both groups of farmers reported maize yield (quintal/hectare gains) improvement after intervention. However, average yield in quintal/hectare gains computations made on both groups revealed 31 and 41 quintal/hectare gains of maize for 'L-CBT' and 'H-CBT' groups, respectively (Figure 5). The average yield achievement of the 'L-CBT' group of smallholder farmers after intervention is closely similar to the national average yield which is estimated >3 MT/hectare (30 quintal/hectare), the second highest in sub-Saharan Africa, after South Africa (Abate et al., 2015). The average yield in quintal/hectare gains achieved by the 'H-CBT' group of smallholder farmers after intervention was closely similar to the average yield in quintal/hectare gains (40.91 quintal/hectare) in 2016 in the localities of follow-up training, Burea district, West Gojjam (CSA, 2016).

It is important to remind the reader that the training provided to smallholder farmers in the 'L-CBT' group paid less attention to the core task, work processes and target competencies needed to perform the core task. More attention was paid to theory, with fewer attempts to link it to professional practice. However, this group of trainee smallholder farmers liked the competence-based extension training provided to them at this time because of its inclusion of the authentic job situation, during maize planting, to improve their performance on the job and yield in quintal/hectare gains. This perception may be due to the comparison made by them between current training and previous ones, which are largely theoretical than practical. According to them, the hitherto training, advisory and support services devoted more time to theoretical aspects in the FTCs. However, smallholder farmers in the 'H-CBT' group were more interested to the current training, since they were engaged in presenting narrative cases and role plays based on given character descriptions, as well as capturing of their experiences and the indigenous knowledge they have (cf. Demssie et al., 2020). This kind of training also strengthened the idea that Africa has to institutionalize home-grown approaches to realize the green revolution and sustainable development (Abate, 2021). Smallholder farmers believed that these exercises helped them conceptualize facts and develop their declarative knowledge. The presentation of role plays based on character description helped them to connect the practical examples with their authentic job situations during maize planting. They were of the view that these exercises helped them develop new patterns and change their declarative knowledge into procedural knowledge. The 'H-CBT' group quickly perceived that their knowledge, skills and attitudes aspects are improved because of their declarative and procedural knowledge developments (cf. Willingham et al., 1989) which were developed by the use of different methods applied in the current training, advisory and support services. The members of the H-CBT group held the view that the use of different methods helped them improve their problem solving and creative thinking (cf. Runco & Chand, 1995). These strengthened competencies helped them to revisit their old and new experiences from a new set of expectations (Mezirow, 1991). Smallholder farmers in the 'H-CBT' group were happy about the delivery mode of current training, particularly related to the interplay made between theoretical and practical engagement. This delivery mode assisted them to structure their experiences and theoretical concepts through exploring a wide range of relevant training and advisory services provided to them so far. Smallholder farmers also held the view that this approach increased their motivation and commitment to engage in lifelong learning (personal development) to transform their farming profession. The views advocated by the 'H-CBT' group of trainee smallholder farmers are underpinning the trainees' competence development from all competence domain dimensions (*cognitive, functional, social and meta-competence*), for

example, understanding agro-ecological farming practices, programme planning and objective preparation, realizing extension communication and relation-building processes and acting ethically, respectively, which also are confirmed in the measurement of their actual competence gain (refer to Table 5 and Figure 4). Furthermore, the 'H-CBT' level has significant added value in improving the performance of smallholder farmers both in authentic job situations; that is, during maize planting and in yield/hectare gain of maize crop different from the baseline.

These realizations confirmed the assertions that a holistic/integrated understanding of competence adds value in improving the performance of individual job holders (Eraut, 1998; Mulder, 2004, 2017a). Field observations were made on the sustainable practice of the CCBT principles in both the 'L-CBT' and 'H-CBT' groups of trainee smallholder farmers for 3 successive production years. A relatively better implementation of CCBT principles in the 'H-CBT' group of trainee smallholder farmers was observed. However, a large number of smallholder farmer trainees in both groups were found to implement the conventional way. For instance, the 'H-CBT' trainee smallholder farmers were observed to be negligent of computing plant population/hectare, measuring inter-and intrarow spacing and soil depth during maize planting and shifting toward planting/sowing using the conventional way. However, in the study context and during the intervention time, smallholder farmers are encouraged to apply 72,000/hectare, 80×40 cm line sowing in which the row-to-row and plant-to-plant distances are uniform and 5–7cm soil depths of placing maize seed.

It is argued that AISs (Klerkx et al., 2012) and the revised theory of strategic alignment (Figure 1) and integrated conceptualization of competencies (Mulder, 2001), operationalized by the holistic learning infrastructure-CCBT and its 'H-CBT' level, have significant added value in the competence development of smallholder farmers and their performances in authentic job situations and yield in quintal/hectare gains improvement. The integration of these views is found to be important since both underpin the centrality of capability, knowledge sharing and holistic system thinking, and it is now understood that they reinforce each other to tackle the problems observed in the agricultural sector.

Thus, it can be concluded that the positioning of the study within the AIS and the theory of strategic alignment and integrated conceptualization of competencies, followed by operationalizing and embedding these theoretical and conceptual frameworks in CCBT principles and use of the authentic core job task, during maize planting as problem-context has added value in enhancing trans-disciplinary, holistic systems perspective and multiactor involvement with the intended outcomes of capacities to innovate, learn and change. The positioning within these frameworks has demonstrated an added insight in enhancing shared vision, coordinated linkages, information flows, negotiated learning/deliberation, adaptation/flexibility, self-regulation and so on, among smallholder farmers, DAs, TAs, district-level experts and key stakeholder groups. Although these approaches are demanding in terms of budget, time and human resources, it is understood that committed and proper application of them can have significant contributions to facilitate competence development and performance improvement. For instance, the researcher demonstrated commitment in this study through taking the role of 'innovation broker'. That is, he purposefully catalyzed innovation through bringing together diverse actors, such as smallholder farmers, DAs, TAs, experts or subject-matter specialists, and key stakeholder groups, along with facilitating their interaction (cf. Klerkx & Gildemacher, 2012) or through establishing community of learners (Wenger, 1998) or stimulating deliberative discussions to facilitate learning (Goodin & Stein, 2008). Of course, the commitment of the innovation broker should also be supported by mutual trust and

commitment of key stakeholder groups (Anderson & Sanga, 2019). What has been discovered is that the theory of strategic alignment and integrated conceptualization of competencies and the AIS perspective operationalized and embedded by the CCBT approach and its 'H-CBT' level are followed by positive outcomes: competence development of smallholder farmers and their performance, improvement in authentic job situations and yield in quintal/hectare gains. However, to effect change in the agriculture sector using these views, individual capacity development programmes should be supported by capacity building initiatives from the public sector (organizational) and stakeholders. Last, it is also now understood that 'sustainability of innovative practices' needs proper institutional set up, policy environments, incentive mechanisms, allocation of budget and human resources, consistency of efforts and committed and coordinated linkages among innovation actors to effectively implement change in the sector.

IMPLICATIONS FOR PRACTICE, THEORY AND FUTURE RESEARCH

This research implies that using CCBT has added value in the competence development of job holders and their performances in authentic job situations and yield in quintal/hectare gains. This implies the necessity of transforming the current public extension services, which are largely conventional, into innovative ones to maximize yield in quintal/hectare gains, improve health and nutrition (Byerlee & Fanzo, 2019), reduce poverty and food insecurity (Christiaensen & Martin, 2018) and practice environmental sustainability (Hansen et al., 2019). Theoretically, the constructive alignment theory developed by Biggs and modified by (Mulder, 2017b), integrated conceptualization of competencies (Mulder, 2001), and the AIS perspective (Klerkx et al., 2012) has also added value in improving both process (e.g., performance on the job) and outcome performance (yield in quintal/hectare gains). It is noted that the fundamental question raised in relation to the AIS perspective is about how to operationalize and embed this perspective in different contexts (Kamara et al., 2020), which resulted in limited use of the perspective in developing countries and widespread use of the linear model, despite AIS's potential advantages (Klerkx et al., 2012). In the context of the study area, this operationalization and embedding problem is solved, for instance, by taking the commitment of innovation brokering and bringing disconnected groups to develop and validate a competence profile for DAs and a competence framework for improving the productivity of smallholder farmers, followed by organizing training for both groups using a validated model. In this regard, the CCBT and its 'High-CBT' level have more added values and can be a solution to operationalize and embed the AIS perspective in a developing country context where the linear technology orientation is largely applied. This study is among the few that attempts to infer the relationship between competence development and performance improvement via conducting a field experiment study which is theoretically postulated but less empirically tested. As stated elsewhere, competences are conceptualized as integrated knowledge, skills and attitudes and should be applied concurrently to improve performance. However, *Performance (P)* is a product of *Ability (A), Motivation (M) and Opportunity (O)* (Appelbaum et al., 2000). This has also been adapted by Mulder (2017b) as a product of competence (knowledge, skills, attitudes), opportunity (including resources, positions, task assignments) and motivation (including incentives, expectations and objectives) mathematically extending the formula to $P = C_{ksa} \times O_{rpt} \times M_{ieo}$. Future research should assess in detail the effect of other factors

(opportunity and motivation) on smallholder farmer performance in a developing country context in relation to the intervention in this study.

LIMITATIONS OF THE STUDY

In most cases, double-blind experiments are regarded to achieve a higher standard of scientific rigour than single-blind or nonblind experiments. Since the number of experts with experience with the CCBE/T model is limited, it was not possible to replace the researcher and conduct a double-blind study. Thus, there might be possible pitfalls in this regard, as the researcher may unconsciously influence the behaviour of the participants. Three educational psychologists took training on the CCBT model of Sturing et al. (2011) and assessed the training provided by the researcher and interrater agreement was computed for them to check the realizations of the 'H-CBT' and 'H-CBT' levels. Similarly, ATVET teachers who served as TAs received training on the model before training started and were provided with checklists that explain basic features of both the 'H-CBT' and 'H-CBT' levels. These teachers were also provided with tasks that smallholder farmers were expected to perform in authentic situations during maize planting and assessed their performance using a Likert-type scale which was defined with descriptors. However, both educational psychologists and ATVET teachers are not absolute creatures and may have made errors, were biased in observation, or did not recall the main features of the levels of 'L-CBT' and 'H-CBT' during their assessment activities. Such kind of sign is observed, for instance, in two or three TAs who were selective of tasks during their observations as evaluated by district experts, which again could result in smallholder's selective performance of tasks. There might be potential limitations in this regard. Besides, assessment of competence in practice is a difficult exercise, and this may affect the findings, particularly those analyzed based on TAs observations during maize planting. Although we applied a Likert-type questionnaire with a descriptor (as criterion-referenced test), inherent subjectivity may be there. Another limitation of assessing competence may emanate from its dependence on inferences derived from limited observations of sampled tasks in authentic job situations, which potentially may affect the validity of the research. Viewed from all these dimensions, there might be limitations. It is now understood that all these limitations, however, can be solved via strengthening multidimensional assessment strategies such as using different formative and summative assessment tools intensively, strengthening the assessments made by experts, and TAs by additional experts and TAs, and developing assessment programmes that are accompanied by institutional support, strengthening mentor support as crucial aspect in facilitating workplace learning (Maxwell, 2014), increasing subject-matter specialists (supervisors) who can act as coaches to help trainee smallholder farmers and DAs make a connection between what is learned at training institutions (FTCs) and how it is applied at work (Jackson et al., 2019), allocation of sufficient time for trainers (Mikkonen et al., 2017), and time to share feedback and to engage in training (Watters et al., 2013), availing resources like funds, infrastructure (Guimón, 2013), and experts in CCBT and strengthening self-regulation and reflection strategies among trainees themselves.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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