Modelling the relationship between prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action using neural networks

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ABSTRACT

Previous work on the relationships between entrepreneurship education, prior entrepreneurial exposure and entrepreneurial action has resulted in mixed findings. However, this work typically relies on linear models which may not adequately account for the relationships. Therefore, we explore artificial neural networks (ANN) to test non-linear relationships and compare these results with a linear regression model to understand the previous mixed findings. Data from 125 entrepreneurship graduates in Zambia revealed that a non-linear model best explained the variation in entrepreneurial action, whereby the relationship was cubic. These results explain some of the previously mixed findings and demonstrate the importance of educators, policy makers and scholars paying attention to non-linear relationships when aiming to promote and further understand entrepreneurship. Therefore, this paper has implications for educational initiatives aiming to augment entrepreneurship education, while also contributing to the development of theory explicating the relationship between entrepreneurial exposure, education and action.

KEYWORDS: Entrepreneurial action; entrepreneurship education; prior entrepreneurial exposure; emerging economy context; neural networks; non-linear relationship

1. Introduction

The weak translation of entrepreneurial intentions into entrepreneurial action seems to be a concern for emerging and advanced economies alike (Nabi et al., 2010). In an attempt to address this intention-action dilemma, entrepreneurship scholars ask some compelling research questions which have important implications for policy and practice. For example: Does having an entrepreneurship education lead to entrepreneurial action (i.e. business start-up)? and, Does prior entrepreneurial exposure influence business start-up? For years, these questions have been investigated by relying mainly on testing linear relationships, with largely ambiguous results (Henry et al., 2005; Falck et al., 2012). Consequently, scholars have begun to question the effectiveness of entrepreneurship education interventions (Rauch & Hulsink, 2015). This paper, therefore, investigates non-linear relationships between these constructs due to the potential to bring more clarity into the role entrepreneurship education and entrepreneurial exposure play in entrepreneurial action (Zekić-Sušac et al., 2013).

The relationship between prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action is supported by the Human Capital (Karlsson & Wigren, 2012); Planned Behaviour (Ajzen, 1991), and Social Learning (Van Auken et al., 2006) theories. While these theories support a positive relationship between these three constructs (Ajzen, 1991; Van Auken et al., 2006; Karlsson & Wigren, 2012), results on the effect of entrepreneurship education on action have been mixed. Some studies find a positive effect (Fayolle et al., 2006; Turton & Herrington, 2012; Fretschner & Weber, 2013; Sánchez, 2013), while others find a negative effect (Oosterbeek et al., 2010; Von Graevenitz et al., 2010; Walter et al., 2013). Furthermore, scholars have pondered the role that prior entrepreneurial exposure plays in this relationship, yet few have empirically investigated it (Hussain et al., 2010; Muofhe & Du Toit, 2011; Conners & Ruth, 2012).

The disjoint between empirical work and theoretical predictions as outlined above suggests that further work from a novel perspective is needed to bring clarity to the relationships under investigation. We contend that research designs sometimes fail to recognise that both prior entrepreneurial exposure and entrepreneurship education may interact to increase the chances of potential entrepreneurs moving into entrepreneurial action. To the degree that we isolate prior entrepreneurial exposure and entrepreneurship education, we risk inflating or diminishing the importance of these constructs in accounting for entrepreneurial action. However, capturing such interaction effects using a pre-specified model may be impracticable, particularly when the effects are complex. Additionally, we identify the investigation of non-linear relationships as a potentially fruitful avenue for enhancing understanding of entrepreneurial action. Hence, we use artificial neural networks, referred to as ANN, (i.e. testing non-linear relationships) as a novel approach to resolve these challenges. This approach has been relatively underutilised in entrepreneurship research, yet has grown in other business and management disciplines and refers to a technique which identifies patterns and trends in a string of behaviours (John et al., 2000). We utilise ANN to model prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action and determine to what extent a non-linear relationship explains entrepreneurial action as well as which pattern of non-linear relationship exists based on curve estimation. More specifically, the objectives of this paper are to: (1) illustrate the use of ANN in the investigation of these constructs, and (2) compare the explanatory power of ANN to regression analysis in predicting entrepreneurial action.

The first contribution of this paper thus lies in the investigation of a more intricate relationship between these three constructs, which has hitherto not received research attention. This paper constitutes a first attempt at modelling the relationship between prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action using ANN. By finding that entrepreneurial action is better explained by modelling non-linear versus linear relationships, we contribute to a more intricate understanding of how entrepreneurial exposure and education may impel entrepreneurial action. Relatedly, the second contribution is the rendering of new insights into the modelling of all three constructs in one relationship which reaffirm the predictions of prior theory. More specifically, this paper supports the positive predictions of the Human Capital; Planned Behaviour and Social Learning Theories; while suggesting there is more to the story in terms of the curvilinearity of the predicted relationships. Thus, this research suggests new directions for entrepreneurship pedagogy to enhance entrepreneurial activity, while also

carrying broader applicability regarding the development of theories explaining the entrepreneurship education, exposure and action relationships. Given the prior mixed results regarding the benefits of entrepreneurial education for subsequent action, it is important to understand whether this pedagogical intervention has the potential to offer tangible value. To this end, the third contribution lies in the findings possibly assisting policy makers, educators and scholars to focus on non-linear relationships by using ANN with the aim of promoting entrepreneurship education, augmenting pedagogical interventions and more accurately measuring the effect thereof.

2. Theoretical foundation and hypotheses development

2.1. Entrepreneurship education

Entrepreneurship education is said to encompass the development of skills, competencies and knowledge in new venture creation, management and growth (Henry et al., 2005; Rideout & Gray, 2013). As such, scholars have investigated the potential for entrepreneurship education to shape attitudes towards entrepreneurship and encourage business start-up (Galloway & Brown, 2002). However, recent evidence shows that emerging and advanced economies alike are rated relatively poorly in terms of the effectiveness of their entrepreneurship education interventions (Singer et al., 2018). This evidence is particularly concerning in emerging economy contexts such as Zambia due to their low entrepreneurial action levels (Turton & Herrington, 2012). Yet, Kassean et al. (2015) highlight that individuals can be taught to start and grow entrepreneurial businesses and research is required to understand how to achieve this goal and enhance entrepreneurial action levels.

2.2. Relationship between entrepreneurship education and entrepreneurial action

Entrepreneurial action, such as starting a business, is a complicated and challenging endeavour, entailing various activities (Souitaris et al., 2007). These activities include: securing facilities and equipment, preparing a business plan, seeking and acquiring financial support, forming a legal entity, organising a team, investing personal funds and devoting full time to the business (Carter et al., 1996). While theory supports a positive relationship between entrepreneurship education and entrepreneurial action, mixed findings are prevalent, and debate has stirred regarding the actual benefits of entrepreneurship education for entrepreneurial action (Rauch & Hulsink, 2015).

Based on human capital theory (Karlsson & Wigren, 2012) skills, knowledge and experience provide individuals with improved human capital which can lead to higher performance outcomes. Therefore, entrepreneurship skills and knowledge acquired through entrepreneurship education should enhance individuals' abilities to recognise (Robinson & Sexton, 1994; Lim et al., 2010) and exploit entrepreneurial opportunities (Souitaris et al., 2007; Oosterbeek et al., 2010; Von Graevenitz et al., 2010). This should lead to a greater likelihood of starting a business (Robinson & Sexton, 1994; Delmar & Davidsson, 2000; Davidsson & Honig, 2003). At the same time, Linan (2008) asserts that the Theory of Planned Behaviour (Ajzen, 1991) supports a positive relationship between entrepreneurship education and entrepreneurial action through the stimulation and augmentation of a

student's attitude and intention towards an entrepreneurial career (Ajzen, 1991). Such theoretical arguments would support suggestions by some scholars that entrepreneurship education can lead to entrepreneurial action (Rauch & Hulsink, 2015; Nabi et al., 2017; Nabi et al., 2018), as well as empirical work finding a positive effect of entrepreneurship education on students' intentions to start a business (Turton & Herrington, 2012; Fretschner & Weber, 2013; Sánchez, 2013; Fayolle & Gailly, 2015). However, some scholars report a low start-up rate among university graduates and further suggest that entrepreneurship education does not necessarily lead to entrepreneurial action (Nabi et al., 2010; Støren, 2014; Zhang et al., 2014). In fact, there is research reporting a negative and discouraging effect of entrepreneurship education on entrepreneurial intention and action (Oosterbeek et al., 2010; Von Graevenitz et al., 2010; Walter et al., 2013).

Prior research (Fayolle & Gailly, 2015; Nabi et al., 2017; Nabi et al., 2018) offers possible explanations for these mixed findings which could put the effect of entrepreneurship education on entrepreneurial intention in perspective. In their past reviews and meta-analysis on the impact of entrepreneurship education in higher education, Nabi et al. (2017) found that prior research predominantly focuses on short-term and subjective outcome measures and do not describe the actual pedagogies being tested. These authors suggest that future research should focus on the impact indicators related to the intention-to-behaviour transition and should explore the reasons for the contradictory findings between entrepreneurial education and intention. Nabi et al. (2018) confirm that the relationship between entrepreneurial education and intentions can be positive or negative depending on the learning and aspirations of students throughout their Higher Education years. These authors emphasise that the effect of entrepreneurial education programmes on entrepreneurial intentions should be measured longitudinally to fully understand the stability of intentions and the influence of entrepreneurship education. Fayolle & Gailly (2015) argue that the mixed findings could be due to the sample that is being measured. Theses authors state that the Theory of Planned Behaviour can only be used effectively in the relationship between entrepreneurship education programmes and entrepreneurial intention if the sample that is measured, is homogeneous. Fayolle & Gailly (2015) state that for heterogeneous groups, factors such as previous entrepreneurial experience and role models cannot properly be defined and taken into account.

The above discussion accentuates that the mixed findings could be due to the sample that is being measured, the lack of longitudinal measurements as well as the lack of determining the impact of the transition between intention and behaviour. One other factor that could also explain the mixed findings, is the typical use of linear models to explain the relationship (Davidsson & Honig, 2003; Wilson et al., 2007; Støren, 2014; Rauch & Hulsink, 2015; Nabi et al., 2018). Indeed, Venesaar et al. (2006) emphasise that graduates are not ready to pursue entrepreneurial action immediately after graduation, and some empirical support has been found for this argument (Botha & Ras, 2016) which suggests that non-linear effects may be present. Another such factor that might contribute to understanding the mixed findings, could be the inclusion of prior entrepreneurial exposure in explaining the relationship (Fayolle & Gailly, 2015).

2.3. Prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action

Prior entrepreneurial exposure includes having entrepreneurial work experience, parents and/or role models (Peterman & Kennedy, 2003). Recent work has called for the inclusion of more real-world entrepreneurial exposure in entrepreneurship education to better stimulate entrepreneurial propensity (Kassean et al., 2015). This call should not be a surprise as prior entrepreneurial exposure has been positively associated with entrepreneurial intentions (Malebana, 2017), and business start-up (Schroder & Schmitt-Rodermund, 2006; Falck et al., 2012). This positive association is consistent with Bandura's Social Learning Theory (Bandura & Walters, 1977) which posits that individuals learn and acquire new behaviours through observing and modelling the actions and attitudes of others (Van Auken et al., 2006). On this basis, the learning opportunities provided by prior entrepreneurial exposure would tie in well with entrepreneurship education to enhance action (Hout & Rosen, 2000; Chlosta et al., 2012). Indeed, Hussain et al. (2010) found that entrepreneurship education and prior entrepreneurial exposure were positively correlated. This is likely because the interest in entrepreneurship arising from prior exposure propels individuals towards entrepreneurship education in order to improve their entrepreneurial abilities and skills (Peterman & Kennedy, 2003). According to Muofhe & Du Toit (2011), entrepreneurship students view the effect of entrepreneurial role models on their career decisions as more influential than non-entrepreneurship students and are inspired to become successful entrepreneurs themselves. Furthermore, Bae et al. (2014) argue that students with prior entrepreneurial exposure have a higher probability, relative to those without such a background, of acquiring key resources and social networks which would assist start-up. Therefore, the mixed findings and debate regarding whether entrepreneurship education can actually lead to entrepreneurial action (Rauch & Hulsink, 2015), may be resolved through the inclusion of entrepreneurial exposure in determining entrepreneurial action.

Having said that, there is evidence that suggests that prior entrepreneurial exposure could have negative or no effects on the relationship between entrepreneurial education, entrepreneurial intention and/or action. Zapkau et al. (2015) argue that prior entrepreneurial exposure can be perceived as positive or negative and can therefore affect an individual's entrepreneurial intentions positively or negatively. Krueger (1993) found no direct effect of prior entrepreneurial exposure to entrepreneurial intention or action. However, Zhang et al. (2014) suggest that the relationship between prior entrepreneurial exposure and action could be negative if a person is exposed to a negative role model or entrepreneurial parent. From this discussion, it is evident that factors such as the type of person as well as the type of entrepreneurial exposure could play a role in how prior entrepreneurial exposure affects a person's intentions and actions. Zapkau et al. (2015) specifically found that entrepreneurial intention is influenced by the type of individual (e.g. entrepreneurial parent or role model) that an individual is exposed to as well as the age of the individual when they are exposed. Kautonen et al. (2014) agree and found that if a person is exposed to prior entrepreneurial experience at a young age, their entrepreneurial intentions are higher compared to an older person who are exposed to prior experience towards the end of their professional career.

This discussion increases our understanding that the relationship between prior entrepreneurial exposure and entrepreneurial intention and action is complex and influenced by various factors. However, the literature does suggest that there is an association between these constructs which could be positively or negatively perceived. It is, thus, hypothesised that:

H1: Prior entrepreneurial exposure and entrepreneurship education are associated with entrepreneurial action in linear models.

Figure 1 depicts the relationship between the three constructs in a linear model where both entrepreneurial exposure and education explain action:

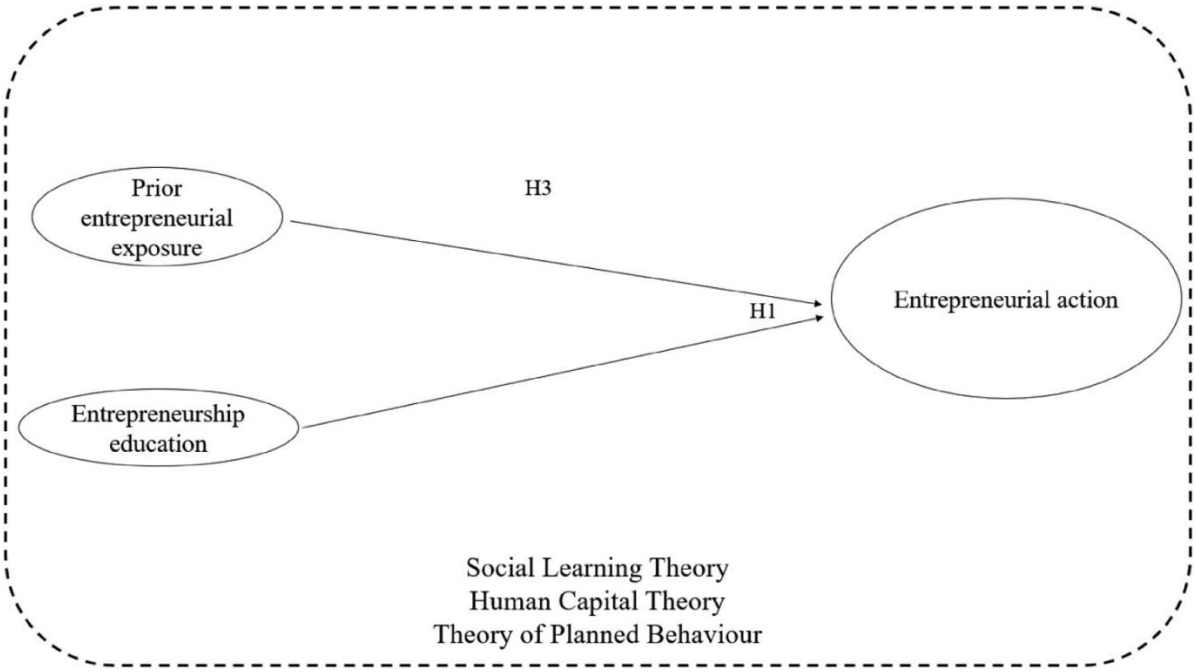

Figure 1. Construct associations in a linear model supported by relevant theories.

2.4. Linear versus non-linear models of the relationship

Most studies focusing on entrepreneurial education and action (Davidsson & Honig, 2003; Wilson et al., 2007; Støren, 2014), as well as prior entrepreneurial exposure and action (Dunn & Holtz-Eakin, 2000; Gird & Bagraim, 2008; Chlosta et al., 2012), employed variations of the General Linear Model, which includes regression, discriminant, and variance analyses, as well as Structural Equation Modelling (SEM). Therefore, mixed findings in the preceding discussion might be a result of linear models not adequately capturing the relationships between these three constructs. Entrepreneurial action involves complex sequences of activities occurring over time (Shepherd, 2015), with positive and negative feedback loops (Shepherd et al., 2010), which may render non-linear patterns over time.

Burke & Ignizio (1992) state that ANN is well suited in the case of complex, intricate and subjective relationships; suggesting an avenue to investigate entrepreneurial action in this paper. Although their interests have predominantly been in the management discipline

rather than entrepreneurship, researchers have investigated neural networks in both disciplines with the aim of modelling prior unexplained non-linear relationships. John et al. (2000) found that the use of ANN provided 95% classification accuracy in modelling the non-linear relationship between corporate strategy and wealth creation, a substantially better result than that of linear models. The work by Lin (2006) drew on social cognitive theory and used ANN to test, and ultimately verify, the relationship between entrepreneurial intentions of firms, environmental uncertainties, decision styles and strategic postures. Furthermore, Zekić-Sušac et al. (2013), found that ANN can be an efficient method for modelling entrepreneurial intention and suggest its use in future research, particularly research into entrepreneurial career choices, which they argue involves several interactional inputs which may influence the choice in a variety of ways and directions (Zekić-Sušac et al., 2013). In agreement, other scholars have recently compared ANN to linear regression analyses in terms of the ability of these two techniques to accurately predict entrepreneurial intentions among university graduates and found that ANN performed significantly better (Moremong-Nganunu et al., 2018). These studies indicate that ANN can be fruitfully used to test complex constructs such as entrepreneurial action (or business start-up). This construct is likely to be explained better (improved model fit) through modelling non-linear relationships as opposed to linear relationships, leading to our second and third hypotheses:

H2: Prior entrepreneurial exposure and entrepreneurship education are associated with entrepreneurial action in non-linear models.

H3: Neural network analysis will provide an improved model fit for entrepreneurial action, prior entrepreneurial exposure and entrepreneurship education than linear regression analysis, which may suggest the presence of non-linear effects.

Figure 2 depicts the relationship between the three constructs in a non-linear model:

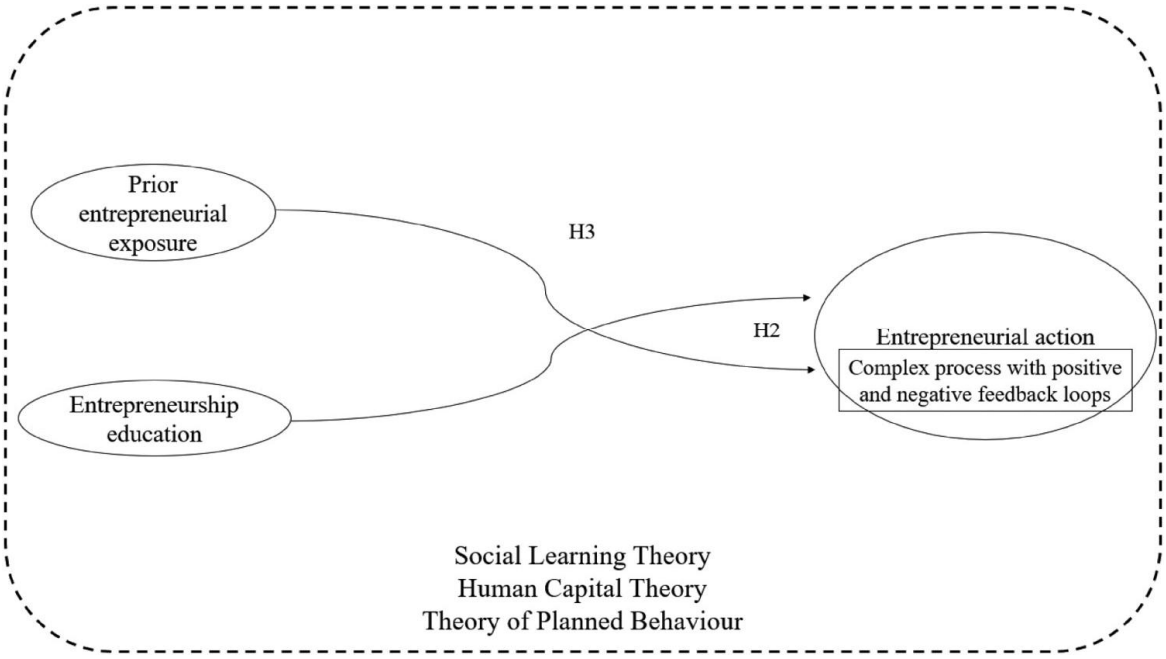

Figure 2. Construct associations in a non-linear model supported by relevant theories.

3. Methodology and research design

The paper adopts an empirical cross-sectional design in order to test the hypotheses. The purpose of this research was to apply both ANN as well as multiple linear regression analysis to understand the relationship between entrepreneurial education and prior entrepreneurial exposure (as the two independent variables) and entrepreneurial action (as the dependent variable). A neural network is an artificial intelligence system, which is structurally designed to resemble the neural system and functionality of the human brain to address the kind of problems that the brain solves efficiently (Rondon et al., 2008; Ciampi & Gordini, 2013). Neural networks techniques include a wide category of flexible, non-linear, regression, discriminant and data reduction models, as well as non-linear dynamical systems.

3.1. Population and sample

The study comprised of a random sample of 150 entrepreneurship graduates from various universities in Zambia such as Mulungushi University, University of Lusaka, Chreso University and Livingstone International University for Tourism Excellence and Business management. A total of 125 entrepreneurship graduates completed the survey, representing a response rate of 83.33%. The distribution according to gender was reasonably equal, 51.2% (64) respondents were female. Most of the respondents were from Lusaka (40) and Copperbelt provinces (59) in Zambia. These two provinces comprise the industrial hubs and most urbanised provinces in the country, hence, explaining the higher number of responses from these provinces. Respondents were relatively evenly dispersed in terms of time elapsed since graduation, with 32.8% indicating they graduated less than one year ago, 29.6% graduating one to five years ago, 24.8% graduating six to 10 years ago, and only 12.8% graduating more than 10 years ago. The mean age for the sample was 30.06 years (SD = 6.43) and ranged between 22 and 48 years.

3.2. Data collection and survey

A structured survey was administered via email. Prior entrepreneurial exposure was measured by adapting the four-item scale by Peterman & Kennedy (2003). The original dichotomous scale was adapted to a five-point Likert scale and the wording adjusted to better apply to the Zambian context. The scale represents a scope of respondents' entrepreneurial experiences ranging from experience from entrepreneurial parents, family members, role models and prior entrepreneurial work experience in a family business. Entrepreneurial action was measured by adapting the scale by Rauch & Hulsink (2015). The original 18-item dichotomous scale was adapted to a five-point Likert scale which covers a representative range of actions associated with new venture creation. For example, it includes items such as; 'I have searched for some facilities and equipment to enable me to start a business' and asks respondents to what extent this is the case. Entrepreneurial education was measured by adapting the scale by Souitaris et al. (2007). The eight-item, five-point Likert scale covers a range of competencies associated with an entrepreneurship education intervention and rates the extent to which the respondent believes these competencies have been developed as a result.

3.3. Data analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSSv25). The neural network (ANN) analysis was conducted using a feed forward network, also known as multilayer perceptron (MLP). In ANN, the independent variables are called inputs and the dependent variables, outputs. Furthermore, a perceptron is a linear classifier; meaning that it is a formula which categorises input by dividing two categories by a straight line. A MLP network comprises of multiple perceptrons, which are formed from an input layer which receives the signal, an output layer which decides or predicts the input, and within those two, a random quantum of hidden layers which are the true computational mechanism of the MLP. The hidden layer (also called a hidden layer neuron) is a neuron which has its output linked to other neurons' inputs and is therefore not observable as a network output (resulting in the term hidden layer). An MLP with a hidden layer is able to estimate any continuous function. In this case, the model includes estimated weights between the inputs and the hidden layer which uses non-linear activation functions, thus the model is genuinely non-linear, i.e. non-linear in the parameters (called synaptic weights).

The sample is divided into a training and testing set where the training/reference set of data is inputted to the classifier to 'learn' about the data. We need to know the correct classes (called labels) in the training set. The testing set of data is used to test the results of the algorithm built based on the training data where the labels are known but have no overlapping individuals with the training set. It is acknowledged that the sample size and number of variables were very small in utilising a ANN. However, this research is regarded as a first step in exploring the use of ANN in studying the relationship between entrepreneurial education, exposure and action and is, hence, deemed acceptable for this explorative purpose.

4. Results

4.1. Scale validity and reliability

Exploratory factor analysis (EFA) was performed to confirm the validity of the measurement scales used in this study and was appropriate since the scales were adapted from a context which differs from where they originated (Field, 2018). Thereafter, Cronbach's Alpha coefficients (α) were calculated to determine these factors' internal consistency reliabilities.

Following EFA, a single factor was extracted for the prior entrepreneurial exposure variables (Eigen value = 2.159), which explained 53.98% of the variance. The entrepreneurial education variables included eight entrepreneurial competency items and EFA revealed only one factor (Eigen value = 2.823), explaining 47.05% of the variance. Similarly, the entrepreneurial action variables revealed a single factor structure (Eigen value = 14.315), which explained 79.53% of the variance. Cronbach alpha values exceeding 0.70 are regarded as acceptable (Nunnally, 1978). The Cronbach Alpha values were 0.787, 0.769, and 0.984 for the entrepreneurial exposure, entrepreneurial education competencies, and entrepreneurial action factors respectively. Therefore, the retained factors had acceptable reliability.

4.2. Descriptive statistics

Table 1 presents the descriptive statistics (Mean, Std Deviation, Skewness and Kurtosis) and Pearson's product-moment correlations between the main variables in this research (prior entrepreneurial exposure, entrepreneurial action and entrepreneurial education).

Table 1. Descriptive statistics and correlation of the main variables in this study.

	Entrepreneurial exposure	*Entrepreneurial action*	*Entrepreneurial education*
Mean	*3.443*	*2.275*	*3.831*
Std. deviation	*1.170*	*1.354*	*0.688*
Skewness	*-0.541*	*0.436*	*-0.897*
Kurtosis	*-0.792*	*-1.518*	*1.920*
Entrepreneurial exposure	*1*		
Entrepreneurial action	*0.217**	*1*	
Entrepreneurial education	*0.233***	*0.183**	*1*

Note: *$p < 0.05$, **$p < 0.01$.

While, on average, respondents reported a large positive impact of an entrepreneurship education intervention (mean = 3.833, SD = 0.688), they reported only experiencing limited prior entrepreneurial exposure (mean = 3.630, SD = 0.787), and only took entrepreneurial action to a moderate extent (mean = 2.275, SD = 1.354). It is evident that multicollinearity does not exist between the independent variables since their Pearson's correlation coefficient is 0.233, which is well below the threshold value of 0.8 for multicollinearity (Field, 2018).

4.3. Regression results

In order to test H1 and H2, multiple linear regression analysis was first conducted to determine the extent to which the independent variables, (1) are linearly associated with; and (2) provide an adequate model fit as a linear model for, the dependent variable.

Table 2. Multiple linear regression results.

	Model 1
Prior entrepreneurial exposure Entrepreneurial education	0.184* 0.140
Adjusted R^2	0.05*
F (p value)	4.27 (0.016)

Note: Standardised Beta-coefficients are presented. *$p < 0.05$, **$p < 0.01$.

From Table 2 it is evident that the results of model 1 indicate that:

1. The R^2 value is very low, indicating that very little (only 5%) of the variation in the dependent variable, entrepreneurial action, can be explained by the independent variables in the model.

2. However, the statistical significance (p = 0.016) of the F-test for regression indicates that the R^2 value differs significantly from zero and, thus, statistically significantly explains the variance in entrepreneurial action.
3. The standardised beta values and associated significance indicate that only entrepreneurial exposure is statistically significant at the 5% level of significance (p = 0.043).
4. A MSE value of 1.742 and a RMSE value of 1.32.

The results thus indicate that both entrepreneurial education and prior entrepreneurial exposure have a positive but weak linear relationship with entrepreneurial action. However, prior entrepreneurial exposure was identified as being the only statistically significant predictor of action. As the core aim was to compare the linear and nonlinear relationship effect between these variables, and not prediction, the low R square value can be taken note of for future research but did not impact the results of this study.

The model was also tested by including control variables and a potential additional explanatory variable. As the research instrument included the measures of entrepreneurship education, entrepreneurship exposure, entrepreneurial action and demographic variables, the following demographic variables could be included:

1. Gender;
2. Province where the respondents' businesses are located;
3. Age; and
4. Time span since the respondents' graduated with a first degree.

Thus, the first three variables can be regarded as control variables while the time span since receiving the degree can either be a control variable or an explanatory variable. However, by adding these variables to the model they do not contribute in explaining the dependent variable, entrepreneurial action and was thus excluded from the model. In fact, the fit according to the adjusted R square is lower (0.02) than in model 1.

4.4. Neural network (ANN) results

In order to test H2 and H3, ANN analysis was conducted to determine the extent to which the independent variables, (1) are non-linearly associated with; and (2) provide an adequate model fit as a non-linear model for, the dependent variable.

For the purposes of ANN model training and testing, the total dataset is divided into two subsamples; a training and testing sub-sample. The case processing summary is presented in Table 3 and provides the number of cases used as the training set. The training sample consists of 71.2% of the cases and the testing sample, 28.8% of the cases.

Table 3. Training and testing sample size.

		N	Percent
Sample	Training	89	71.2%
	Testing	36	28.8%
Valid		125	100.0%

In Table 4 below, the number of units in the input layer is obtained by combining the number of covariates and factor levels.

Table 4. Network information.

Input layer	Covariates	1	NewEntExp
		2	EntEdu
	Number of units[a]		2
Hidden layer(s)	Number of hidden layers		1
	Number of units in hidden layer 1[a]		3
	Activation function		Hyperbolic tangent
Output layer	Dependent variables	1	NewEntAction
	Number of units		1

The independent variables or predictors (inputs) are specified as covariates as they were scale variables. The number of units in the hidden layer is the number of input units and the hidden layer neuron, thus 3 units. The activation function used is the hyperbolic tangent (tanh) function and is a transfer function that determines the output of the ANN. In Figure 3, the ANN architecture obtained is represented and indicates a three-layer architecture, which comprises an input layer, hidden layer, and output layer.

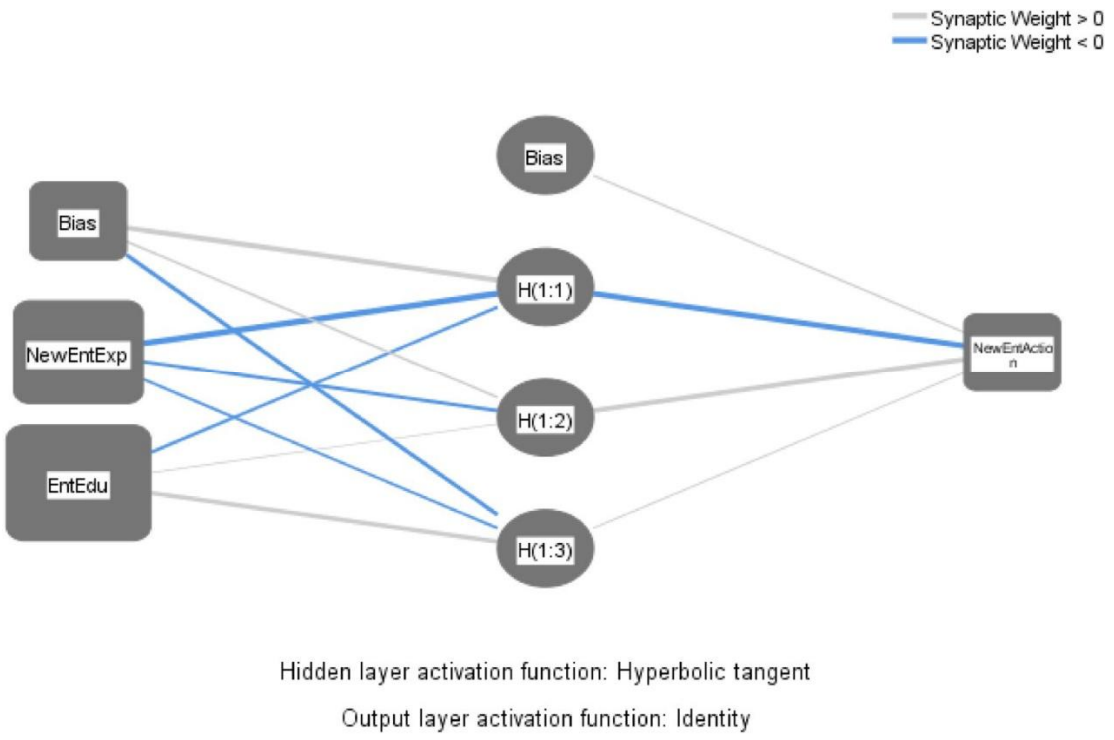

Figure 3. Artificial network architecture.

Scholars such as Burke & Ignizio (1992) argue that in order to understand the bias unit and its role, it is necessary to know that, in a typical ANN, each neuron/activity in one 'layer' is linked via a weight to each neuron in the subsequent activity. Each of these activities store a form of algorithm, which is normally an aggregate of the weighted activities in previous layers. A bias unit refers to an 'extra' neuron linked to individual pre-output layers and holds a value of 1. Bias units are not linked to any previous layer, as such they don't signify an actual 'activity'. In essence, it plays the same role as that of a constant in linear regression. The synaptic weight refers to the strength of the connection between two nodes.

Table 5 indicates the importance of each predictor in determining the ANN, also referred to as sensitivity analysis. The combined training and testing sample are used in this analysis. This result shows that entrepreneurship education was the most important in building the ANN.

Table 5. Importance of inputs (independent variables).

	Importance	Normalized importance
New entrepreneurial exposure	0.457	84.2%
Entrepreneurial education	0.543	100.0%

Compared to the previous linear model tested, the non-linear patterns through the use of ANN indicated differing results. Entrepreneurial education was identified as having a stronger influence on entrepreneurial action than entrepreneurial exposure in the ANN. This finding runs counter to the linear model which found that only entrepreneurial exposure made a significant contribution. Furthermore, the relative error indicates the amount of variance explained, which is 11.5% (relative error is 0.885) for the neural network model. Therefore, the ANN results indicate a larger, although still low, percentage of variance explained compared to linear regression analysis (variance explained = 5%) which confirms that an improved model fit for entrepreneurial action is achieved with neural network analysis. Furthermore, comparing the MSE and RMSE values for both models (MSE and RMSE = 1.724 and 1.32 for the linear regression model and 0.418 and 0.647 for the neural network analysis), the latter has lower estimation errors and can be considered as an overall stronger model compared to the linear regression model. By executing curve estimation, it was evident that a potential cubic relationship exists between entrepreneurial education, exposure and entrepreneurial action that explains more variance than the linear relationship.

5. Discussion of the findings

The findings of the multiple regression analysis indicated a statistically significant association between only prior entrepreneurial exposure and entrepreneurial action. Therefore, we cannot accept H1: Prior entrepreneurial exposure and entrepreneurial education are associated with entrepreneurial action in linear models. This result should not be completely unexpected, however, as conflicting findings appear to be prevalent when testing linear models in the relationship between entrepreneurial education and action (Davidsson & Honig, 2003; Wilson et al., 2007; Støren, 2014).

Although the regression analysis indicated an insignificant relationship between entrepreneurship education and action, ANN demonstrated that both independent variables were important in determining the neural network, thus, confirming H2: Prior entrepreneurial exposure and entrepreneurial education are associated with entrepreneurial action in non-linear models. The results thus indicate that the true nature of the relationship between the two independent variables with the dependent variable is non-linear and further research on larger samples should be conducted to confirm the results obtained in this study. This result is consistent with studies suggesting non-linearity in the entrepreneurial education-action relationship, such as the findings of Venesaar et al. (2006) as well as Botha & Ras (2016) which indicate that most entrepreneurship graduates are not ready for business start-up directly post-graduation but rather plan to engage in entrepreneurial action at some later stage once certain a certain level of entrepreneurial experience is obtained and obstacles to start-up are overcome.

The multiple regression and ANN models were compared to test H3: Neural network analysis will provide an improved model fit for entrepreneurial action, prior entrepreneurial exposure and entrepreneurship education than linear regression analysis, which may suggest the presence of non-linear effects. The results indicated that the percentage variance explained by the ANN analysis was 11.5% in contrast to the 5% of the multiple linear regression model. The ANN analysis also showed lower estimation errors than the linear regression model (MSE and RMSE = 1.724 and 1.32 for the linear regression model and 0.418 and 0.647 for the ANN analysis). Therefore, we confirm that ANN provided a stronger model for entrepreneurial action and the nature of the relationship between these variables is non-linear. In particular, it is noteworthy that, in the linear model, entrepreneurial education did not make a significant contribution, but prior entrepreneurial exposure did make a significant contribution, to explaining entrepreneurial action. However, in the non-linear model, entrepreneurial education appears to be the predictor with the most importance in explaining entrepreneurial action-the opposite result of the linear model. This finding suggests that, more so than with entrepreneurial exposure, the entrepreneurial education-action relationship, in particular, may be better accounted for by non-linear model testing.

The above results, thus, indicate that non-linear effects are present in this paper and confirm suggestions by Zekić-Sušac et al. (2013) that ANN is a suitable method for modelling and accounting for entrepreneurial action as it is a complex construct involving non-linear effects. By modelling a non-linear relationship, the results also support prior studies finding a positive relationship between prior entrepreneurial exposure and entrepreneurial action (Lentz & Laband, 1990; Dunn & Holtz-Eakin, 2000), as well as those suggesting a positive relationship between entrepreneurship education and action (Rauch & Hulsink, 2015; Nabi et al., 2017; Nabi et al., 2018) and may explain the conflicting findings of other studies (Oosterbeek et al., 2010; Von Graevenitz et al., 2010; Walter et al., 2013).

6. Conclusion and contributions

Although the Human Capital (Karlsson & Wigren, 2012), Planned Behaviour (Ajzen, 1991), and Social Learning (Van Auken et al., 2006) Theories all strongly support a link between prior entrepreneurial exposure, entrepreneurship education and action, empirical evidence

has been conflicting. However, this may be the case since most studies focusing on entrepreneurial education and action (Davidsson & Honig, 2003; Wilson et al., 2007; Støren, 2014), as well as entrepreneurial exposure and action (Dunn & Holtz-Eakin, 2000; Gird & Bagraim, 2008; Chlosta et al., 2012), employed variations of the General Linear Model rather than using non-linear models. Linear models may produce conflicting findings since entrepreneurial action is a complex process (Shepherd, 2015), with several positive and negative feedback loops (Shepherd et al., 2010), which may give rise to non-linear patterns over time. Therefore, the use of new techniques, such as ANN, for analysing entrepreneurial action can be particularly beneficial in terms of better accounting for, and understanding ways to enhance entrepreneurial action (business start-up). This paper constitutes a first attempt at using ANN to model the relationship between prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action and through its use, we establish support for the existence of non-linear effects, suggesting that linear techniques may be inadequate, and ANN should be investigated further to more clearly explain entrepreneurial action.

The contributions of this paper are threefold: Firstly, this paper investigated a more complex relationship between these three constructs, which has received scarce research attention to date. By doing so, we contribute towards resolving the conflicting findings of previous studies by potentially explaining why mixed results were obtained for the relationship between entrepreneurial education and entrepreneurial action. We demonstrate that entrepreneurial education and exposure, play a significant role in explaining entrepreneurial action when a non-linear relationship is modelled. This suggests the need to focus on non-linear relationships when aiming to explain the complex entrepreneurial action construct. Secondly, by modelling all three constructs in one relationship, and testing a non-linear relationship, this study contributes to the unveiling of novel insights into the tested relationship. More specifically, our research shows that a cubic relationship best describes the effects of entrepreneurial education and exposure on action. Furthermore, this study contributes to theory development by linking this cubic relationship to the Human Capital (Karlsson & Wigren, 2012), Planned Behaviour (Ajzen, 1991) and Social Learning (Van Auken et al., 2006) theories. While these theories are applicable to the tested relationship in this context, it is likely under the auspices of a non-linear, more specifically, cubic pattern. Finally, the third contribution lies in the findings possibly assisting policy makers and educators to promote entrepreneurship education and improve pedagogical interventions with the ultimate goal of enhancing entrepreneurial action. In this regard, this research demonstrates that linear techniques are inadequate and educators, as well as scholars, should pay attention to non-linear relationships (perhaps by using ANN) in future attempts to understand and enhance the entrepreneurial education-action relationship.

6.1. Limitations and recommendations for future studies

No study is without limitations. Firstly, while the results in this paper support the argument of a non-linear relationship, it is acknowledged that the sample size was very small, which may have weakened the results. However, this study represents a first attempt at modelling a non-linear relationship between entrepreneurial education, prior entrepreneurial exposure and action. Since the results indicate that ANN is a fruitful technique for explaining entrepreneurial action, future research on larger samples should be conducted to confirm

the results found in this study. Secondly, it is important to take into account that the study comprised of participants within a single, emerging economy context and, thus, caution should be applied when generalising the results beyond this context. It is, thus, worthy to investigate the relationship in other emerging economies, as well as advanced economies to enable a comparison and determine the boundary conditions of these relationships. Finally, while we were able to identify that the non-linear relationship between entrepreneurial exposure, education and action was potentially cubic, further data analysis is required to determine the exact nature of the relationship at particular levels of prior entrepreneurial exposure and education. In this regard, since entrepreneurial action appears to be complex and vary over time, with positive and negative feedback loops (Shepherd et al., 2010), it may be worthwhile to use ANN to investigate a sample of entrepreneurs in various stages of entrepreneurial action (including nascent, start-up, and existing entrepreneurs) to more clearly define the shape of this non-linear relationship and how it varies at different stages.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Ajzen, I, 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes 50(2), 179–211.

Bae, TJ, Shanshan, Q, Chao, M & O'Fiet, J, 2014. The relationship between entrepreneurship education and entrepreneurial intentions: A meta–analytic review. Entrepreneurship Theory and Practice 38(2), 217–54.

Bandura, A & Walters, RH, 1977. Social learning theory. Prentice-hall, Englewood Cliffs, NJ.

Botha, M & Ras, R, 2016. Entrepreneurship education: Enhancing or discouraging graduate start-up at the University of Pretoria. Africa Education Review 13(2), 96–114.

Burke, LI & Ignizio, JP, 1992. Neural networks and operations research: An overview. Computers & Operations Research 19(3–4), 179–89.

Carter, NM, Gartner, WB & Reynolds, PD, 1996. Exploring start-up event sequences. Journal of Business Venturing 11(3), 151–66.

Chlosta, S, Patzelt, H, Klein, SB & Dormann, C, 2012. Parental role models and the decision to become self-employed: The moderating effect of personality. Small Business Economics 38(1), 121–38.

Ciampi, F & Gordini, N, 2013. Small enterprise default prediction modeling through artificial neural networks: An empirical analysis of Italian small enterprises. Journal of Small Business Management 51(1), 23–45.

Conners, SE & Ruth, D, 2012. Factors influencing success in an introductory entrepreneurship course. Journal of Entrepreneurship Education 1(15), 63–74.

Davidsson, P & Honig, B, 2003. The role of social and human capital among nascent entrepreneurs. Journal of Business Venturing 18(3), 301–31.

Delmar, F & Davidsson, P, 2000. Where do they come from? Prevalence and characteristics of nascent entrepreneurs. Entrepreneurship & Regional Development 12(1), 1–23.

Dunn, T & Holtz-Eakin, D, 2000. Financial capital, human capital, and the transition to self-employment: Evidence from intergenerational links. Journal of Labor Economics 18(2), 282–305.

Falck, O, Heblich, S & Luedemann, E, 2012. Identity and entrepreneurship: Do school peers shape entrepreneurial intentions? Small Business Economics 39(1), 39–59.

Fayolle, A & Gailly, B, 2015. The impact of entrepreneurship education on entrepreneurial attitudes and intention: Hysteresis and persistence. Journal of Small Business Management 53(1), 75–93.

Fayolle, A, Gailly, B & Lassas-Clerc, N, 2006. Assessing the impact of entrepreneurship education programmes: A new methodology. Journal of European Industrial Training 30(9), 701–20.

Field, A, 2018. Discovering statistics using IBM SPSS statistics. 5th edn. Sage, Thousand Oaks.

Fretschner, M & Weber, S, 2013. Measuring and understanding the effects of entrepreneurial awareness education. Journal of Small Business Management 51(3), 410–28.

Galloway, L & Brown, W, 2002. Entrepreneurship education at university: A driver in the creation of high growth firms? Education + Training 44(8/9), 398–405.

Gird, A & Bagraim, JJ, 2008. The theory of planned behaviour as predictor of entrepreneurial intent amongst final-year university students. South African Journal of Psychology 38(4), 711–24

Henry, C, Hill, F & Leitch, C, 2005. Entrepreneurship education and training: Can entrepreneurship be taught? Part I. Education + Training 47(2), 98–111.

Hout, M & Rosen, HS, 2000. Self-employment, family background, and race. National Bureau of Economic Research, w7344, 1–31.

Hussain, JG, Scott, JM & Matlay, H, 2010. The impact of entrepreneurship education on succession in ethnic minority family firms. Education + Training 52(8/9), 643–59.

John, CH, Balakrishnan, N & Fiet, JO, 2000. Modeling the relationship between corporate strategy and wealth creation using neural networks. Computers & Operations Research 27(11–12), 1077–92.

Karlsson, T & Wigren, C, 2012. Start-ups among university employees: The influence of legitimacy, human capital and social capital. The Journal of Technology Transfer 37(3), 297–312.

Kassean, H, Vanevenhoven, J, Liguori, E & Winkel, DE, 2015. Entrepreneurship education: A need for reflection, real-world experience and action. International Journal of Entrepreneurial Behavior & Research 21(5), 690–708.

Kautonen, T, Down, S & Minniti, M, 2014. Ageing and entrepreneurial preferences. Small Business Economics 42(3), 579–94.

Krueger, N, 1993. The impact of prior entrepreneurial exposure on perceptions of new venture feasibility and desirability. Entrepreneurship Theory and Practice 18(1), 5–21.

Lentz, BF & Laband, DN, 1990. Entrepreneurial success and occupational inheritance among proprietors. Canadian Journal of Economics 23(3), 563–79.

Lim, DSK, Morse, EA, Mitchell, RK & Seawright, KK, 2010. Institutional environment and entrepreneurial cognitions: A comparative business systems perspective. Entrepreneurship Theory and Practice 34(3), 491–516.

Lin, WB, 2006. A comparative study on the trends of entrepreneurial behaviors of enterprises in different strategies: Application of the social cognition theory. Expert Systems with Applications 31(2), 207–20.

Linan, F, 2008. Skill and value perceptions: How do they affect entrepreneurial intentions? International Entrepreneurship and Management Journal 4(3), 257–72.

Malebana, MJ, 2017. Knowledge of entrepreneurial support and entrepreneurial intention in the rural provinces of South Africa. Development Southern Africa 34(1), 74–89.

Moremong-Nganunu, T, Rametse, N, Al-Muharrami, S & Kumar, SS, 2018. Perceptions towards entrepreneurship and intention to become entrepreneurs: The case of Sultan Qaboos University female undergraduate students. In N Faghih & MR Zali (Eds.), Entrepreneurship education and research in the middle east and North Africa (MENA) (pp. 215–238). Springer, Germany.

Muofhe, NJ & Du Toit, WF, 2011. Entrepreneurial education's and entrepreneurial role models' influence on career choice. SA Journal of Human Resource Management 9(1), 15.

Nabi, G, Holden, R & Walmsley, A, 2010. Entrepreneurial intentions among students: Towards a re-focused research agenda. Journal of Small Business and Enterprise Development 17(4), 537–51.

Nabi, G, Liñán, F, Fayolle, A, Krueger, N & Walmsley, A, 2017. The impact of entrepreneurship education in higher education: A systematic review and research agenda. Academy of Management Learning and Education 16(2), 277–99.

Nabi, G, Walmsley, A, Liñán, F, Akhtar, I & Neame, C, 2018. Does entrepreneurship education in the first year of higher education develop entrepreneurial intentions? The role of learning and inspiration. Studies in Higher Education 43(3), 452–67.

Nunnally, JC, 1978. Psychometric theory. McGraw-Hill, New York.

Oosterbeek, H, Van Praag, M & Ijsselstein, A, 2010. The impact of entrepreneurship education on entrepreneurship skills and motivation. European Economic Review 54(3), 442–54.

Peterman, NE & Kennedy, J, 2003. Enterprise education: Influencing students' perceptions of entrepreneurship. Entrepreneurship Theory and Practice 28(2), 129–44.

Rauch, A & Hulsink, W, 2015. Putting entrepreneurship education where the intention to act lies: An investigation into the impact of entrepreneurship education on entrepreneurial behavior. Academy of Management Learning & Education 14(2), 187–204.

Rideout, EC & Gray, DO, 2013. Does entrepreneurship education really work? A review and methodological critique of the empirical literature on the effects of university-based entrepreneurship education. Journal of Small Business Management 51(3), 329–51.

Robinson, PB & Sexton, EA, 1994. The effect of education and experience on self-employment success. Journal of Business Venturing 9(2), 141–56. https://EconPapers.repec.org/RePEc:eee:jbvent:v:9:y:1994:i:2:p:141-156.

Rondon, RLA, da Carvalho, AS & Hernández, GI, 2008. Neural network modelling and simulation of the scheduling. In A Azevedo (Ed.), Innovation in manufacturing networks (pp. 231–238). Springer, Boston.

Sánchez, JC, 2013. The impact of an entrepreneurship education program on entrepreneurial competencies and intention. Journal of Small Business Management 51(3), 447–65.

Schroder, E & Schmitt-Rodermund, E, 2006. Crystallizing enterprising interests among adolescents through a career development program: The role of personality and family background. Journal of Vocational Behavior 69(3), 494–509.

Shepherd, DA, 2015. Party on: A call for entrepreneurship research that is more interactive, activity based, cognitively hot, compassionate, and prosocial. Journal of Business Venturing 30(4), 489–507.

Shepherd, DA, Patzelt, H & Haynie, JM, 2010. Entrepreneurial spirals: Deviation–amplifying loops of an entrepreneurial mindset and organizational culture. Entrepreneurship Theory and Practice 34(1), 59–82.

Singer, S, Herrington, M & Menipaz, E, 2018. Global entrepreneurship monitor: Global report 2017/2018. Global Entrepreneurship Research Association, London. https://www.gemconsortium.org/report/50012 Accessed 5 March 2019.

Souitaris, V, Zerbinati, S & Al-Laham, A, 2007. Do entrepreneurship programmes raise entrepreneurial intention of science and engineering students? The effect of learning, inspiration and resources. Journal of Business Venturing 22(4), 566–91.

Støren, LA, 2014. Entrepreneurship in higher education-impacts on graduates' entrepreneurial intentions, activity and learning outcome. Education and Training 56(8/9), 795–813.

Turton, N & Herrington, M, 2012. Global Entrepreneurship Monitor 2012 South Africa. http://www. gemconsortium.org/docs/download/2801 Accessed 5 March 2019.

Van Auken, H, Fry, LF & Stephens, P, 2006. The influence of role models on entrepreneurial intentions. Journal of Developmental Entrepreneurship 11(02), 157–67.

Venesaar, U, Kolbre, E & Piliste, T, 2006. Students' attitudes and intentions toward entrepreneurship at Tallinn University of Technology. Working Papers in Economics 154(21), 97–114.

Von Graevenitz, G, Harhoff, D & Weber, R, 2010. The effects of entrepreneurship education. Journal of Economic Behavior & Organization 76(1), 90–112.

Walter, SG, Parboteeah, KP & Walter, A, 2013. University departments and self–employment intentions of business students: A cross–level analysis. Entrepreneurship Theory and Practice 37(2), 175–200.

Wilson, F, Kickul, J & Marlino, D, 2007. Gender, entrepreneurial self-efficacy, and entrepreneurial career intentions: Implications for entrepreneurship education. Entrepreneurship Theory and Practice 31(3), 387–406.

Zapkau, FB, Schwens, C, Steinmetz, H & Kabst, R, 2015. Disentangling the effect of prior entrepreneurial exposure on entrepreneurial intention. Journal of Business Research 68(3), 639–53.

Zekić-Sušac, M, Šarlija, N & Pfeifer, S, 2013. Combining PCA analysis and artificial neural networks in modelling entrepreneurial intentions of students. Croatian Operational Research Review 4(1), 306–17.

Zhang, Y, Duysters, G & Cloodt, M, 2014. The role of entrepreneurship education as a predictor of university students' entrepreneurial intention. International Entrepreneurship and Management Journal 10(3), 623–41.