An action research study of the growth and development of teacher proficiency in mathematics in the intermediate phase – an enactivist perspective. Work-in-progress
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Abstract
This paper reports on a current research project that focuses on an action research study of a pre-service mathematics education module to grow and develop proficient teaching in mathematics in the intermediate/middle school phase. The aim of this research study is to ascertain if a fourth year mathematics education module whose teaching pedagogy is informed by the underlying themes of enactivism will develop and grow pre-service teachers’ proficiency in teaching mathematics in the intermediate phase. The focus of this presentation will be to report on the outcome and my analysis of the first research cycle and to highlight the way forward in the second cycle of this action research project.

Introduction
The intention of this research project is to determine if a mathematics education module informed by an enactivist orientation and teaching pedagogy will enable pre-service teachers participating in the module to unpack the reality of their teaching practice in terms of proficient teaching through active participation in lectures and practical tutorial sessions. My theoretical framework is informed firstly by enactivism and secondly by the use of the underlying themes of enactivism, as introduced by Di Paolo, Rohde and De Jaegher (2007), as a vehicle to develop teaching proficiency.

The investigation is an action research study that encompasses a fourth year mathematics module for BEd. Degree pre-service teachers training to teach in the foundation phase. The module has been designed to equip the foundation phase pre-service teachers with the necessary skills and content to teach mathematics in the intermediate phase. The aim of this mathematics module is to develop and grow pre-service teachers who will one day be role models for their learners and instil in their learners a love and interest in mathematics. Thus the module has been designed to augment the pre-service teachers’ basic skills in mathematics and provide them with opportunities to become competent in basic mathematics and pedagogic skills for the Intermediate Phase. The intention of this module is to develop both their confidence and proficiency in mathematics and their proficiency in teaching mathematics in the Intermediate Phase.

Enactivism
Enactivism is a philosophy that views the body, mind and world as inseparable and was originally developed by Merleau – Ponty. It was then further developed by Maturana and Varela; Thompson and Rosch (Davis, 1996), as an alternative to the bipolar and divisive nature traditionally associated with western thinking. As a philosophy enactivism recognises the structure of an individual to be a combination of both their biological composition and their personal history of interacting with the world. Enactivism also “focuses on the importance of embodiment and action to cognition” (Li, Clark & Winchester, 2010:403). Consequently the structure of the individual is considered to be adaptable as it changes to make sense of new experiences and challenges.

Since enactivism considers cognition to be a complex co-evolving process of systems interacting and affecting each other, cognition is deemed to be a producer of meaning and not a processor of information. Therefore an individual’s interactions with the world and their past experiences will shape and influence the meaning that they make of their world (Lozano, 2005). Thus any perturbation will present an opportunity for an individual to act according to his/her structure and it is the structural make up of the individual that determines what and the extent of the change that occurs. Enactivism encourages learning and the construction of knowledge by means of a collaborative process, thus any given learning situation must encompass the lecturer, the student, the content and the context in order for some form of interaction to take place.

From an enactivist perspective the role of the lecturer is that of a “perturbator” in order to encourage and provoke learners into “thinking differently” about mathematical concepts that may not form part of their personal
construct. With this in mind, I have chosen to use five underlying themes of enactivism (Di Paolo, Rohde and De Jaegher, 2007; McGann, 2008) namely autonomy, sense-making, emergence, embodiment and experience to underpin my pedagogic practice. A number of tasks and practice will be developed or drawn from the literature where they have been applied in other mathematics contexts and adapted with the intention of developing teaching for mathematical proficiency skills.

**Underlying themes**

I have used the five underlying themes to assist pre-service teachers to determine what embodied views of cognition reveal about their personal proficiency in mathematics, their mathematical identity and their self development. Furthermore the themes will help to ascertain how the pre-service teachers’ embodied perceptions of their mathematical proficiency support their own teaching for mathematical proficiency during the practical tutorial sessions.

Di Paolo, Rohde and De Jaegher (2007) indicate that living organisms are autonomous due to their ability to create their own identity that characterises them as a unique entity. In this research study the pre-service teachers’ mathematical identity is representative of autonomy since enactivism argues that one’s identity is enacted and therefore determined by the interplay between biology and human culture and the individual’s manner of dealing with life’s experiences.

With regard to the second theme, namely sense-making, according to Di Paolo, Rohde and De Jaegher (2007) this refers to the way an individual actively participates in generating meaning of their world with changes occurring as a result of dialogue between the individual and the environment. Davis (1996) introduces the notion of listening as an embodied action that enables one to understand human communication and collective action. Thus sense-making will manifest in my pedagogy through encouraging and creating opportunities for the pre-service teachers to play an active and participatory role in emerging conversations and to engage in different types of listening.

The third theme, emergence, is explained by Davis (2004) as the notion that understanding and interpretations are generated through shared activities over a period of time, as opposed to predetermined learning objectives. In addition, Davis (2004) raises the point that learning is not the site of the individual, be it learner centred or teacher centred, but rather the collective generation of knowledge and understanding. Therefore this research study will use various reflective techniques to encourage the students to reflect on what they have learnt during a particular lecture or tutorial and to acknowledge the role that the community of practice, autonomy and sense making have played in their understanding of and culmination of the learning process.

According to Li, Clark and Winchester (2010) the embodied experience that an individual undergoes is due to the bringing together of the mind and body by means of reflection. Di Paolo, Rohde and De Jaegher (2007) augment this notion indicating that cognition is an “embodied action” (p.11) in that the mind and body form part on a living system composed of various “autonomous layers of self-coordination and self-organization” (p.12) which allow it to interact with the world in “sense-making” activities, with the understanding that the body is not controlled by the brain. Davis (2004) suggests that embodiment refers to the idea that individuals are all part of a larger collective system and cites Kauffman’s description of the relationship between the collective and the individual as one in which “the collective is enfolded in and unfolds from the individual” (p. 213). With this in mind an aspect of the pedagogical practice is to encourage the formation of a mathematical community of practice amongst the pre-service teachers to research its influence on the lesson preparation and sense making processes.

Finally the pre-service teachers will be given the opportunity to experience developing lessons for the intermediate phase and teaching for proficiency. Furthermore, it is anticipated that these experiences will change through embodied action and the emergent process. In the initial stages of the module,
activities are incorporated to encourage pre-service teachers to discuss their experiences and critical incidents of mathematics teaching. Further the students will need to determine the influence that these experiences have had in determining what they understand by proficiency and their role as a teacher in trying to teach for mathematical proficiency.

In order to analyse the growth in proficiency, Kilpatrick, Swafford & Findell’s (2001) framework for mathematical proficiency is the core analytical framework for the research project, since the authors are cognisant of the importance of noticing and analysing learners’ interpretations and of the role that different contexts, especially environmental and situational elements, play in the teaching and learning process. Kilpatrick et al (2001) identify mathematical proficiency as encompassing five interwoven and interdependent strands, namely, conceptual understanding; procedural fluency; strategic competence; adaptive reasoning and a productive disposition.

Action Research Cycle
In this study the pre-service teachers’ involvement in the decision process entails providing feedback on the tutorial sessions in the form of a class group interview at the conclusion of each tutorial session and through their reflective journals. Enactivism views cognition as a complex co-evolving process of systems interacting and affecting each other, not as processors of information but as producers of meaning. Lozano (2005) explains this as the manner in which an individual’s interactions with the world and their past experiences shape and influence the meaning that they make of their world. The pre-service teachers will reflect on their experiences at each tutorial session and identify what aspects or critical incidents they believe have influenced their proficiency. As the researcher, I will analyse this data using Kilpatrick et al’s (2001) five strands of mathematical proficiency to determine the growth and development of proficiency. This information in turn will be used to inform the development of the next lecture so that different activities and tasks can be developed to encourage and grow proficiency.

The module comprises a double lecture weekly in which enactivist pedagogy is role-modelled and mathematical theory and content discussed. In addition to the lectures, weekly practical tutorials are held during which the pre-service teachers are given the opportunity to develop their mathematics teaching skills. Since there are fifty pre-service teachers, the class has been divided into two groups with each group attending fortnightly tutorials.

Each of the tutorial groups is further subdivided into five groups with 5 pre-service teachers in each, three teaching groups, one learner group and one observation group (see figure 1). Therefore at each tutorial session the three teaching groups are given the opportunity to teach a mathematical concept, the learner group takes on the role of the learners and the observation group monitors and analyses the teaching process identifying critical incidents and completing an observation sheet underpinned by the 5 strands of proficiency. Over the duration of the year the groups in each tutorial session will rotate so that each pre-service teacher will have the opportunity to be either in a teaching, learner or observation group. The pre-service teacher will remain in the same group of 5, both for tutorial sessions and lectures, thus forming their own mathematical community to assist with the sense making process.

![Figure 1](image.png)
The three teaching groups will be given prior warning of the content that they will be required to teach with the expectation that they will then develop a 15 minute micro lesson that encompasses some of the strands of mathematical proficiency. All the members of the teaching groups contribute to the preparation of the lesson and resources, although only one member from each teaching group is given the opportunity to teach the lesson at the tutorial session. During the course of the year a number of pre-service teachers will be given an opportunity to teach a lesson. At the conclusion of the first micro lesson, the pre-service teachers will be given a few minutes entering into conversation as to the outcome of the lesson with regard to teaching for proficiency. The teaching group and the learner group will discuss what strands of proficiency they believed had been addressed, while the observation group will identify critical incidents that they deem to have impacted on and affected teaching for proficiency. The role of the observation group is to notice and identify which strands of proficiency have been addressed, what enactivist pedagogic strategies and themes have had a positive effect and where and what difficulties have arisen in the lesson delivery and activities. This same process will then be repeated for the second and third teaching group. Following the final lesson, the tutorial session concludes with a class group interview with all the pre-service teachers, relating to the lessons observed and the perceived growth and development of teaching for mathematical proficiency and the contributing factors.

Conclusion
In presenting this paper it is my intention to discuss and reflect on my experiences pertaining to the first cycle of the research. Since enactivism is a theory that has not been researched widely in South Africa, I hope to engage the audience in a conversation as to the merits of my research to date and my objectives for the second cycle.

References
Di Paolo, E, M Rohde and H De Jaegher (2007) Horizons for the enactive mind:

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