

Enhancing Pedagogy to Andragogy in the Redesign of Teacher Training Courses on Programming

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Abstract: Many countries have a new policy with an aim of involving computer programming earlier in the compulsory school curricula. In Sweden this should be implemented as a part of secondary school mathematics and technology. This reform has created a nation-wide need for teacher professional development with programming courses given by universities. For the universities this is a new learner group with a higher average age and different learning needs than the traditional younger students. The aim of the study was to identify and discuss opportunities and barriers for increasing the pass rate and learner satisfaction in programming courses for secondary school mathematics and technology teachers.

Main research questions in the study were, 1) Which factors for increased pass rates and participant motivation could be identified for teacher training courses on programming? and 2) How might these identified factors be related to course participants learning needs? This study was carried out as a case study involving triangulation of multiple data sources. Data has been gathered in a combination of self-assessment questionnaires, course evaluations and essays written by course participants from three different course instances. A content analysis was conducted to find and group themes in the data that are relevant to answer the research questions. The analysis has been partly inductive, and partly deductive with adult learning as the theoretical lens.

The study identifies 8 main themes that are important to consider as factors for course pass rate and participant motivation. The identified themes are: 1) Exchange of experience, 2) Practical work, 3) Help and support, 4) Alignment to prior knowledge, 5) Required time and commitment, 6) Level of difficulty, 7) Clarity and structure, 8) Participant expectation. Dependent on how these are addressed in teacher professional development courses, they can be opportunities or barriers for increased pass rate. The next step will be to apply and evaluate the identified themes in future course re-design.

Keywords: Adult learning, Andragogy, Programming, Teacher training, Teacher professional development

1. Introduction

Teacher professional development on 21st century skills such as technology literacy is an important ongoing process where higher education needs to adapt to adult learners' daily work and life conditions. Several research studies have found examples of traditional educational methods failure, and that the frequently linear instructional design in higher education does not align to the dynamic nature of contemporary workplaces (Hase, 2009; Moore, 2020). The Corona/Covid-19 pandemic has also been a catalyst for the shift from face-to-face activities to online learning (Hodges et al., 2020; Mozelius, 2020), a fact that strengthens the need for redesign of technology enhanced teacher professional development.

Many countries have recently introduced new policies on involvement of computer programming early in the compulsory school curricula. An ongoing process in the Swedish context is to introduce computer programming as a tool to reinforce problem solving and visualisation in K-12 education. A reform that has created a nation-wide need for teacher professional development on computer programming with contract courses given by universities. This is a new learner group with a clearly higher average age, and with different learning needs if compared to student groups at the regular bachelor's and master's programmes. For this new learner group there is a need for a tailored pedagogical model related to the daily life situation for adults with full-time employment. The aim of the study was to identify and discuss opportunities and barriers for increasing the pass rate and learner satisfaction in programming courses for secondary school mathematics and technology teachers.

This study was carried out with a case study approach with data gathered from three instances of a teacher training course on fundamental programming. In all the course instances authors have had the roles of teachers, subject matter experts and course designers. The important research questions to answer were: 1) Which factors for increased pass rates and participant motivation could be identified for teacher training courses on programming? and 2) How might these identified factors be related to course participants learning needs?

2. Theoretical framework

Looking at adult learning as a concept of its own with a specialised design, there are still similarities to what we call traditional pedagogy for childhood learning (Brookfield, 1995). Instead of emphasising the differences between the two, the recommendation is to also pay attention to what they have in common (Tuijnman and van der Kamp, 1992), and to see adult learning as an extension building upon pedagogy (Knowles, Holton & Swanson, 2015). Furthermore, it seems sensible to choose the parts of adult learning that are relevant for the actual learning context. This study has focused on how adult learning has been described by Knowles, Holton and Swanson (2015), with a set of fundamental core principles. According to Knowles, Holton and Swanson (2015) it is especially important for the adult learner to be able to relate what is to be learnt with previous knowledge and experiences. Besides goals and purposes, and situational and individual differences, that affect the learning, adult learning also has a set of core principles. The core adult learning principles that should guide the adult learning are summarised in 1) Learner's need to know; 2) Self-concept of the learner; 3) Prior experiences of the learner; 4) Readiness to learn; 5) Orientation to learning; 6) Motivation to learn. (Knowles, Holton & Swanson, 2015)

The first core principle (Learner's need to know), state that it is important that the adult learner not only know *what* is to be learnt; but also, *why* and *how* it is to be learnt. Learning how to learn might look superfluous in teacher training, but a concrete example from the teacher training courses on programming is that participants with a long experience of traditional learning sometimes have no experience at all of online learning. Learning to learn should also consider awareness of individual learning preferences. Most adult learners have developed a self-conscious awareness of how they have learnt what they know, and also an insight into the process of assumptions and justifications of what can be seen as true. (Brookfield, 1995) The second core principle (Self-concept of the learner), explains that the learning should be autonomous and self-directed by the adult learner. Self-directed learning, building on the idea that learners take control of their learning process, could preferably be applied to younger target audiences as well. Anyhow, adult learners with a long professional experience have a better opportunity to outline their own suitable learning methods. They also know better where to search and find relevant resources to facilitate the learning process. This might probably be pushed even further in teacher training, where participants are trained in pedagogy and didactics.

In the presentation of adult learning, Knowles, Holton and Swanson (2015) have argued that Andragogy should not be set in opposition to Pedagogy, and rather seen as a complementary extension for adult learning. Building on the same idea, adult learning can preferably also involve the extension of Heutagogy in what has been defined as the pedagogy–andragogy–heutagogy continuum (Blaschke, 2019; Moore, 2020). Applying this continuum, the learner's personal journey should involve the transition from traditional learning towards a more self-directed and self-determined learning. Course design must of course be related to this continuum, with a dependency on factors such as learning objectives and assessment requirements. The self in self-direction must not be interpreted as selfishness, and au contraire include that an adult learner ought to engage in social networks and collaborative learning (Brookfield, 1995). Adult learning also involves that the teacher role should shift towards a coach or facilitator of learning, instead of the traditional lecturer role (Hase & Kenyon, 2007; Henschke, 2011). However, as highlighted by Knowles, Holton and Swanson (2015, p. 53), adults can have strong habits of teacher dependency from earlier education, and *that "they often experience a culture-chock when first exposed to adult educational programs that require them to participate in the planning"*.

The third core principle (Prior experiences of the learner), suggest that the mental models and prior experiences of the adult learner should be used as a resource for learning. Experiential learning is a recommendation both in adult learning and in Heutagogy. An important principle that should build upon the learners' earlier unique experiences, and that those experiences become an integrated part of a more non-linear learning process (Hase, 2009). Like in other forms of work-integrated learning, diversity must be seen as an asset, and not the opposite. Learners with different backgrounds, different skill sets, and different perspectives should solve real-world problems in interdisciplinary activities with a course design instructional design that emphasises context-aligned

and problem-focused assignments (Cremers et al., 2016) This is aligned to the fourth core principle (Readiness to learn), and to highlight the importance of that adult learning should be life related and that tasks conducted in this setting are developmental. Adult learning should, by definition, adapt to adults' life conditions (Brookfield, 1995), which like the third principle, also can be found in constructionism, the pedagogical branch that is frequently used in programming education (Boyer, Langevin & Gaspar, 2008; Konecki, 2014). Constructionism should be implemented as learner-centred activities where learners are supposed to work with concrete tasks using prior knowledge to acquire new knowledge and to create mental models. A fundamental idea in constructionism is to visualise learning and thinking to engage learners in a process-oriented construction of useful real-world artefacts. (Alimisis & Kynigos, 2009)

The fifth core principle (Orientation to learning) points out that the adult learning should be problem centred and contextual. Problem-based learning could preferably be combined with constructionism in programming education (Mozelius, 2017), but the combination has been found to be fruitful also in the context of social sciences (Hmelo-Silver & Barrows, 2006). Regarding the aspect of contextualisation, teacher training courses on programming need a different course outline than traditional programming courses. Programming courses at university level has a tradition of training younger students for system development in the industry. Teacher training courses should instead have a focus on didactic concepts that after the course could be reused in the teachers' daily activities. An important design idea is to use programming techniques in teaching and learning activities aligned to the teachers' actual curricula (Mozelius, 2018). Finally, the sixth core principle (Motivation to learn), stress that the learning should focus on intrinsic value and personal payoff for the adult learner. This principle could further be underpinned by the Self-determination theory, an approach to understand human motivation and the role of humans' inner resources for personal development (Ryan, Kuhl & Deci, 1997). The Self-determination theory is based on three psychological needs, the need for competence (White, 1963; Harter, 1978), the need for relatedness (Reis, 1994; Baumeister & Leary, 1995), and the need for autonomy (deCharms, 1968; Deci, 1975).

3. Method

The study has been conducted as a case study with data collected from three different sources with the idea of data triangulation (Denzin, 2007; Fusch, Fusch & Ness, 2018). The use of multiple data sources is a common approach in case studies, since it allows for a deeper understanding of the studied phenomenon (Remenyi et al., 2002; Denscombe, 2014; Bryman, 2016). Data used in this study have been collected from three different instances of a professional development course on programming fundamentals for K-12 teachers (autumn semester of 2018, spring semester of 2019, and autumn semester of 2019). The three different data sources consist of self-assessment questionnaires conducted before the course, course evaluations conducted at the end of the course, and essays written by the course participants during the course (Table 1).

	Autumn 2018	Spring 2019	Autumn2019
Participants	60	32	15
Self-assessment questionnaires	57	26	15
Course evaluations	25	9	6
Essays	31	18	6

Table 1. Collected data

Data have been collected with the same instructions and within a similar context and time frame in all three course instances. The self-assessment questionnaire asked the course participants about their previous experience in programming and their expectations on the course. The course evaluation asked the course participants about their perception of the course and how it related to their expectations about the course. The self-assessment questionnaires and the course evaluations were free-text answers, except for some initial background questions. The instruction for the essay was to write a reflection on what challenges the course participants experienced in learning programming during the course.

The collected data have been analysed with content analysis to identify themes of interest to answer the study aim and research questions (Drisko & Maschi, 2016; Bryman, 2016). A mixture of inductive and deductive coding was used in the process of analysis. Inductive coding was used to identify and group themes of opportunities and barriers for increasing pass rate and learner satisfaction. Deductive coding was used to group these themes in bigger themes (categories) that relate to the core principles of adult learning (Knowles, Holton & Swanson, 2015).

4. Results and discussion

This study has identified 8 main factors (opportunities and barriers) for increased pass rate and learner satisfaction in programming courses for secondary school mathematics and technology teachers. In this section, these are presented and discussed in relation to the core principles of adult learning (Knowles, Holton & Swanson, 2015).

4.1 Exchange of experience

A theme in the course evaluations is that the teacher participants appreciated the discussion and cooperation with fellow teachers in the course. In this, they had the opportunity to share and learn from each other's experience and reflections on using programming in classroom practice. The self-assessment questionnaires also show that many teachers have a similar background and previous knowledge of programming. That is, teachers in grade 7-12 mathematics or technology with little or no prior knowledge in programming. This facilitates the exchange of experience among the teachers.

The exchange of experience is considered an opportunity for increasing the pass rate and learner satisfaction in the programming course. It is something that the teacher participants mention that they appreciate in the course evaluation, and it can be related to the core adult learning principle of *Learner's need to know* (Knowles, Holton & Swanson, 2015). By sharing and learning from each other, the course's *what* to learn is complemented by the teacher participants *why* and *how* to learn.

4.2 Practical work

A theme in the course evaluations is that the teacher participants appreciated the practical, hands-on, work with programming in the course. In this, they had the opportunity to test and develop their skill as programmers and develop their own teaching and learning material. A theme in the essays that the teacher participants wrote during the course is also that programming is perceived as a fun activity. Which is an important factor if the teacher participants are to pass this knowledge along to their students.

The practical work with programming in the course is mainly considered an opportunity for increasing the pass rate and learner satisfaction; and have a clear connection to the *what* in the core adult learning principle of *Learner's need to know* (Knowles, Holton & Swanson, 2015). Although many teacher participants considered programming difficult, and the pass rate could be increased by reducing the programming exercises in the course. It would be difficult to motivate teachers to take a course in programming if they did not learn how to program, which would affect learner satisfaction.

4.3 Help and support

A theme in the essays that the teacher participants wrote during the course is that there is a lot of freely accessible material available on the web. This can act as support for the teachers during and after the course in developing their own programming skill and their teaching and learning materials to be used with students. In the course evaluations it was also pointed out that the teacher participants wished for more one-on-one help by the course teachers.

The factor of help and support is considered both an opportunity and a barrier for increasing the pass rate and learner satisfaction in the programming course. It is a problematic factor since most teachers would, if they could, provide their students (adult or not) with all the help and support that they wanted. However, teachers at all levels of education are limited by the time that they are allocated. The factor could be made an opportunity for increasing pass rate and learner satisfaction by drawing on the core adult learning principle of *Orientation to learning* (Knowles, Holton & Swanson, 2015). By helping the teacher participants to orient their learning towards

seeking their own support, for example through the web, they gain a skill that will serve them even after the end of the course.

4.4 Alignment to prior knowledge

A theme in the essays that the teacher participants wrote during the course is that they consider programming easy to relate to their subjects and to previous knowledge in other fields. Some examples that the teachers mention are the subjects of mathematics, crosswords, problem solving and logical thinking. The teachers further state in the essays that they believe that this could be used to motivate their own students when they integrate programming.

The alignment to prior knowledge is considered an opportunity for increasing the pass rate and learner satisfaction in the programming course; and can also be related to the core adult learning principle of *Prior experiences of the learner* (Knowles, Holton & Swanson, 2015). But it can also be related to the core adult learning principle of *Self-concept of the learner* (Knowles, Holton & Swanson, 2015). By building on what the teacher participants already know, it allows for the learners to take control over their own learning; and the learning can be both autonomous and self-directed.

4.5 Required time and commitment

A theme in the course evaluation is that the teacher participants wished for more time in the course to learn programming, get help and tutoring from the course teachers, and have more campus lessons. Further, the teacher participants mentioned that they had not received sufficient time from their employer to participate in the course. A theme in the essays that the teachers wrote during the course is also that programming is perceived to take a lot of time and commitment to reach the level of proficiency that is required to be able to use it as a tool in their teaching and learning activities.

Required time and commitment is considered a barrier for increasing the pass rate and learner satisfaction in the programming course. It is an especially difficult barrier to overcome since it to a great extent is outside the course teachers and the participating teachers control how much time they get allocated. But it is a crucial barrier to overcome since it considerably undermines the core adult learning principle of *Learner's need to know* (Knowles, Holton & Swanson, 2015). To overcome this barrier both university/department leaders and school leaders must be included in the dialogue. In the meantime, the core adult learning principle of *Orientation to learning* (Knowles, Holton & Swanson, 2015) can be drawn upon to orient the participants towards problem centred learning that is situated in their own teacher practice. But this also requires time to prepare the teacher participants with sufficient programming knowledge to build upon.

4.6 Level of difficulty

A theme in the essays that the teacher participants wrote during the course is that programming is perceived as difficult to learn. Some reasons provided in the essays are that there are many new concepts to learn and a structure and logic that is unfamiliar to the participants. Further, some of the teachers mention that they consider it difficult to judge what learning support on the web is valid to use.

The level of difficulty in the course and the course-material is considered a barrier for increasing the pass rate and learner satisfaction. It is a delicate balance to find a level of difficulty that is appropriately challenging to motivate the participants to keep developing their knowledge; and not simply give up. This barrier relates to the core adult learning principles of *Prior experiences of the learner* and *Readiness to learn* (Knowles, Holton & Swanson, 2015). The course content should be based in what the participants already know. But the participants also need to be in a state or situation where they are ready, or are encouraged, to learn and be challenged.

4.7 Clarity and structure

A theme in the essays that the teacher participants wrote during the course is that they perceive a lack of guidance and clarity for the integration and use of programming in K-12 education. Some questions that are asked in the essays are: what is expected by the teachers? How should programming be used in their subjects? What is expected to improve by integrating programming? A theme in the course evaluation is also that some

of the teacher participants perceived a lack of structure in the programming course. An assignment that was added during the course, in an early iteration of the course, was mentioned in relation to this.

Clarity and structure are considered a barrier for increasing the pass rate and learner satisfaction in the programming course. It is a difficult barrier to address since perceived clarity and structure are individual to each participant; and you mainly notice them when they are lacking. A possible approach to address the barrier is to draw on the core adult learning principles of *Learner's need to know* and *Readiness to learn* (Knowles, Holton & Swanson, 2015). The course content should be as clear and structured as possible regarding *what* is to be learnt, and *why* and *how* this is to be done. Unnecessary surprises, such as adding course assignments during a course, should of course be avoided since the participants' allocated time is limited. But the teacher participants should also be made aware that not everything can be understood and perceived as clear in the beginning of a course. To reach this is part of the learning.

4.8 Participant expectation

There are three important themes in the self-assessment questionnaires that the teacher participants conducted before the course that related to their expectations on the course. The first theme is that they expect to learn more about programming. The second theme is that they expect to learn how to integrate and use programming in classroom practice. The third theme is that they expect to receive suggestions, ideas, and materials that they can use in their own teaching activities.

Participant expectation is considered both an opportunity and a barrier for increasing the pass rate and learner satisfaction in the programming course. The decisive factor if it is an opportunity or barrier is how the teacher participants expectations are addressed during the course. Some of the expectations that the teacher participants express in the self-assessment questionnaires are easier to satisfy. The expectations to learn more about programming and how it can be used and integrated in classroom practice are reasonable in a programming course for teachers. However, the expectation to receive suggestions, ideas and materials that can be used in teaching activities is more demanding and not typically what a university course provides. Nevertheless, since the participants' expectations on the course is closely related to the core adult learning principle of *Motivation to learn* (Knowles, Holton & Swanson, 2015) it is important that these are addressed. If the expectations cannot be meet, this should be explained to the participants, in line with the core adult learning principle of *Learner's need to know* (Knowles, Holton & Swanson, 2015).

4.9 General discussion

The identified factors for increased pass rate and learner satisfaction that has been presented and discussed in this section are all considered either an opportunity or a barrier, in some cases both, in relation to the programming courses in which they have been identified. All identified factors can of course be both an opportunity and a barrier for increased pass rate and learner satisfaction. This is dependent on how the course in question addresses these factors.

The identified factors have all been discussed and related to one or two core adult learning principles (Knowles, Holton & Swanson, 2015). This was based on the most obvious connections between the core adult learning principles and the identified factors in the programming course and should not be viewed as the only possible connections. If the identified factors are to be placed in another learning context, other connection to the core adult learning principles could potentially emerge.

In the analysis of the collected data, all identified factors for increased pass rate and learner satisfaction could be related to one or more core adult learning principles. In that sense, the study could be considered to confirm what is already known about adult learning. However, the study has also highlighted practical examples of these factors, or core adult learning principles, in action. An especially interesting example is that of *Required time and commitment*, which has the potential to undermine other core adult learning principles if not properly addressed. Further, in the context of teacher professional development courses, the participants' time and commitment for learning needs to be part of an ongoing discussion between the university/department and the participating teachers' schools and school leaders.

5. Conclusion

This study has identified 8 important factors for increased pass rate and learner satisfaction in teacher professional development courses. All of these relate to learning needs among the participants and can constitute opportunities or barriers for increased pass rate and learner satisfaction. Although these factors are identified in professional development courses on programming, they might also be valid for other forms of adult learning. The identified factors are: 1) Exchange of experience, 2) Practical work, 3) Help and support, 4) Alignment to prior knowledge, 5) Required time and commitment, 6) Level of difficulty, 7) Clarity and structure, 8) Participant expectation.

6. Critical reflection and future research

As highlighted by Agonács and Matos (2019), and further discussed by Moore (2020), self-determined learning and heutagogy have, despite their popularity and wide use, been criticised for lack of thorough evaluation. The same criticism can be found for adult learning and andragogy, and that Knowle's assumptions have become a wide-spread doctrine in adult education without solid empirical evidence (Henschke, 2011). Quite surprising since the term andragogy was used by the German educationalist Alexander Kapp as early as in 1833 (Henschke, 2011; Loeng, 2017). However, with the increased use in lifelong learning more evaluations will probably be carried out in the coming years.

As mentioned earlier, it is for every actual learning context a matter of choosing the parts of theory that are relevant, and to be open for other aspects of adult learning. The next step for further redesign and refinement of the teacher training courses on programming could be to further investigate the pedagogy-andragogy-heutagogy continuum and look at how ideas from heutagogy might facilitate adult learning in technology-supported personal learning environments (Blaschke, 2019). In a strive towards teacher professional development with autonomous learners who are capable of self-determined learning, and to build upon their earlier knowledge in tailored online environments.

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