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Mu'tah Lil-Buhuth wad-Dirasat
"Natural and Applied Sciences Series"
A refereed and indexed research Journal
Published by Mu'tah University

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Prof. Dr. Abdullah Odienat
Editor-in-Chief
Mu'tah Lil-Buhuth wad-Dirasat
Natural and Applied Sciences Series
Mu'tah University, Mu'tah (61710),
Karak, Jordan.
Tel: . +962-3-2372380 Ext. 6117
Fax. +962-3-2370706
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Editorial Correspondence
Prof. Dr. Abdullah Odienat
Editor-in-Chief
Mu'tah Lil-Buhuth wad-Dirasat
Deanship of Scientific Research
Mu'tah University, Mu'tah (61710),
Karak, Jordan.
Tel: . +962-3-2372380 Ext. 6117
Fax. +962-3-2370706
Email: **Darmutah@mutah.edu.jo**

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Silicon Mitigate Salinity Stress on Gerbera Cut Flower

Sameeha Salameh Al-Maitah*

sameeha_98@yahoo.com

Abstract

Gerbera *(Gerbera jamesonii)* is an important ornamental flower in global flower market, it is one of the most herbaceous, perennial herb belongs to Asteraceae (compositae) family. Gerbera is very popular and widely used as a decorative garden plant or as a cut flower; can be used in landscapes as bedding plants for borders or as a cut flower for table arrangement. Silicon (Si) is a spread widely element and the second most abundant after oxygen in the soil, covering approximately 28 % of the Earth's crust. Silicon is not an essential nutrient, but it is known to have beneficial effects when added to plants. In the soil, most sources of silicon are present as crystalline aluminosilicates, which are inert, insoluble, and not directly available for plants. Silicon provides strength to the plant by making the plant tissues strong and rigid. Salinity is one of the abiotic stresses that negatively influence agricultural production. Recent review has proved that supplementary application of silicon involved in ornamental plants tolerance such as gerbera against salinity, it positively increases the activity of antioxidant enzymes, decreases the plasma membrane permeability, resulted in decreasing levels of lipid peroxidation. Also, reduces the transpiration ratio and increases root activities. Decreases in transpiration lead to decreased osmotic stresses in plant cells and root activities improved, because of root activities, uptake of nutrients by plants improved and salt toxicity decreased.

Keywords: Silicon, Gerbera plants, Abiotic stress, an antioxidant enzyme.

* College of Agriculture, Mutah University.

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التخفيف من الاجهاد الملحي على نبات الجربيرا باستخدام السيليكون

سميحة سلامة المعايطة*

ملخص

يعد نبات الجربيرا من أزهار الزينة المهمة في سوق الأزهار العالمي، ويصنف على أنه نبات عشبي معمر ينتمي إلى العائلة المركبة. يستخدم على نطاق واسع في الحدائق أو أزهار القطف، وكذلك يمكن استخدامه في المناظر الطبيعية كأسيجة أو لترتيب الطاولات. يعتبر السيليكون (Si) عنصر منتشر على نطاق واسع وهو العنصر الثاني بعد الأوكسجين في التربة يغطي حوالي 28% من القشرة الأرضية. لا يعتبر السيليكون من العناصر الأساسية للنبات ولكن ذو تأثير مفيد عند اضافته للنباتات. يوجد السيليكون في التربة على صوره سيليكات الألمنيوم بشكل خامل غير قابل للذوبان، وليس متاح للنبات. عند اضافته للنبات يقوي الأنسجة ويجعلها أكثر صلابة. الاجهاد الملحي من العوامل الغير حيوية والتي تؤثر على الإنتاج الزراعي. حيث أنه عند معاملة النباتات بالسيليكون يؤدي إلى زيادة نشاط الأنزيمات المضادة للأكسدة داخل النبات، كما أنه يقلل من نسبه التبخر وزيادة نشاط الجذور تحت الاجهاد الملحي. إضافة الى انخفاض النتح الذي بدوره يؤدي إلى التقليل من الاجهاد الاسموزي في الخلايا النباتية ويحسن من نشاط الجذور حيث يؤدي إلى زيادة امتصاص العناصر الغذائية بواسطة النبات وتقليل سمية النباتات.

الكلمات الدالة: السيليكون، نباتات الجربيرا ، الإجهاد اللاأحيائي، إنزيم مضاد للأكسدة.

* **كلية الزراعة، جامعة مؤتة.**

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Introduction

Gerbera (*Gerbera jamesonii*), grown throughout the world in a wide range of climatic conditions (Sujatha et al., 2002). Gerbera belongs to the family compositae (Asteraceae) (Cardoso and Silva, 2013). It is a native of South Africa and tropical Asia, gerbera comprises 45 species, this plant is widely created for commercial use as cut, pot and garden flowers (Keditsu, 2013; Khalaj et al., 2011; and Vidalie, 2007).

Agricultural productivity is largely affected by major biotic and abiotic factors including drought, salinity, extreme temperatures and pathogens (Shrivastava and Kumar, 2015). Salinity is one of the most important environmental factors, which limit growth and productivity of plants (Kaya et al., 2003).

In Jordan, agricultural land is limited to 8% of the total land area, which is heavily dependent on irrigation due to the arid climate conditions, approximately 20% of irrigated lands affected by salinity, which comprises one-third of food-producing land (Ammari et al., 2013). However, the total area cultivated with gerbera plants in Jordan is estimated at about 20 du (40 plastic house); according to JCFA (2020). The annual production and income of gerbera for the last three years are illustrated in the table 1.

Table(1) Annual production and income of gerbera in Jordan (JCFA, 2020)

Year	Annual production (flower)	Annual income (JD)
2018 (1/1-2018)-(31/12/2018)	3,527, 362	215,169.082
2019 (1/1-2019)-(31/12/2019)	2,847, 280	210,698.72
2020 (1/1-2020)-(31/7/2020)	610, 360	40,894.12

Salinity stress leads to ionic imbalances, insufficient water use, and nutrient (e.g. N, Ca, K, P, Fe, and Zn) deficiency, which ultimately leads to oxidative stress in plants (Rehman et al., 2019). Under normal physiological conditions, reactive oxygen species (ROS) produced in plant cells either in a radical or non-radical form (Winterbourn, 2019). Gerbera plant classified as moderately sensitive to salinity, so the maximum salinity (electrical conductivity (EC) of nutrient solution) is 1.5–2.8 $dS \cdot m^{-1}$ without yield reduction (Bilal et al., 2020; Carmassi et al., 2013b; Sonneveld et al., 1999; and Baas et al., 1995).

Savvas et al. (2002) found that when the electrical conductivity (EC) in the gerbera plant root zone of increased from 1.8-3.2 $dS \cdot m^{-1}$, resulted in decreased in number of flowers per plant and the mean flower weight , then restricted the fresh weight of flowers per plant. Silicon is the only element safe to plants when excessive uptake occurs. Deficient levels of silicon makes the plant weaker in structure and induce abnormalities in growth and reproduction (Ma and Yamaji, 2006).

Plant description

Gerbera plant is a perennial and herbaceous plant in Mediterranean area, has cylindrical, smooth stem with full green pigmentation (Akter et al., 2012). Leaves arranged in basal rosettes, petiolate, oblong-spatulate and lobed; color ranges from deep green to light green in color (Infoagro, 2015; Akter et al., 2012). Gerbera plant requires between 90-150 days for flowering, depending on the sowing date and soil conditions, (Infoagro, 2015). There are many different gerbera colors including red, yellow, white, pink, dark orange, and even violet. The flower size varies from 6 cm to 9.5 cm in diameter (Cardoso and Silva, 2013; Akter et al., 2012). Gerbera propagates by seed (Seed germination has traditionally, non-uniform flowering) division, and recently tissue culture. Breeding programs (Keditsu, 2013) reported a significant increase in uniformity of seed germination and the percent of germination. Gerbera has many medicinal uses such as to treat cold, fever, and have broad-spectrum anti-tumor and anti-bacterial activity and improving indoor air quality (Nungki et al., 2015).

Silicon in nature and soil

In soil solutions, silicon- mostly- is present as uncharged monomeric silicic acid at rates from about 0.1 mM to 0.6 mM (Epstein, 1994). The major soluble forms of Si in the soil are monosilicic acid (H_4SiO_4) and poly acids (Matychenkov and Snyder, 1996). In highly weathered soils (Tropical soils), free silicon dioxide (SiO_2) may become depleted from soils leaving sesquioxides of iron and aluminum as the major residual minerals (Janislampi, 2012). However, silicon amendments can be important for increasing crop yields in some soils (Korndörfer and Lepsch, 2001). Sahebi et al. (2015) indicated that increasing concentration of the monosilicic acid in the soil solution, improves the ability of plants to absorb phosphates directly. The amount of monosilicic acid is increased because of chemical resemblance between phosphate and silicate anions causing a competitive reaction in the soil (Matychenkov and Snyder, 1996). Plants can absorb phosphates directly when an increase of the monosolic acid in soil solution occurred (Sahebi et al., 2015).

Sources of silicon

Silicon is available from natural resources: organic, inorganic fertilizers, and industrial by-products (Gascho, 2001). By-products involve potassium silicate, which used in fruit tree production to help against plant disease (Mitre et al., 2010), and improve horticultural traits in ornamental sunflowers, zinnia, and gerbera (Kamenidou, 2010). Rice hulls are derived from plant residues have sufficient silicon concentration (Tubana, 2016). Rice hulls help in mitigation the side effects of the disease (as anthracnose) and improve some growth and fruit parameters of capsicum grown in a hydroponics system (Jayawardaba et al., 2016). Diatoms, a group of algae, accumulates amorphous silica when fossilized (Mills, 2017).

Uptake, transportation, deposition, and accumulation of Si in plants

All plants contain Si at different concentrations ranging from 0.1% to 10% dry weight, depending on species (Epstein, 1994) due to the differences in capability for absorption of silicon (Ma and Yamaji, 2008). Plants mainly absorb and utilize silicon in the form of orthosilicic acid $Si(OH)_4$, but Si mainly exists in soil as silica and silicates, most of which cannot be absorbed by plants (unavailable) (Zhu and Gong, 2014).

Generally, there are three main mechanisms by which plants absorb Si through root—active, passive, and rejective (Zhu and Gong, 2014). When plants having uptake of silicon higher than water are classified as active such as rice and barley, but when the rate of silicon and water uptake is similar are classified as passive such as oat, and those with lower rates classified as rejective (Kaur and Greger, 2019).

Plant species classified into three categories according to silicon content (accumulator, intermediate, and non-accumulator) (Yan et al., 2018) (Table 2). Tropical and subtropical soils have low silicon concentrations due to highly weathering and leaching processes (Epstein, 1999),while an estimated 210–224 million tons of Si is taken out annually from the world's arable soils (Meena et al., 2014).

Table (2) Plant categories based on silicon uptake capacity (Yan et al., 2018)

Accumulator (>1.5% Si) Dry weight	**Intermediate (1.5-0.5% Si) Dry weight**	**Non-Accumulator (<0.5% Si) Dry weight**
Rice	Cucumber	Tomato
Wheat	Rose	Pansy
Lentils	Squash	Grapes
Spinach	Chrysanthemum	Gerbera
Sugarcane	Zinnia	Petunia
Mosses	Marigold	Snapdragon

Effect of Silicon on plant growth and quality

Silicon plays an important role in plant growth and quality. Kamenidou et al. (2010) found that the application of Si enhanced the growth and quality of important floricultural crops such as 'Acapella' gerbera (Gerbera jamesonii L.). The effect of weekly application of potassium silicate drenches at 100 mg/L Si on the morphological characteristic of different species of floriculture grown in a soilless substrate; they found that, a significant height response with Si treatment (Mattson and Leatherwood, 2010). Silicon supplementation increases stem diameters of chrysanthemum (Chrysanthemum ×morifolium) (Moon et al., 2008), and gerbera (Savvas et al., 2002). Moreover, Si additions increased both stem and flower diameter of greenhouse-grown sunflower (Kamenidou et al., 2008) and zinnia (Zinnia elegans) (Kamenidou et al., 2009). Silicon concentration in leaf tissue varied from 237 $mg \cdot Kg^{-1}$ Si for petunia (Petunia ×hybrida Vilm) to 11,700 $mg \cdot Kg^{-1}$ for zinnia (Frantz et al., 2008). Addition of silicon solution in a closed hydroponic system improved stem quality of cut rose (Ehret et al., 2005).

Effect of silicon on strength of tissue

Silicon deposited in plant cell walls as amorphous silica oxide (SiO_2, nH_2O) form (Pilon-Smits et al., 2009). A considerable relationship between cell wall macromolecules and silicon was found (Yamamoto et al., 2012). Intra or extracellular silica in plants is useful for improving mechanical strength and alleviating biotic and abiotic stress (He et al., 2013). Deposition of Si in the leaves enhances the strength and rigidity of cell walls, decreases water loss from the cuticle, and increases the resistance to lodging, low and high temperature, radiation, UV, drought stresses and increased postharvest quality (Ma and Takahashi, 2002).

Application of potassium silicate (K_2SiO_3) at 100ppm had increased in the thickness of xylem in Zinnia elegans than untreated plants. The increment may be attributed to the silicon deposition in epidermal and in turn strengthening storage and vascular tissues (El-Serafy, 2015). About 90% of the total absorbed Si, accumulated in the epidermis of leaf and cell walls, which accounts for 10% of the dry weight of grass shoots (Ma and Takahashi, 2002). Savvas et al. (2002) found that silicon improved quality of gerbera flowers by providing mechanical strength to the stems since stem diameter increased with increasing silicon concentration in the nutrient solution.

Babalar et al., (2016), found that the significant effect of silicon supplementation on the gerbera plant strengthened lower part of the stem but had no effect on the top of the stem. Silicon affects the mechanical properties of cell walls, permeability to water; it is involved in the biosynthesis of cell wall components (Liang et al., 2015). In addition, it had significant influence on metabolism and concentration of polyphenols in the xylem cell walls. Silicon doesn't only involve in the strength of cell walls, but it, also, increases the elasticity of the wall during cell growth (Broadley et al., 2012). Babalar et al. (2016) demonstrated that application of silicon could enhance the mechanical strength of inflorescence stem and improve the cut flower quality in gerbera.

Effect of silicon on flowering parameters and post-harvest quality

Savvas et al. (2002) illustrated that the higher percentage of flowers grading as class I and peduncle stem thickness increased in Gerbera when potassium silicate (1.25 mM) was included in the hydroponic nutrient solution. The maximum value of flower number per gerbera plant reached when treated by 7.3g/ pot calcium silicate and flower diameter reaches the maximum value when treated by 3.6g/pot, compared to the control (Moyer et al., 2008).

Foliar application of potassium silicate ($KSiO_3$), sodium silicate ($NaSiO_3$), and rice husk ash on gerbera plant, resulted in thicker flower peduncles, increased height, and earlier flowered more than control (Kamenidou et al., 2010). The short vase life of gerbera cut flowers leads to difficulties with long-distance transportation and subsequent marketing (Aghajani and Jafarpour, 2016). The effect of different levels of silicon on gerbera flower longevity; when the increasing concentration of silicon to 2mM Si in the vase solution significantly raised the longevity and significantly reduced the fresh weight alters of gerbera flower comparison to the control while increasing the rate to 3mM Si decreased the vase life comparison the control by decreasing ethylene biosynthesis (Kazemi et al., 2012c). Pre-harvest treatment of different sources of Si as well as salicylic acid and methyl jasmonate as postharvest treatment can significantly affect the marketability of cut gerbera flowers (Aghajani and Jafarpour, 2016). Richter (2001) found that supplying different gerbera cultivars with silicon can extend vase life. In addition, the number of flowers with a bent neck can be decreased. Foliar sprays of sodium silicate at 50–100 mg L^{-1} resulted in taller gerbera plants combined with larger flower diameters and drenches

potassium silicate at 200 mg L^{-1} resulted in increased basal and apical diameters in flower peduncles (Kamenidou et al., 2010).

Silicon and salinity stress

Salinity stress is one of the most common environmental stresses that deterioration to the agriculture industry worldwide. The elevated supply of Si (2 mM) improved the quality of the gerbera flowers when salinity was low (0.8mM) (Savvas et al. 2007). Reezi et al. (2009) found that the flower number increased when the application of 50 ppm Si in nutrient solution compared with unstressed conditions. Supplementary of silicate in gerbera plant resulted in slightly increased plant growth, similar to those obtained in plants under the control treatment (without salinity) and root fresh weight was slightly higher than salinized plants (Savvas et al. 2002). Foliar application of Si reduced the effect of salinity on the flower vase life of gerbera in case of using low-quality water (Torkashvand and Shirghani, 2015) and high-quality water (Oliveira et al., 2012).

Mechanisms of silicon in mitigation of salinity stress

The exogenous application of silicon (Si) has been used as an eco-friendly approach (Almeida et al., 2017). In general, under salinity conditions, the soil has a high level of sodium (Na^+) ions and chloride (Cl^-) ions content, leads to plants have low water potential and salt deposition in the other plant cellular regions (Romero-Aranda et al., 2001). Sodium (Na^+) and chloride (Cl^-) ions move to the aerial parts of plants through transpiration, and when Na^+ and Cl^- are at a toxic threshold, several tissues of a plant can be damaged (Sahebi et al., 2015). Shi et al. (2013) reported that Si decreases the apoplastic transportation of sodium ions (Na^+) and chloride ions (Cl^-) under salinity stress.

Silicon mitigates salt stress by inhibition of sodium ion (Na^+) transport to the leaves and specific accumulation of Na^+ in the roots (Tuna et al., 2008). Shi et al., (2005) found that treatment of plants with silicon under saline stress has a smaller specific leaf area and a larger leaf weight ratio when compared with untreated plants. Silicon increases salinity tolerance capacity of rose plant by increased photosynthetic activity, improving water status and stimulation of antioxidant system by reducing salt uptake and increasing K uptake (Tahir et al., 2006).

Abiotic stresses cause oxidative stress in plants that induce the production of reactive oxygen species (ROS) (Mc Cord, 2000). The application of silicon increases the activity of an antioxidant enzyme in plants under salinity (Liang et al., 2003). Sahebi et al., (2015) reported that silicon decrease the permeability of the plasma membrane in plants leaf cells resulted in decreasing levels of lipid peroxidation. Sahebi et al. (2015) indicated that the treatment of various plants with silicon under salinity stress reduces the transpiration ratio and increases root activities, decreases in transpiration lead to decreased osmotic stresses in plant cells and root activities improved, as a result of root activities, uptake of nutrients by plants increased and salt toxicity decreased (Figure 3).

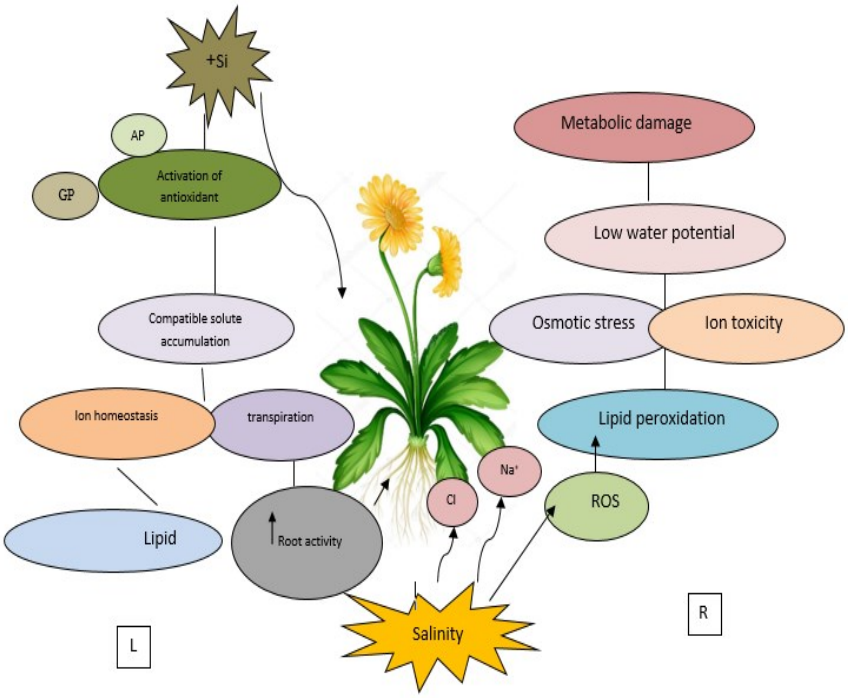

Figure (3) A schematic model for the mechanism of silicon in plant under salinity

The right (R) side refers to effect of salinity on plant, the lift side (L) refers to the effect of exogenous silicon on plant under salinity.

The main purpose of this review is to understand the role of silicon in the growth and development of gerbera plants and clarify the effect of silicon in mitigate salinity stresses. Treatment of plants with silicon under salinity stress decreases transpiration, which, in turn, decreases osmotic stresses in plant cells and improves root activities. This may be attributed to improving uptake of nutrients by plants and decreasing salt toxicity, then, growth, quality and prolonged vase life of gerbera cut flowers improved.

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Alleviation of capsaicin-induced mechanical allodynia by *Arbutus andrachne* L. methanolic leaf extract in male rats

Sahar Jaffal *
sjaff333@gmail.com

Sawsan Oran
Mohammad Alsalem

Abstract

Pain is one of the major health problems that impose huge social and economic burdens all over the world. Mechanical allodynia is a symptom of pain defined as a painful sensation resulting from innocuous stimuli such as touch. Currently available drugs have several side effects urging the need for new natural sources that alleviate mechanical allodynia. This study investigated the effect of *Arbutus andrachne* L. (a medicinal plant growing in Jordan) on capsaicin (Caps)-induced mechanical allodynia in male rats and the mechanism that underlie its effect. Caps injection decreased paw withdrawal threshold (PWT) significantly compared to control group. Mechanical allodynia was detected 30, 90 and 150 min after Caps injection to the plantar surface of the left hind paw of rats. The intraplantar (ipl) injection of 100 µg (but not 50 or 200 µg) of *A. andrachne* extract, ipsilaterally, prior to Caps injection increased PWT at all-time points similar to the anti-nociceptive effect in the positive group that was treated with 2.5% diclofenac sodium prior to Caps injection. The ipsilateral pre-treatment with the antagonists of transient receptor potential vanilloid-1 (TRPV1), cannabinoid receptor 1 (CB1) and peroxisome proliferator-activated receptor alpha (PPARα) reversed the activity of the leaf extract in contrast to the antagonists of PPARγ and α2-adrenergic receptors. In all groups, no effect was detected on the contralateral hind paw of animals at any time point. In conclusion, *A. andrachne* can be exploited as an anti-nociceptive agent.

Keywords: *Arbutus andrachne,* TRPV1, mechanical allodynia, PPAR, CB1, α2-adrenergic

*College of Science, University of Jordan.
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تخفيف تأثير الألم الميكانيكي المحفز عن طريق كابسيسين بواسطة المستخلص الميثانولي لأوراق نبات القيقب في ذكور الجرذان

سحر جفال *

سوسن العوران

محمد السالم

ملخص

يعتبر الألم أحد المشاكل الصحية الرئيسية التي تفرض أعباء اجتماعية واقتصادية ضخمة في جميع أنحاء العالم. الألم الميكانيكي هوعرض من أعراض الألم والذي يعرف بالألم الناتج من محفزات غير ضارة مثل اللمس. هناك العديد من الآثار الجانبية للأدوية المتوفرة حاليًا مما يزيد الحاجة لمصادر طبيعية جديدة تخفف من الألم الميكانيكي.

بحثت هذه الدراسة تأثير نبات القيقب (نبات طبي ينمو في الأردن) على الألم الميكانيكي المحفز بواسطة كابسيسين في ذكور الجرذان وآلية عمله. إن حقن كابسيسين قلل حد الوزن المسبب لرفع القدم بشكل ملحوظ مقارنة مع المجموعة المرجعية. تم الكشف عن الألم الميكانيكي بعد 30 و 90 و 150 دقيقة من حقن كابسيسين على السطح الأخمصي للقدم الخلفية اليسرى. إن حقن 100 ميكروغرام من المستخلص الميثانولي لأوراق نبات القيقب (و ليس ٥٠ أو 200 ميكروغرام) قبل حقن كابسيسين في نفس القدم زاد حد الوزن المسبب لرفع القدم في جميع النقاط الزمنية المقاسة. كان تخفيف الألم الميكانيكي مشابها لتأثير المسكن الذي ظهر في المجموعة ذات التأثير الإيجابي والتي عولجت بنسبة 2.5٪ من ديكلوفيناك الصوديوم قبل حقن كابسيسين. عكست المعالجة المسبقة بمضادات المستقبلات CB1, TRPV1 و PPARα على نفس القدم تأثير مستخلص الأوراق على الألم الميكانيكي المحفز بواسطة كابسيسين بشكل ملحوظ على النقيض من مضادات المستقبلات PPARγ وadrenergic−α2. لم يتم الكشف عن أي تأثير على القدم اليمنى وغير المحقونة في أي نقطة زمنية. الإستنتاج ، مستخلص أوراق نبات القيقب يمكن استغلاله كعامل مضاد للألم.

الكلمات الدالة: Arbutus andrachne, TRPV1, آلام ميكانيكية, α2- , PPAR, CB1, adrenergic,

* **كلية العلوم، الجامعة الأردنية.**

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1. Introduction:

Pain is one of the major health problems that lead to disability, mortality and the need for health care services (Brooks and Tracey, 2005). Transient receptor potential vanilloid-1 (TRPV1) is a key receptor involved in the detection of different painful stimuli including mechanical allodynia (Caterina et al., 1997; Gilchrist et al., 1996). TRPV1 is a non-selective cation channel that is activated by noxious heat (> 43°C), anadamide, protons as well as endogenous activators 'endovanilloids' (Caterina et al., 1997; Brandt et al., 2012). It is also activated by the potent and highly selective agonist capsaicin (Caps), the active ingredient in chilli peppers (Caterina et al., 1997). According to Caterina and Julius (2001), the deletion of TRPV1 gene in mice attenuated paw swelling in Caps-treated animals. Thus, TRPV1 is considered a promising target for pain control (Jara-Oseguera et al., 2008).

Previous studies confirmed an interaction between TRPV1 channel and other receptors in pain modulation. These receptors include cannabinoid receptor 1 (CB1) (O'Sullivan, 2016), alpha 2 (α2)-adrenergic receptor (Filippi et al., 2016) and peroxisome proliferator-activated receptors α and gamma (PPAR α and γ) (Ambrosino et al., 2014, O'Sullivan, 2016). Noteworthy, CB1 receptor is expressed in peripheral sensory neurons and epidermal layers in human skin (Caterina, 2014). CB receptors play a crucial role in itch and pain responses through several mechanisms (Caterina, 2014). Also, α2-adrenergic receptor is among the receptors that contribute to TRPV1 functionality (Dessaint et al., 2004; Matsushita et al., 2018). It was documented that the application of yohimbine (an antagonist for α2-adrenergic receptor) inhibited the firing of dorsal root ganglia (DRG) neurons, induced by Caps (Dessaint et al., 2004; Matsushita et al., 2018). With respect to PPAR receptors, Alsalem et al. (2016) reported that TRPV1 channel can be modulated by a dual agonist for PPARγ and PPARα receptors.

Notably, natural compounds from various sources can modulate TRPV1 channel. In this regard, (Abbas, 2020) reviewed 137 natural products that

affect TRPV1 activity in different assays highlighting that natural sources, including medicinal plants, can be good sources for analgesics. According to (Oran, 2014), there are 363 medicinal plants in Jordan including *Arbutus andrachne* L. (Qaiqab or Qatlab in Arabic) which is a medicinal plant growing in Ajloun, Irbid, Amman, Jarash and Salt (Al-Eisawi, 1998; Oran, 2015). It belongs to Ericaceae family (Oran, 2015) and Arbutoideae sub-family (Tenuta et al., 2018). It is a laurel-like genus described as long evergreen shrub that reaches 2-4 m (Tenuta et al., 2018; Al-Eisawi, 1998; Oran, 2015). This plant is edible and has many uses in traditional medicine (Oran, 2015). Several studies were conducted to determine the biological effects of this medicinal plant. However, there is lack in the studies that evaluate the anti-nociceptive effect of *A. andrachne* in pain models induced by mechanical stimuli. The aim of this study was to determine the effects of different doses of *A. andrachne* leaf extract on Caps-induced mechanical allodynia in rats. Also, to explore the roles of TRPV1, CB1, PPARα, PPARγ, and α2-adrenergic receptors in mediating the effect of *A. andrachne.*

2. Materials and methods:

2.1. Drugs

GW9662, GW6471, yohimbine, capsazepine, Caps and SR141716A were from Tocris Bioscience, UK. Diclofenac sodium was purchased from Novartis, Switzerland. Olive oil was brought from the Department of Agriculture, the University of Jordan, Amman, Jordan. Ethanol and methanol were purchased from Scharlau, Spain. Syringes (1 ml) were from Becton, Dickinson and Company, United States. Caps was dissolved in olive oil while other drugs were freshly prepared from stock in sterile saline.

2.2. Collection and identification of *A. andrachne* leaves

The leaves of *A. andrachne* were collected in March 2019 from Jarash in Jordan and were authentically identified by Prof. Sawsan Oran, a plant taxonomist at the Department of Biological Sciences, the University of Jordan, Amman, Jordan. A voucher specimen was placed at the herbarium in the same department.

2.3. Preparing the methanolic extract from *A. andrachne* leaves

The leaves of *A. andrachne* were washed, dried, ground with a blender, then were soaked in methanol (100 g in 1000 ml) at 10:1 v/w ratio for 72 hrs at room temperature with continuous shaking (Pandey and Tripathi, 2014) followed by filtration using Whatman filter paper and evaporation of methanol by rotary evaporator at 45 °C. Successive extractions were used to prepare the methanolic extract. The extract was kept in a container at -20 °C.

2.4. Experimental animals

The procedures in all experiments were approved by the ethical committee at the University of Jordan (ethical approval number 235/2020/19). Male Wistar rats (200-250 g) were used in the experiments. The animals were kept in the animal house, the University of Jordan in controlled conditions and had free access to food and water.

2.5. Measurement of Caps-induced mechanical allodynia

Each group included 6 animals. The rats were allowed to acclimatize for 1 hr in inverted cages covered with perforated lids placed on an elevated wire mesh surface. Baseline withdrawal thresholds were determined to ensure that the animals have equivalent baseline readings before being divided into different groups. The animals were assigned into control and experimental groups. Mechanical allodynia was induced by the intraplantar (ipl) administration of 30 µg Caps (dissolved in olive oil) into the left hind paw of animals. Control group received ipl injection of olive oil. Other groups received different doses of *A. andrachne* extract (50, 100 or 200 µg extract/paw) 30 min prior to Caps injection. Positive control group received 2.5% diclofenac sodium 30 min prior to Caps injection (according to Nozadze et al., 2016). The dose of the extract that reversed Caps-induced mechanical allodynia (100 µg) was selected to determine the effect of pre-treatment with different antagonists on the anti-allodynic activity of the leaf extract. Different antagonists were administered ipsilaterally to the dorsal side of the hind paw, 30 min prior to extract injection. The dorsal side of the hind paw was chosen for the injection of antagonists to allow local administration of drugs while minimizing the effects of multiple injections to the plantar surface of the hind paw (Ibrahim et al., 2005). The following doses were used for the antagonists: 50 µg GW9662, a PPARγ antagonist

(Alsalem et al., 2016), 1 µg capsazepine, a TRPV1 antagonist (Alsalem et al., 2016), 0.01 µg SR141716A, a CB1 antagonist (Sagar et al., 2004), 50 µg GW6471, a PPARα antagonist (Alsalem et al., 2016) and 100 µg yohimbine, an α2-adrenergic receptor antagonist (Lee et al., 2013). The volume injected to the paws was 50 µl/injection in all groups.

Paw withdrawal thresholds (PWT) of the ipsilateral and contralateral hind paws were determined 30, 90 and 150 min after the injection of Caps or its vehicle. Mechanical allodynia was measured using von Frey anesthesiometer (Gilchrist et al., 1996). Briefly, thin filament was used to press against the plantar surface of the hind paw of animal till the animal lifts its paw. The number of grams (gm) that caused paw withdrawal was recorded. A cut-off mass unit of 80 g was used in this experiment as in Ferrier et al. (2016).

2.6. Statistical analysis

Normality test for all groups was performed using Shapiro–Wilk test**.** Kruskal-Wallis non-parametric test was used to examine the statistical differences between groups followed by Dunn's post hoc test. The tests were performed using GraphPad Prism version 6. $p < 0.05$ was considered significant. Data were presented as Means±standard error of means (SEM).

3. Results:

The ipl injection of 30 µg Caps to the left hind paw was used to induce mechanical allodynia in male Wistar rats. Caps injection decreased PWT in the left hind paw significantly compared to control group after 30, 90 and 150 min of injection (figures 1A, 1B and 1C, respectively). No effect was detected on the contralateral hind paw at any time point (figures 2A, 2B and 2C). Pre-injecting the animals with 100 µg *A. andrachne* methanolic leaf extract alleviated Caps-induced mechanical allodynia at all measured time points similar to the effect that was observed in the positive control group treated with 2.5% diclofenac sodium/Caps (figures 1A, 1B and 1C). Two doses of *A. andrachne* (50 and 200 µg) did not show significant effect in reversing or decreasing the mechanical allodynia that was evoked by Caps (figures 1A, 1B and 1C).

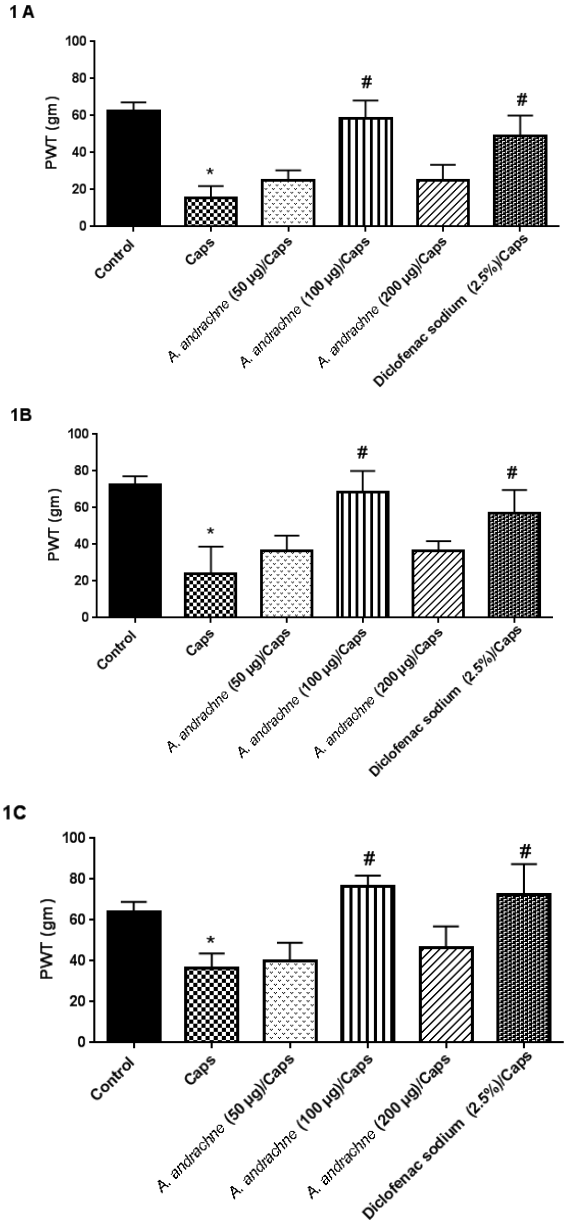


Figure 1: PWT of the injected left hind paw measured 30 min (1A), 90 min (1B) and 150 min (1C) after the ipl injection of vehicle (control), Caps, *A. andrachne*/Caps or diclofenac sodium/Caps.

* Significant compared to control group, # Significant compared to Caps-treated group ($p<0.05$).

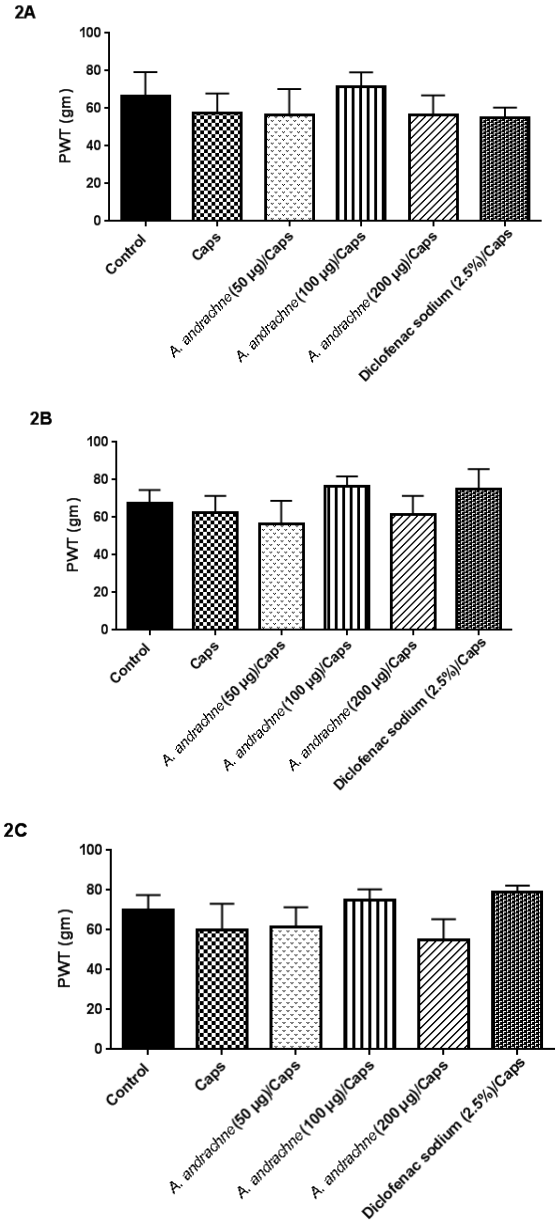
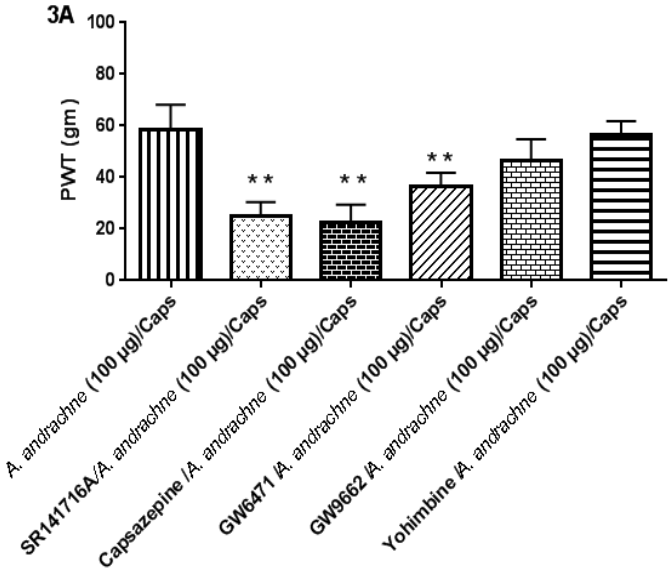


Figure 2: PWT of the right hind paw (contralateral to the site of injections) measured 30 min (2A), 90 min (2B) and 150 min (2C) after the ipl injection of vehicle (control), Caps, *A. andrachne*/Caps or diclofenac sodium/Caps.

Figures 3A, 3B and 3C present PWT measured at 30, 90 and 150 min, respectively (after Caps injection) for animals treated with different antagonists prior to *A. andrachne*/Caps. The anti-nociceptive effect of *A. andrachne* in this mechanical allodynia model decreased when the animals were injected with 0.01 µg SR141716A, 1 µg capsazepine or 50 µg GW6471 prior to *A. andrachne/*Caps at all-time points (after 30, 90 and 150 min of Caps injection). Generally, the animals that had low PWT displayed guarding behaviour for their paw. No effect was detected in the groups that were pre-treated with 50 µg GW9662 or 100 µg yohimbine. Also, no effect was found on the contralateral hind paw in any group at any time point (figures 4A, 4B and 4C).



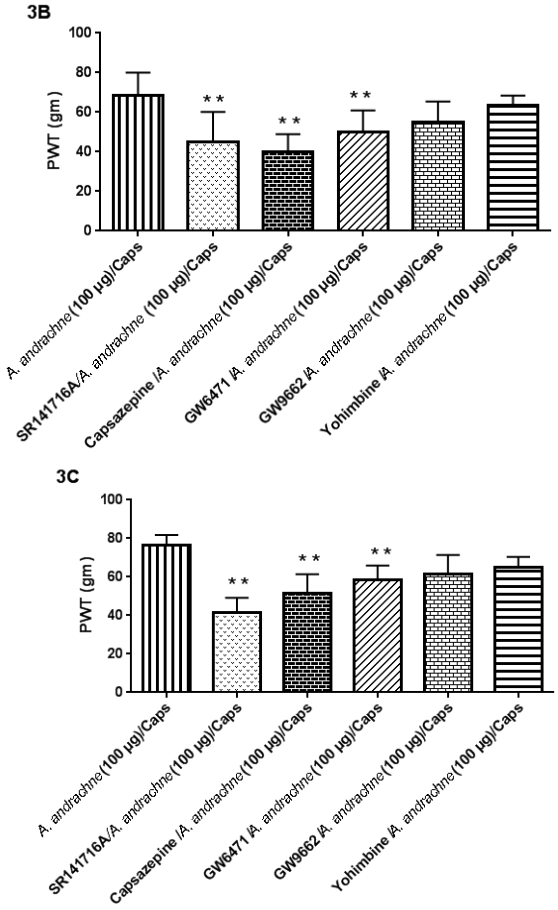


Figure 3: PWT of the injected left hind paw measured 30 min (3A), 90 min (3B) and 150 min (3C) after the ipl injection of *A. andrachne* (100 µg)/Caps or different antagonists prior to *A. andrachne/*Caps injection.

** Significant compared to *A. andrachne* (100 µg)/Caps ($p<0.05$)

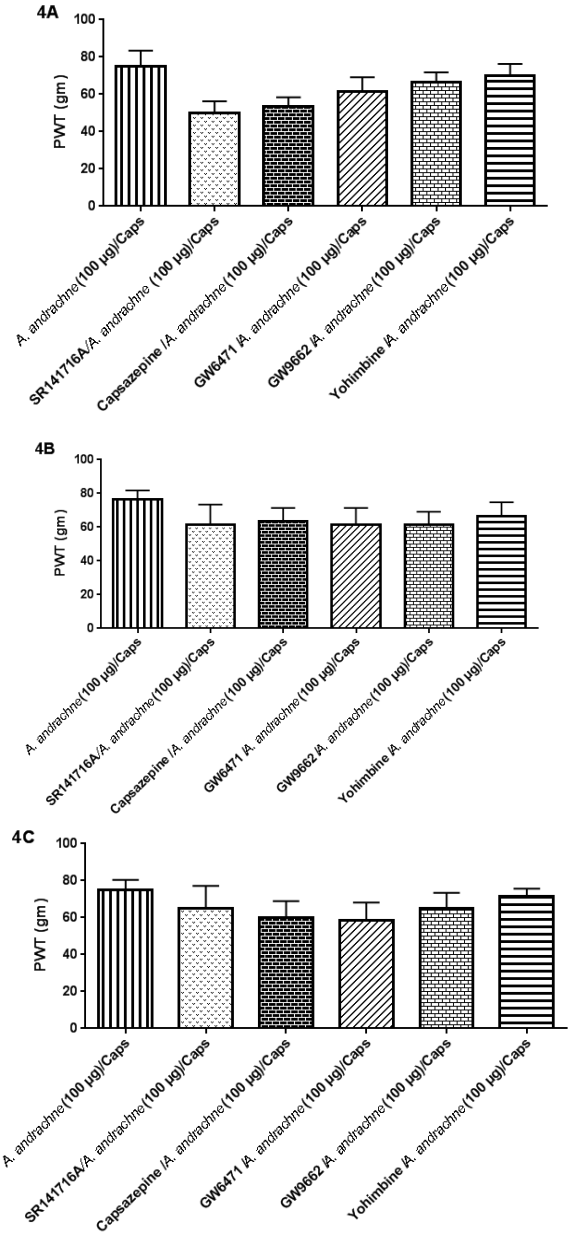


Figure 4: PWT of the right hind paw (contralateral to the site of injections) measured 30 min (4A), 90 min (4B) and 150 min (4C) after the ipl injection of *A. andrachne* (100 µg)/Caps or different antagonists prior to *A. andrachne*/Caps injection.

4. Discussion:

The present study sheds the light on the effect of *A. andrachne* methanolic leaf extract on Caps-induced mechanical allodynia in rats and highlights the involvement of key receptors in its effect.

A. andrachne methanolic extract (100 µg per paw) increased PWT in animals that received Caps injection. The lower dose of the leaf extract (50 µg) didn't inhibit Caps-induced mechanical allodynia and this can be attributed to the faster inactivation or clearance of this dose (Andersen, 1981). Other scenario for explaining this finding can be that the lower dose of *A. andrachne* was not sufficient to activate receptors that are likely correlated with this response. On the other hand, the lack of effect in the higher dose of *A. andrachne* leaf extract (200 µg) can be attributed to an *in vivo* pharmacokinetic mechanism of drug clearance and excretion to avoid toxicity (Andersen, 1981). Other explanation is that the high dose of the leaf extract caused off-target effects that antagonized the anti-allodynic effect of the extract. No influence was detected on the contralateral hind paw confirming the local effect of *A. andrachne*. This is the first study that examined the effect of *A. andrachne* on the alleviation of Caps-evoked mechanical allodynia. Moreover, the ipsilateral pre-treatment with SR141716A, GW6471 or capsazepine reversed the anti-allodynic effect of *A. andrachne* reflecting that CB1, PPARα and TRPV1 receptors contribute to the effect of the leaf extract in this model. In contrast, no effect was found for the antagonists of PPARγ or α2-adrenergic receptors on the effect of *A. andrachne* in response to mechanical stimulus in this model.

Importantly, the activity of *A. andrachne* was similar to the effect of the non-steroidal anti-inflammatory drug (NSAID), diclofenac sodium. In fact, the action of the leaf extract on Caps-induced mechanical allodynia implies the pathway through which the anti-nociceptive effect was mediated. In more details, the neurons that transmit the signals from mechanoreceptors synapse at the superficial lamina of the spinal cord, while the signals from thermoreceptors synapse at the superficial and deep laminae of the spinal cord (Benarroch, 2016; Greenspon, et al., 2019). Of note, *A. andrachne* methanolic leaf extract exhibited anti-nociceptive effect in thermal and chemical models of pain (Jaffal et al., 2020). Furthermore, the extract had strong anti-inflammatory and antipyretic potential in carrageenan-induced paw edema model and yeast-evoked pyrexia models, respectively (Jaffal et al., 2021).

Based on the findings of this study and earlier reports, there is possibility that the injection of the leaf extract evoke the release of endogenous

cannabinoids that inhibit, at certain dose, neuropeptides release in the skin (Engel et al., 2011). In more details, previous studies showed that the stimulation of calcitonin gene-related peptide (CGRP) release by anandamide and tetrahydrocannabinol was antagonized by TRPV1 knockout and by using the antagonists of TRPV1 (BCTC) and CB1 implying the crosstalk between these two receptors (Engel et al., 2011; Ahluwalia et al., 2003). Additionally, anti-allodynic effects of the synthetic cannabinoids (WIN55212 and HU210) and tesaglitazar (a dual PPAR agonist) were reported in streptozotocin (STZ)-induced diabetic neuropathic pain model (Alsalem et al. 2019; 2020). Furthermore, Caterina (2014) reviewed the importance of CB and TRPV1 receptors in cutaneous sensation. Additionally, many reports revealed that TRP channels (including TRPV1) can be inhibited or activated by phytocannabinoids, synthetic cannabinoids and/or endocannabinoids (Caterina, 2014). In fact, the effects of cannabinoids on skin were attributed to the modulation of TRPV1 directly and indirectly (Caterina, 2014). At high doses, cannabinoids directly induce TRPV1 activation while at low doses; they suppress TRPV1 channel indirectly by CB1 receptors (Litwack, 2013; Caterina, 2014). On the other hand, the results of this study demonstrated that inhibiting CB1, TRPV1, PPARα receptors reversed the anti-allodynic effect of *A. andrachne* while the previous results revealed that the anti-nociceptive effect of *A. andrachne* in thermal models was inhibited by the antagonists of CB1, TRPV1 and PPARγ receptors (Jaffal et al., 2020). Accordingly, the modulation of TRPV1 channel by PPAR receptors *in vivo* depends on the type of stimulus and the used model of pain.

More importantly, our previous analysis of *A. andrachne* methanolic leaf extract indicates that the extract is rich in 17 active constituents (Jaffal et al., 2020). Many of these compounds exhibit anti-allodynic effects. For instance, previous studies demonstrated that the ipl injection of linalool attenuated mechanical allodynia in a mouse model of neuropathic pain (partial sciatic nerve ligation, PSNL) in a dose dependent manner (Kuwahata, et al., 2013). Also, the single and repetitive intraperitoneal (i.p) injection of 100 mg/kg body wt quercetin produced an anti-mechanical hypersensitivity in cancer-induced bone pain model in Sprague-Dawley rats (Liu, et al., 2018). Similar effect in attenuating mechanical allodynia was depicted after the i.p and intrathecal (i.t) injection of isoquercetin in diabetic rats (Resham, et al., 2020). Moreover, Azevedo, et al. (2013) reported that all doses of rutin and quercetin inhibited mechanical allodynia in a mouse model of oxaliplatin-induced neuropathy accompanied with a decrease in nitric oxide (NO) synthase immunostaining in the spinal cord (Azevedo, et

al., 2013). Moreover, kaempferol extracted from *Eruca sativa* produced an anti-allodyniac effect in STZ-induced diabetic neuropathy (Kishore, et al., 2018). The amelioration of mechanical alldoynia in different animal models was also mediated by linoleic acid (Shi, et al., 2019), gallic acid (Trevisan, et al., 2014), α-tocopherol (Tiwari, et al., 2009), ursolic acid (Bhat, et al., 2016), myricetin (Meotti , et al., 2006) and epigallocatechin-3-gallate (An, et al., 2014). These findings justify the results of this study and suggest that *A. andrachne* extract is a potential source of anti-allodynic compounds.

In conclusion, *A. andrachne* exhibited anti-nociceptive properties in Caps-induced mechanical allodynia in a mechanism that involves PPARα, CB1 and TRPV1. The use of this plant can open a gate towards finding promising therapeutics for mechanical allodynia which is a key symptom of many chronic pain conditions.

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Conflict of interest:

The authors confirm that there is no conflict of interest.

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Patient Safety Education: A Perspective of Southern Jordan Nursing Students'

Ahmad H. AlNawafleh *
alnawafleh@mutah.edu.jo
Muwafaq Al-Momani
Fadwa Alhalaiqa

Abstract

Background: Health care organizations are challenged to improve patient safety. Establishing baseline data on patient safety education is an effective intervention in this domain. This study aims at measuring nursing students' perceptions of patient safety.

Methods: Quantitative methodology, utilising cross sectional survey distributed to 158 final year nursing students and analysed by confirmatory factor and descriptive statistics.

Results: The model produced 4 components and their Cronbach Alpha reliabilities are: Comfort (0.778), Error reporting (0.638), Denial (0.510) and Culture (0.739), while the overall reliability for is (0.845). While 62% of students have observed medical errors during their clinical practice; only 25% of them have reported an error using incident report.

Discussion and conclusion: It is significant to include Patient Safety in nursing education and training programs. The inclusion will excel the level of clinical excellence, shed a light on trimming down medical errors, and enhancing health outcomes.

KeyWords: Patient Safety, Education, Nursing, Jordan, Students, HPPSACS

* College of Nursing, Mutah University.

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تعليم سلامة المرضى: من منظور طلاب التمريض الأردنيين

أحمد النوافله *
موفق المومني
فدوى الحلايقه

ملخص

خلفية: منظمات الرعاية الصحية تواجه تحدي تعزيز سلامة المرضى. إنشاء قاعدة بيانات حول تعليم سلامة المرضى يعتبر اجراءا فعالا في هذا المجال. تهدف هذه الدراسة إلى قياس توجهات طلاب التمريض لسلامة المرضى.

المنهجية: تم توظيف المنهج الكمي، باستخدام مسح مقطعي لعينة (158) من طلاب التمريض في السنة النهائية وتحليلها بمعامل توكيدي والإحصاء الوصفي.

النتائج: نتج عن التحليل نموذج بأربع مكونات وبمصداقية ألفا كرونباخ لكل منها: الراحة (0.778)، والخطأ في الإبلاغ (0.638)، والإنكار (0.510) والثقافة (0.739)، بينما الإعتمادية للمقياس كانت (0.845). في حين، 62% من الطلاب لاحظوا خطأ طبيا أثناء التدريب السريري؛ فقط 25% منهم ابلغوا عن الخطأ باستخدام تقرير الحوادث.

المناقشة والاستنتاج: من المهم تضمين "سلامة المرضى" في برامج التعليم والتدريب للتمريض. تضمينها سوف يرفع مستوى الكفاءة السريرية، ويسلط الضوء على التقليل من الأخطاء الطبية، ويحسن المستوى الصحي للمرضى.

الكلمات المفتاحية: سلامة المريض، التعليم، التمريض، الأردن، الطلاب، HPPSACS

* كلية التمريض، جامعة مؤتة.

تاريخ تقديم البحث: 2020/8/25. تاريخ قبول البحث: 2021/1/19م .

1 - Background

Health care organizations has been facing the challenge of improving patient safety (Singh & Graber, 2015). It was proposed that the student's safety behavior in clinical settings can be influenced by the quality, content and delivery of nursing education (Walton & Barraclough, 2011). Measuring the competence of any recommended curriculum to develop nursing patient safety education require establishment of base-line evidence on the existing position of patient safety education (Walton & Barraclough, 2011). While several studies have been conducted worldwide to evaluate the student nurses views on their undergraduate patient safety education, such research has mostly focused on the local and national perspective in the developed countries (Attree, Cooke, & Wakefield, 2008; Chenot & Daniel, 2010; Madigosky, Headrick, Nelson, Cox, & Anderson, 2006). Limited research has been carried out to compare the nurses' perceived Knowledge and attitudes regarding patient safety education in low resource countries and across several countries, therefore, missing an important opportunity to highlight an international pattern on the student nurses' perceived patient safety education in nursing domain. This paper is part of a wider research proposal, therefore, addressed the apparent gap in the literature. It outlined a quantitative study, by distributing a survey to the final year undergraduate nursing students in three nursing institutions in the UK, Jordan, and Saudi Arabia. The aim of the wider study was to provide a comparison of the student nurses' perceived Knowledge, skills, and attitudes regarding patient safety education across the three sites and examining any pattern or common relationships among the students' perceptions that may emerge in the study. This paper is reporting only patient safety education among Jordanian nursing students through a survey on knowledge, skills and attitudes in one of the nursing schools.

2- Literature review:

There is a dearth of empirical research examining the relationship between patient safety and education of health professionals in both quality management and health service literature (Han, Kim, & Seo, 2020; Kirwan, Riklikiene, Gotlib, Fuster, & Borta, 2019; Taskiran, Bacaksiz, & Seren, 2020; Yoo, Park, & Kwon, 2019). There have been some descriptive works suggesting the link between patient safety and undergraduate nurses' curriculum and education practices (Yoo et al., 2019).

health care organizations encounter a challenge of sustaining health care service delivery under safety measures. thoughtful patient safety, and safe patient care delivery can be achieved through health professional's knowledge, skills and attitudes. Those, usually gained during education when it contains patient safety contents and courses (Greiner & Knebel, 2003; Hwang et al., 2016; Kongsvik, Halvorsen, Osmundsen, & Gjøsund, 2016). Nursing education worldwide was investigated to measure the students' patient safety knowledge, skills and attitudes (Han et al., 2020; Johnson, McNally, Meller, & Dempsey, 2019; Kirwan et al., 2019; Okuyama, Martowirono, & Bijnen, 2011; Taskiran et al., 2020; Yoo et al., 2019). In the UK, Attree, et al (2008) examined the undergraduate nursing degree curriculum to find contents related to patient safety. The study utilized various qualitative data collection methods, including curriculum analysis, focus group interviews with 15 students, 10 educators, and 6 education delivery key informants. The study found a lack of patient safety knowledge based on the systems approach and the nursing curriculum had no learning objectives with direct focus on patient safety (Reason, 2000). Pearson, Steven, & Dawson (2009) also carried out a study on nursing students beside three other health professions to understand patient safety learning. The study utilized a qualitative design encompassing range of data collection methods, such as curriculum analysis, interviews with students, patients, academics, qualified health care professionals, and observation of

teaching methods. The study found lack or sometimes several gaps in the curriculum content of subjects related to patient safety.

In the context of North America and the US specifically, undergraduate nursing students before licensed submit approval of patient safety education. This came as recommendation from Smith, et al (2007) study which concluded that qualified nurses must demonstrate patient safety competencies. In their study, Smith, et al (2007) investigated the curriculum of more than 600 nursing schools and programs in the US to find whether it contains competencies related to quality and safety. The online survey of the schools yielded that schools' curriculum threaded with (95%) patient – centred care, followed by (89%) safety and (82%) teamwork collaboration. In another study, Chenot and Daniel (2010) evaluated the Knowledge of pre-licensure nursing students about patient safety topics. They implemented pre and post curriculum survey of Patient Safety/Medical Fallibility Assessment -which published by Madigosky et al. (2006)- and they developed the Health Care Professionals Patient Safety Assessment Curriculum Survey (HPPSACS). They collected their data from seven universities in the USA through a questionnaire distributed to a sample of 618 students and more than half responded. The researchers concluded that patient safety knowledge measures are valid and reliable. Their conclusion based on results indicate HPPSACS items scored Alphas estimates above or near the range of the recommended level of 0.70 (Cortina, 1993; Nunnally 1978).

Although most research in nursing patient safety education appears to have been undertaken in Western Europe and North America, there were some attempts to carry out similar research in other countries. Vaismoradi et al (2011) explored the role of nursing education on patient safety from the point view of Iranian nurses. Their sample was seventeen undergraduate nursing students enrolled in one university in Tehran. Their data collected through personal interviews and qualitative content analysis reported dissatisfaction with the classroom conversations about patient safety issues.

The students expressed concerns about the medical domain of handling the topics. Therefore, the students highlighted difficulty in making the connection between the theoretical courses directed toward patient safety standards and their nursing practice applications. However, the Iranian culture, values, and educational systems may differ from others and the context may apply elsewhere. To generalize these findings in different cultural contexts, there is need to carry out further investigations.

Assessing the patient safety education in nursing programs in Jordan received little attention, while it was prone to numerous investigations internationally. Moreover, Jordan is less involved in patient safety education based on a recent recommendation from the World Health Organization office in Amman to design a patient safety and quality curriculum for health disciplines' students. Conducting such research on the local level would help to evaluate the Jordanian nursing students current perceived status of patient safety education. On the international level, such research would help to highlight more visibly the themes in patient safety education, across-county, which are lacking, or exiting, in the current nursing curriculum. This would contribute to establishing across-countries shared indicators for patient safety education in nursing, but the results would also inform policy makers of areas of patient safety education that may be best addressed by shared efforts. The World Health Organization (WHO) is going ahead in developing and implementing Patient Safety Curriculum Guide for Multi-professions students (Walton & Barraclough, 2011). However, the patient safety education in nursing run in short of trustworthy baseline data on the current status. This hinders measuring the impact of any proposed intervention, including the new curriculum guide, on the health care professional' KSA toward patient safety education.

Aim and purpose

This paper aims to assess nursing students in Jordan current perceived status of patient safety education. The purpose is to provide recommendations of basic knowledge required to develop nursing competencies for undergraduate nurse student to carry safe nursing practice therefore it attempts to answer the following questions:

Is the HPPSACA suitable for measuring nursing students KSA in Jordan?

What are the undergraduate nursing students' KSA regarding patient safety (PS) in Jordan?

3- Methodology

this study used a cross sectional survey based on quantitative methodology distributed to undergraduate nursing students in one academic nursing institution in Jordan during four semesters. The study utilized the previously validated Health Care Professionals Patient Safety Assessment Curriculum Survey (HPPSACS) (Chenot & Daniel, 2010). Permission from the author has been sought. Although the nursing education is delivered in English, Arabic language is the native language in Jordan. Therefore, the survey tool was combined with a translation for the items to Arabic to support students understanding of every item. The items in the survey translated into Arabic and back translated to English by two independent translators (Ryan & Bernard, 2000).

The survey distributed to the final year undergraduate nursing students in a public university in the south of Jordan during four different semesters. By the time data collection started, final year students have covered most of the courses during their curriculum and are likely to provide more informed evaluation of their knowledge, skills, and attitudes regarding patient safety education. Moreover, selecting undergraduate nursing students for

evaluating their nursing education would be more appropriate. This is because while they are still students, their patient safety behaviours are likely to be influenced by their educational program, before they qualify as registered nurses where their patient safety knowledge, attitude and behavior become more influenced by their new working climate (Flin & Patey, 2009; Mansour, 2015). The survey distributed to 158 final year undergraduate nursing students in the academic institution. In total, 125 of final year students returned surveys, in a response rate of 79%, two were excluded as they were incomplete and 123 considered for the analysis.

The students on the nursing training course received a questionnaire after a consent from them and from the other academic colleagues who were delivering teaching to the final year nursing students. The researchers chose a lecture, whereby the final year nursing students were attending, and the questionnaires delivered. The students were encouraged to return the questionnaires after the lecture finishes, but also given opportunity to return the completed questionnaires to a designed mailbox in the institution at later date.

1.1 Data analysis:

Data analysis involved:

The researcher coded the retuned questionnaires and entered the data into SPSS Software version 20 (Allen & Bennett, 2012). The data statistically analysed using factorial Analysis to ascertain the students' knowledge and attitudes regarding patient safety. This study tested HPPSACS scores for validity and reliability by employing alpha reliability analysis and confirmatory factor analysis (CFA). The underlying constructs was revealed by grouping the items into subscale scores on the patient safety instrument. The students' KSA concerning patient safety was reported by descriptive statistics.

1.2 Ethical approval:

Mutah Faculty of Nursing Research Ethics Committee granted the institutional review approval before data collection commences. Moreover, a permission to distribute the questionnaire from the dean of the Nursing Faculty was obtained in advance. Information sheet distributed to the participants, which states the purpose of the research, the likely benefits, and the voluntary nature of participation. The students assured their identity will never be sough at any stage of the research. Each questionnaire was assigned a code to facilitate the data entry and analysis. There was no physical risk to the students participating in this project, and to minimise any potential psychological distress on the participants. A research assistant who is not part of the teaching or assessment of the nursing students collected the data.

4- Results

The survey analysis conducted on data from hundred twenty-three nursing students. Most of them were females 41.5% (n=51), 32.5% (n=40) were male, and 26% (n= 32) left the item without answer. The students mean of age was 21, although the youngest was 20 and the older was 27 years old. All the students enrolled in three nursing programs and respondents represent 54.5% (n=67) morning program, 12.2% (n=15) parallel program, 1.6% (n=2) bridging program and 31.7% (n=34) did not indicate their program.

Table 0: Confirmatory Factor Analysis for the tool.

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.518	28.339	28.339	4.331	18.829	18.829
2	1.927	8.378	36.718	3.426	14.894	33.723
3	1.656	7.201	43.918	1.966	8.550	42.273
4	1.480	6.434	50.353	1.858	8.080	50.353
5	1.281	5.570	55.923			
6	1.095	4.761	60.684			
7	.991	4.309	64.992			
8	.892	3.878	68.871			
9	.813	3.533	72.403			
10	.766	3.330	75.733			
11	.687	2.987	78.720			
12	.660	2.868	81.589			
13	.577	2.507	84.095			
14	.560	2.434	86.529			
15	.529	2.298	88.827			
16	.485	2.107	90.935			
17	.429	1.867	92.802			
18	.379	1.646	94.447			
19	.342	1.487	95.934			
20	.280	1.219	97.153			
21	.253	1.098	98.251			
22	.225	.978	99.229			
23	.177	.771	100.000			

Extraction Method: Principal Component Analysis.

This study reports on usability of a framework for examining the knowledge and attitudes about patient safety education from the perspective of undergraduate nursing students'. Using Likert scale, the participants selected their level of disagreement and agreement with the items 1-18 and their discomfort and comfort for items 19-23. Patient safety situations the students may had experienced during their last year training examined by chooing yes or no reply for items 24-29 of the questionnaire. CFA examined the data and confirmed the factor model of patient safety education reported by Chenot and Daniel (2010) as illustrated in tables 0 and 1. Four factors identified in this model.

Table 1: HPPSACS factors and associated items

	factor	Item no.	Item description
1	Comfort (5 items)	19	Accurately completing an incident report.
		20	Analysing a case to find the causes of an error.
		21	Supporting and advising a peer who must decide how to respond to an error.
		22	Disclosing an error to a faculty member.
		23	Disclosing an error to another healthcare professional.
2	Error reporting (9 items)	2	Competent healthcare professionals do not make medical errors that lead to patient harm.
		4	Only physicians can determine the causes of a medical error.
		5	Healthcare professionals should not tolerate uncertainty in patient care.
		6	The culture of healthcare makes it easy for healthcare professionals to deal constructively with errors.
		8	Healthcare professionals routinely share information about medical errors and what caused them.
		10	Healthcare professionals routinely report medical errors.
		12	Physicians should be the healthcare

	factor	Item no.	Item description
			professionals that report errors to an affected patient and their family.
		13	Effective responses to errors focus primarily on the healthcare professional involved.
		17	After an error occurs, an effective strategy is to work harder to be more careful.
3	Denial (4 items)	11	Reporting systems do little to reduce future errors.
		14	If there is no harm to a patient, there is no need to address an error.
		15	If I saw a medical error, I would keep it to myself.
		16	Most errors are due to things that healthcare professionals can't do anything about.
4	Culture (5 items)	1	Making errors in healthcare is unavoidable
		3	Healthcare professionals should routinely spend part of their professional time working to improve patient care.
		7	Learning how to improve patient safety is an appropriate use of time in health programs in school.
		9	In my clinical experiences so far, faculty and staff communicate to me that patient safety is a high priority.
		18	There is a gap between what we know as 'best care' and what we provide on a day-to-day basis.

The 23 items produced a good model fit in CFA. The 23 items are abstracted in 4 factors, those are:

1. 'Comfort' factor labelled the comfort feeling level of the student when they complete revelation of medical errors and writing incident reports.

2. ‘Error reporting’ a factor labelled for dealing with medical errors and reporting its incidence.
3. ‘Denial’ factor labelled the medical errors denial.
4. The ‘’culture’’ factor was used to label the rest of items.

Those factors have a relationship with the student knowledge and attitudes toward patient safety education. Patient safety education measured by recognising patient safety occurrence, disclosing this error to others and education coverage of patient safety theme within the curriculum.

Table (1) Student response to the second section of the survey.

	Uncomfortable	**Neutral**	**Comfortable**
Accurately completing an incident report.	20.5%	30.3%	49.2%
Analysing a case to find the causes of an error.	20.8%	26.7%	52.5%
Supporting and advising a peer who must decide how to respond to an error.	18.2%	23.1%	58.7%
Disclosing an error to a faculty member.	21.5%	27.3%	51.2%
Disclosing an error to another healthcare professional.	26.5%	28.9%	44.7%

Cronbach Alpha scores for HPPSACA indicated reliability and internal consistency of the measure. Cronbach Alpha over all scored (0.845), however, the model components reliability scores are (0.778) for Comfort, (0.638) for Error reporting, (0.510) for Denial and Culture (0.739). Apart from Denial, the other three components are within accepted range of recommended threshold of 60. These coefficients are satisfactory in the light of few items for each component and the exploratory nature of this construct validity analysis.

Table (2) Student response to the first section of the survey.

	Disagree %	Neutral %	Agree %
In my clinical experiences so far, faculty and staff communicate to me that patient safety is a high priority.	20.5%	17.2%	62.3%
Healthcare professionals routinely report medical errors.	35.8%	25.8%	38.3%
If I saw a medical error, I would keep it to myself.	65.7%	13.5%	20.7%
There is a gap between what we know as 'best care' and what we provide on a day-to-day basis.	19.5%	26.8%	53.7%

The study reports that 62% of students have observed medical errors during their clinical practice; however, only 25% of them have reported an error using incident report (see table 4). On the other hand, disclosing of these errors to faculty member represented third only while almost all the students witnessing errors disclose it to their colleagues. This is an indication that there are barriers in communicating errors to the faculty. It may also indicate that there is a culture of blame rather than a reporting errors within the training area.

Table (3) Student response to questions regarding experience of patient safety situation

	Yes	No
Have you observed a medical error in your clinical experiences?	61.7%	38.3%
Have you disclosed a medical error to a faculty member?	32.8%	67.2%
Have you disclosed a medical error to a staff member?	50.4%	49.6%
Have you disclosed a medical error to a fellow student?	58.8%	41.2%
Have you reported an error using an incident report?	24.6%	75.4%
Did your nursing program of study provide sufficient coverage on the topic of patient safety?	65.3%	34.7%

Next section presents a brief for the discussion, the study implications, and conclusions. It gives further discussion for the study results in the light of the theoretical context. It closes with future studies speculation based on the findings of this study.

2- Discussion

This study examined undergraduate nursing students' KSA regarding patient safety that were in BSc nursing degree programs in Jordan. It is significant to include Patient Safety in nursing education and training programs. More specifically there is a need to add the socio-cultural aspects of safety to the nursing curriculum. Although curriculum development in nursing education is demanding, efforts to include PS are not satisfactory. This indicates the value of conducting research to recognise the senior nurse students' level of patient safety awareness.

This study suggests the HPPSACA can be used to assess senior undergraduate nursing students KSA about patient safety. Indeed, the student's perception of professional confidence in providing safe patient care is one of several indicators for assessing the student's competency and effectiveness of nursing education. Existing instruments to measure patient safety KSA were developed primarily to explore the impact of curriculum proposals for patient safety.

Several tools used to assess safety competencies of nursing students, however, most measures have few aspects of PS competencies outlined by national and international bodies (Okuyama et al., 2011). Using the CFA to analyse the wide range patient safety competencies as measured by HPPSACA, this study addressed the literature gaps.

Our results confirmed previous results of four-factor, 23-item model of student nurses' patient safety competence (Ginsburg, Tregunno, & Norton, 2013; Mansour, 2015). Those can be used to assess senior students learning about Patient Safety competence: (1) comfort, (2) reporting, (3) denial, (4) Culture of safety. Evaluation of students KSA in the main safety competencies is essential, mainly due to small evidence about patient safety competency assessment.

The HPPSACA can be used to investigate whether the students attained the learning objective of patient safety during their training. Therefore, it is helpful for the academics in their class room teaching, clinical training and to design curriculum for professional nursing (Ginsburg et al., 2013). It does worth to mention that we found during this study few academic members

expressing understanding the basic knowledge and skills required to teach patient safety related materials.

Curriculum at the undergraduate nursing programs is modified every 4-6 years in Jordan, however, it is difficult to find who has the power to include new competencies and subjects in the curriculum. Further research is necessary to understand how to include PS knowledge in this curriculum. Moreover, it is important to determine which PS aspects and teaching approaches are more appropriate considering the stage and the setting.

Since academic and hospital environment can influence the adoption of PS for quality health care service it is necessary also to assess the formal and informal factors related to inclusion of PS in nursing education curriculum. Despite this problem adoption of PS in nursing education is important; because, there is evidence supporting PS knowledge achievement from the curriculum. The key issue of this argument is the identification that nursing students' KSA of PS is essential and adjustable.

This study recommends for a future research to build on these findings and examine academics interpersonal relationships impact on patient safety knowledge among students in nursing bachelor programs in Jordan. Learning patient safety component would need to incorporate an appraisal of pedagogic teaching concepts and tools. There is need to identify any barriers to report errors mainly to instructors. It may also identify any curriculum aspects that influence students' interpersonal relationships. Also, an examination of nursing teachers and instructors' ability to conduct patient safety knowledge and convey it to their students to build KSA. Thus, we propose that an increase in students KSA of patient safety might correlate with an increase in patient safety KSA among nursing teachers and instructors. A future research would be to develop a study to assess the nursing curriculum contents of patient safety domains in Bachelor programs. Likewise, there is need to determine the correlation of patient safety learning outcomes with indicators of health outcomes through an examination of patient safety courses and teaching practices. This may include topics related to incidence reports and medication errors.

This study may present issues related to generalisability of its results to wider population which may be considered during future implications. Its data come from senior nursing students in the clinical training in one Jordanian governorate, Karak. In Jordan, there tends to be some variation in nursing school curriculum. Internationally, Jordan's nursing training

structure and environment are equivalent to the wider programs adopted by other countries in Europe and North America. It is however possible that our four patient safety factors validated in this study will be translated in different way for new graduates from other national cultures. Additional exploration and cross-validation with wider samples of senior student nurses or fresh graduates of the HPPSACA is necessary to generalise wider implication.

3- Conclusion

This study added to the literature of patient safety the value of its integration in nursing curriculum. This integration would contribute to improving health outcomes, reduce medical errors and lead to quality health service. Conducting a study using HPPSACS with undergraduate nursing students would shed a light on their awareness about patient safety. Descriptive statistics of this study reported that the nursing students' have positive attitude and highlight their patient safety awareness on scores expressed by the HPPSACS.

Patient safety should be considered in nursing curriculum and should be taught by nursing academics. Policy development must include patient safety, and this is the responsibility of nursing leaders. Both the nursing leaders and academics must work toward approval of the patient safety competencies at the national level and at the level of nursing education programs. Nursing academics in the accreditation boards, Jordanian Nursing Council and nursing institutes are required to address nursing students' competencies of patient safety. This is required to enhance health care and health outcomes. Adoption of patient safety in the nursing curriculum will enhance health, save patients' lives, and it will sustain Jordan's health system.

This study should be followed up by examining patient safety KSAs of associate, bachelor, master's, and doctoral nursing students. Further examination is recommended for nursing academics perceptions of patient safety and its applications for their students.

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Towards a Multi Classifier Machine learning Based Approach for Course Cancelation Problem Avoidance

Obada Alhabaasneh *

O.alhabashneh@mutah.edu.jo

Abstract

The course cancelation problem (CCP) is one of the main problems of the university timetabling process. The problem usually occurs when the academic registry at the university cancels a course section for violating the "minimum number" hard constraint which refers to the minimum number of students enrolled in the course section. CCP is common within the universities in which the timetable is created before the student registraion process strats.

This paper discusses the development of a multi-classifier machine learning-based approach for course section cancellation risk estimation. The approach analyzes the enrollment historical data of the university to identify the common features of the canceled sections. These features include the course, section time-slot, the number of students who are eligible to take it, and the lecturer. These features are then associated with section cancellation status. The resulted dataset is fed into a multi-classifier component to predict the risk level of the section cancellation. The proposed approach aims to advice the academic departments in preparing the timetable of the upcoming academic term to avoid including the high risk courses in the time table which ,in turn, is expected to inance the stabilty of the time table by minimzing the number of canclection cases.

Results have shown that the proposed approach has achieved 85% classifying accuracy in identifying the cancelation risk level of sections before including them in the timetable. The classifying accuracy is expected to improve with the growth of the data volume. Also, using different gives the approach the dynamicity to use the most accurate classier to achieve the highest accuracy based on the provided case.

Keywords: Machine Learning, University Timetabling, Course Cancelation, Multi-Classifier.

* College of Business, Mutah University.

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نحو طريقة معتمدة على تعلم الآلة ومتعددة المصنفات لتجنب مشكلة شطب الشعب

عباده الحباشنة*

ملخص

تعد مشكلة شطب الشعب من المشاكل الأساسية التي تنطوي عليها عملية التسجيل الفصلي حيث أنه يتم شطب العديد من الشعب التي لم يبلغ عدد الطلبة المسجلين فيها العتبة المحددة لها حسب سياسة الجامعة وتعد هذه المشكل من المشاكل الشائعة في الجامعات التي تقوم بطرح الجدول لدراسي وتجهيزه قبل بدء عملية التسجيل.

تناقش هذ الورقة تطوير طريقة معتمدة على تعلم الآلة ومتعددة المصنفات لحل مشكلة شطب الشعب عن طريق توقع مستوى خطورة شطب الشعبة قبل طرحها وبذلك يتم تجنب طرح الشعب التي من المرجح شطبها أو إلغاؤها. تقوم الطريقة بتحليل البيانات التاريخية للتسجيل في الجامعة لتحدي السمات المشتركة للشعب التي تم إلغاؤها سابقا مثل: المادة، وقت الشعبة، عدد الطلبة المستحقين للمادة، والمدرس. وبعد ذلك يتم إدخال البيانات الناتجة إلى المكون متعدد المصنفات حتى يقوم بتحديد مستوى الخطور المترافق مع طرح الشعبة على الفصل الأكاديمي المقبل حيث يتكون من عدة مصنفات ويم أخذ نتيجة المصنف الأكثردقة. تهدف هذه الطريقة لتوفير آلية إنذار مبكر للأشخاص القائمين على إعداد الجدول الدراسي لتخفيض عدد الشعب الملغاة كل فصل وذلك بتجنب طرح الشعب ذات مستوى الخطورة العالي.

أظهرت النتائج أن الطريقة المقترحة حققت دقة تصنيف قدرها ٨٥% في توقع احتمالية إلغاء الشعب وأن هذه النسبة مرشحة للزيادة مع تزايد حجم البيانات المستخدمة في تدريب المصنفات وباستخدام تعلم الآلة.

الكلمات الدالة: التعلم الآلي، الجدول الزمني للجامعة، إلغاء الدورة، المصنف المتعدد.

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* كلية الأعمال، جامعة مؤتة.

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1- Introduction

Timetabling is one of the key tasks in the enrollment process in the universities as the course offering must be ready for the students every academic term brfore they start their study. Usually, the academic departments prepare the course timimtable in collaboration with the academic registry to ensure it is convenient for the students, complying with the academic plan and the university policy. However, the credit hours system adopted by different universities over the world requires that the student have the right to select the courses offered by the university based on their preferences of the class time and lecture. This requires, usually, to offer different sections of the same course with different timeslots and/or different lecturers to give students enough flexibility on their choices. Moreover, the timetable must also be compatible with the lectures' specialties and availability. Preparing a suitable timetable that meets all these requirements might sound simple at the theoretical level, but it is more complicated in practice as such it must satisfy the students, lecturers, and university constraints including the academic plans and other academic and financial constraints.

Due to the prolonged global financial hardship, financial modeling has become a critical factor at all levels in university planning, in general, and in course offering in particular. To minimize cost, the course offering process often applies a strict section cancelation policy that identifies a minimum number of student enrollments, referred to as the threshold, required to survive section cancelation. The threshold is identified based on different factors such as the nature of the course (lecture-based or lab-based), the program level (BSc, Masters, Ph.D.), the course role in the academic plan (mandatory or elective), and the course's level (university, faculty or program).

Such policy helps the university minimizing the teaching cost, but it causes problems for the students and the academic departments due to regular cancelation of significant sections. The cancellation usually happens in the early weeks of the academic term. This causes a huge disturbance since the students need to look for an alternative section, or even a course, to replace the canceled section. Even though, this might go smoothly in some cases, finding the alternative often involves complexities related to resolving conflicts in sections timeslot. In some other cases, the situation

becomes more complicated especially with the students who are graduating on that term or the following one as they need to apply for permission to take a course that is not part of their academic plan and it is the responsibility of the academic department to identify which course to take. This leads to a shift of the actual start of the learning and teaching process as the timetable takes two to three weeks to stabilize.

University Course Timetabling Problem (UCTTP) is an optimization problem that occurs every semester .(Asmunim,2015) (Babaei, Karimpour & Hadidi,2015). The goal of the university course timetabling problem (UCTTP) is to create a timetable in which all events are assigned to a set of predefined timeslots and rooms in such a way all constraints (hard and soft) are satisfied .(Babaei, Karimpour & Hadidi,2015). A set of events include the subsets: courses, students, and lectures. Constraints have two categories; hard and soft. Hard constraints refer to those conditions that must be met such as minimum and maximum number of students in the class and there is no tolerance for violation. Soft constraints refer to those constraints that are preferred to satisfy to make the timetable more efficient such as minimizing the time gaps between students' classes or minimizing the distance between the rooms for students .(Asmunim,2015) (Babaei, Karimpour & Hadidi,2015).

Course/section cancelation problem (CCP) can be defined as the situation in which the academic registry at the university cancels a course or a course section because of the violation of one of the hard constraints which is usually the minimum number of students enrolled in the course. This problem is quite common in the university in which the timetable is created before the enrollment process. In this case, course sections are offered and assigned to timeslots and lectures before students enrollment, Consequently, the students have the choice to select the courses based on their preferences under the condition of satisfying the academic plan constraints such as the prerequisites and the maximum number of courses taken of each requirement type in the academic plan of the student's program. This margin of selection freedom often leads to a lack of enrollment in some sections due to the tendency of students to avoid certain time slots (early morning and evening), lectures, or courses. These sections are usually canceled especially if didn't achieve the minimum number of students which causes a significant distribution for the teaching process as the students in the canceled courses start to look for other courses to enroll again. Course cancellation usually takes place after the first week of the

semester. This leads to a delay in the actual start of the teaching process and long queues of students asking for the advice of the academic departments. Another complication of this problem is that the academic departments in many cases must reassign lecturers to courses to meet the academic load of each lecturer in the department.

In the light of the above, providing an effective approach to help the academic departments in preparing an optimal course offering that meets the student's requirements and minimizes the number of the canceled sections has become imperative.

This paper discusses the development of multi-classifier machine learning- based approach for course's section cancellation risk estimation. The approach analyzes the enrollment historical data of the university to identify the common features of the canceled sections. Such features may include the course itself, section-time slot, the number of students who are eligible to take it, the lecturer. These features are then with section cancellation status. The resulted data set then is red into a multi classifier to predict the likelihood of the section cancellation. The proposed approach aims to assist the academic departments in preparing the timetable of the upcoming academic term by predicting the likelihood of the section cancellation before including it in the timetable. This in turn is expected to minimize the number of the canceled section.

2- Related Work

The ACTTP has been studied extensively and several researche have attempted to provide efficient solutions. However, due to the high dimensionality of the problem together with a variance of the rules applied in different countries and universities, providing a comprehensive approach that can overcome all subproblems sounds nonrealistic which makes this research area still lacking.

One of the earliest attempts to solve this problem used graph coloring problem in 1967(Welsh,1967). The graph coloring-based approach was further developed to solve the timetabling problem using a non-directional graph to prevent the conflict in the timetable (Werra,1985). To reduce the number of resulted graphs a separated graph was used on separate students' groups (Selim,1988). This method has been modified to direct the vertices and edges of the graph to common courses to create a uniform distribution of the courses (Amal & Mayez,2010).

Another graph-based approach has been proposed using genetic coloring to find the least colors of the graph (Asham, Soliman& Ramadan,2011). A genetic algorithm has been proposed for maximizing the number of enrolled students in the course using bipartite graphs (Long,2019). A modified grouping-based algorithm has been proposed to solve the course timetabling problem (Kralev, Kraleva& Kumar,2019).

The integer programming(IP) method is used to split the timetabling into two subproblems: timetabling and grouping. An IP-based heuristic approach was applied to the two groups until finding the optimal timetable (Aubin,Ferland,1989). Another IP-based method was introduced to solve the timetabling problem. The method aimed to produce the best fit timetable by allocating a set of courses to a lecturer, groups of students, and timeslots (Daskalaki,Birbas & Housos,2004). An IP-based relaxation method was proposed to create an optimal timetable on two steps (Daskalaki,Birbas,2005). The courses with one timeslot were timetabled in Step.1 while the courses with more than one timeslot were timetabled in Step.2. The IP has also been used to improve the rule finite and constraint satisfaction in timetabling (Bakir & Aksop 2008). Lecturer university timetabling was looked at as an NP-hard problem (Luisa& Meurant,2020)and both algorithms were evaluated on this base. Genetic Algorithm was shown to outperform Hybrid Genetic Algorithms-Hill Climbing in finding the optimal solution. (Yusoff,Roslan,2019).A binary integer programming formulation has been used to solve the university timetabling problem(Erim Chung & Kim,2019).

Constraint satisfaction programming (CSP)has also been used to solve the time baling problem. A constraint-based approach has been integrated with a genetic algorithm to find the optimal timetable (Deris, Omatu & Ohta,1999). In another research, the object-oriented approach and constraint-based reasoning have been combined to find an optimal timetable (Deris,Omatu,&Ohta,2000).In more recent research, constraint satisfaction programming has been used to find the objective function to allocate resources required for an optimal timetable[19](Lixi, SimKim,2005). A Constraint satisfaction (CS) model was introduced in (Lixi, SimKim,2005) to automatically construct the university timetable. The model uses the university constraints such as the academic plan, time slots lecture availability to produce the timetable. A list of hard and soft problems relating to university timetabling was provided in (Herres, Schmitz,2019).

The list included different problems such as the time overlapping and the lecturer's double booking.

Other researchers adopted a heuristic Approach. For example, in the Greedy Randomized Adaptive Search Procedure (GRASP), a maximum flow partial solution and simulated Annealing were integrated to find the optimal university timetable (Lixi&SimKim,2005). The introduced componential model was developed using the second International Timetabling Competition (ITC-2007). A meta-heuristic algorithm was integrated with a non-dominated sorting genetic algorithm to find the best solution for the timetabling problem (Al-ghamdi,2012). The education quality measure was used as a base for the solution selection. The education quality included different factors such as the teaching capabilities of lecturers, student counseling, and tutorials time during the day. The Simulated Annealing (Kirkpatrick,Gelatt&Vecchi,1983) was used to optimize the Reheating (SAR) (Goh, Kendall& Sabar,2017) algorithm to find the optimal solution for the post-enrollment course problem. The introduced approach started with finding a feasible solution first then optimizing that solution (Goh, Kendall& Sabar,2019). Ant colony optimization (ACO) algorithm has been used to optimize the university timetabling. The algorithm was applied on Faculty of Informatics and Computing (FIC) datasets and achieved an acceptable accuracy level in assigning the offered courses to the available time slots (Mazlan, Makhtar& Ahmad Khairi,2019). A Genetic Algorithm was introduced in (Mazlan, Makhtar& Ahmad Khairi,2019) for the timetabling problem. The algorithm was designed to increase the convergence rate of the new schedule. An extensive computational experiment was conducted on the International Timetabling Competition ITC-2007 data set (Gülcü& Akkan,2020). In their experiment, the researchers applied a multi-objective simulated annealing (MOSA) algorithm to achieve the optimal solution for the soft constraint problem. Tabu search based approaches for timetabling were proposed in (Gaspero & Schaerf 2001) (Abdalla,Obit&Alfred,2019). The proposed approaches used the diversification of the neighborhood to find the optimal solution. The approach focused on reducing the number of potential solutions to speed up the optimization process.An agent-based framework for the university course timetabling was proposed in (Abdalla,Obit&Alfred,2019). The framework used distributed multi-agent system based on integer programming. The approach consisted of a central agent that is coordinating between the other agents to find the optimal solution. A model-driven approach has been proposed to solve the time tabling problem (Eke.,et al 2019). The approach used a model-driven UI to

generate an initial solution then give the user the ability to adjust the solution.

Recently, machine learning has been used for university timetabling problem. A naïve Bayesian approach was proposed to identify preferred timeslots by lecturers to resolve the soft constraint (Tharwat,2018). Support Victor Machine and Leaner Regression were both used for feature extraction and selection to identify the hard and soft constraints. Neural Network was integrated with the heuristic approach for better performance in the class/teacher timetabling problem (CTTP) (la Rosa-Rivera.,et al 2020). Fuzzy logic has been used to solve the problem of course timetabling. A fuzzy c-mean based approach has been introduced to handle the uncertainty in clustering students' courses in a weekly program. The approach reduced conflict in the student's preferences and class time (Asmuni.,et al 2020). Another research (Rachmawati& Srinivasan,2005) proposed a hybrid fuzzy approach to students' projects. The approach used an objective satisfaction method for assigning students to projects. A fuzzy genetic heuristic has been applied to the University course timetabling problem (Chaudhuri&De,2010). The genetic heuristic has been used to match the events(classes) with the features while the fuzzy sets have been used to handle the soft constraints' violation. In another research, A fuzzy genetic algorithm has been integrated with local search to solve UCTP (Kohshori & Abadeh,2012). The fuzzy genetic algorithm has been used to produce the optimal timetable and the local search for improving the efficiency of the algorithm. Fuzzy logic has been integrated with a local search algorithm to address the ambiguity in soft constraints of the timetable and the local search was used to find the optimal solution (Babaei,Karimpour&Hadidi,2019). In another research (June .,et al 2020), the fuzzy logic has been integrated with a sequential constructive algorithm to optimize the course timetable. Fuzzy logic has been used expand produce multiple sequences that are normalized to find the best sequence. Fuzzy sets have been used in modeling the violations of the soft constraints (Perzina&Ramík,2013). The sets were incorporated in a self-learning genetic algorithm with indirect representation to produce a low-cost optimal course timetable.

3- The Proposed Approach and its Results.

As shown in Figure(1), this paper proposes a multi classifier machine learning based framework to support the decision of the academic departments in building the timetable. It uses the classifiers to identify the cancelation risk level of the suggested course sections during the timetable construction process. The aim of using different classifiers is to maximize classifying accuracy. This can be achieved by evaluating the accuracy performance of different classifiers first. Consequently, the classifier with the highest accuracy performance is selected.

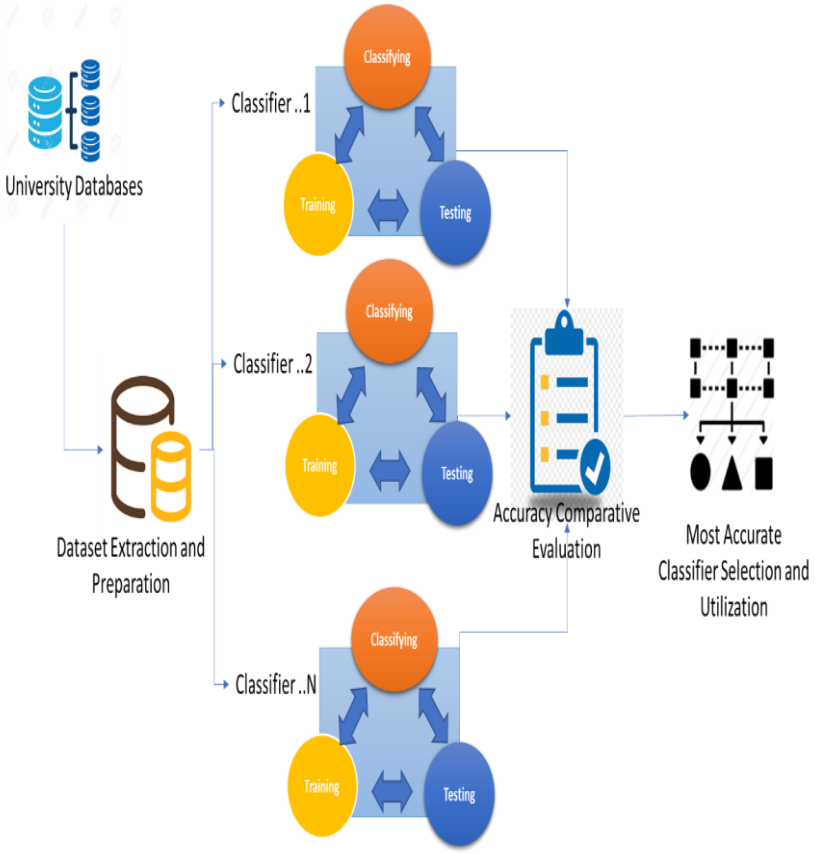

Figure 1: The Proposed Approach

1.1 Dataset Extraction and Preparation.

1.1.1 Data Collection

In this step, a dataset is collected from the university enrollment and registration databases. The collected data may include data related to the number of the students who are eligible to take each course, the minimum number of students allowed for each course section, the academic plan for each academic program, the average number of sections canceled for each lecturer in the past, the average number of sections that have been previously canceled for each course and the status of each course section in the time table history.

The proposed framework has been developed, trained, and evaluated based on real data collected from MU academic registry system databases. The dataset used in this study has been extracted from the Mutah University (MU) enrollment records focusing on the data of the canceled course' sections over the last 5 years. The dataset consisted of 5000 records and included data on the timetable history, lectures, courses, and academic plans of the academic programs.

MU is one of the largest public universities in Jordan. It has been founded in 1981 to be the first university in the southern part of Jordan. MU encompasses two wings; Military and Civilian. The Civilian wing contains 14 colleges: Arts, Business, Law, Social Sciences, Social Sciences, Educational Sciences, Sport Sciences, Medicine, Pharmacy, Nursing, Engineering, Science, Information Technology and Agriculture. The university offers 56 academic programs on Bachelor, Master, and Doctorate levels. The university has around 18,000 students currently enrolled in all programs.

Like the other Jordanian universities, MU adopts the credit hour system in which each credit hour equates to three class hours per week throughout the academic semester which spans over 16 weeks. Each program has an academic plan that defines the program requirements and their dependencies. The program completion requirements are released in the form of courses which are of different requirement types such as university-level mandatory, university-level elective, college-level mandatory, college level elective, program level mandatory, and program level elective. Each requirement type has a specific number of credit hours that should be

completed successfully by the students to graduate. The academic plan defines course dependencies by enforcing a prerequisite mechanism by which the student can't enroll in a course until he/she completed (either successfully or unsuccessfully) the prerequisite in a previous semester.

1.1.2 Dataset Prepossessing and construction

In this step, the collected data is processed and prepared for training the classifiers. In our case, the dataset consisted of six features (predictors) and one target as shown in Figure (2).

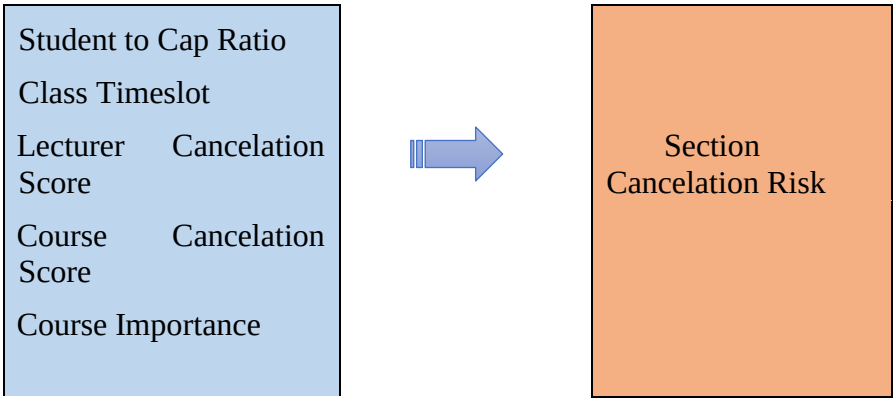

Figure (2) Predictors – Target

The table below describes how these features have been constructed and calculated

Table (1) Features Values Calculation

	FEATURE	DESCRIPTION	VALUE GUIDE
1	The student to Cap Ratio	Represents the scaled ratio between the number of students who are eligible to take the course (according to the program academic plan constraints) and the minimum number of students to keep the section according to the university policy.	1: High (=<02) 2: Medium (01< X <02) 3: Low (01>= X)

2	Class Timeslot	Refers to the time of the day in which the section is scheduled. This feature can take one of three values.: Early, Middy or Late.	1: Early (08:00-10:00) 2: Middy (10:00-14:00) 3: Late (14:00-18:00)
3	Lecturer Cancelation Score	This is a score of the cumulative number of sections that were canceled for the lecturer in the past. It is a scaled ratio between the number of the sections canceled for the lecture and the average number of the section canceled for lectures across the university.	1: High (=<02) 2: Medium (01< X <02) 3: Low (01>= X)
4	Course Cancelation Score	This is a score of the cumulative number of sections that were canceled of a specific course in the past. It is a scaled ratio between the number of the sections canceled for the course and the average number of the section canceled for courses across the university.	1: High (=<02) 2: Medium (01< X <02) 3: Low (01>= X)
5	Course Importance	This is a scaled weight of the importance of the course for the students in the academic plan and takes its value based on the type of the requirement the course belongs to in the academic plan such as mandatory or elective and if the course is a prerequisite of other courses.	1: High 2: Medium 3: Low

1.1.3 Labeling

The data was labeled by associating the five features in the previous table with the scaled cancelation risk which has been calculated based on the cancelation history of the previous timetables and as follows:

1: High: refers to the case in which the course section was canceled from the first round of the timetable review due to not meeting the minimum number of students' constraints. In most cases, the number of students enrolled in these sections is significantly below the

threshold. Therefore, sections in this category do not pass to the second round of the timetable review.

2: Medium: refers to the case where the course section passes the first round of the timetable review with several students that is slightly below or above the threshold. Hence, another chance in the second-round timetable review is granted for such sections.

3: Low: refers to the case in which the course section passes the first round with a students' number that is fairly above the threshold.

The table below shows a sample of the labeled dataset.

Table 2: Dataset Sample

Student to CapRatio	Timeslot	Lecture Cancelation Score	Course Cancelation Score	Course Importance	Cancelation Risk
1	1	1	1	3	1
1	2	1	1	3	1
1	1	1	1	3	1
1	1	1	1	3	1
1	3	1	1	3	1
1	1	1	1	3	1
1	1	1	1	3	1
1	2	1	1	3	1
1	1	1	1	3	1
1	1	1	1	3	1
1	1	1	1	3	1

1.2 Multi Classifiers training and testing

A supervised machine learning approach has been used to develop a model to predict the cancelation risk of course sections. As shown in Figure (3), different classifiers have been trained and tested on the dataset to compare their accuracy performance. In turn, this comparison provides an indicator of the optimal classifier for the data set. The used classifiers

included Neural Networks, Decision Tree, Naïve Bayes, SMV, Random Forest, and KNN.

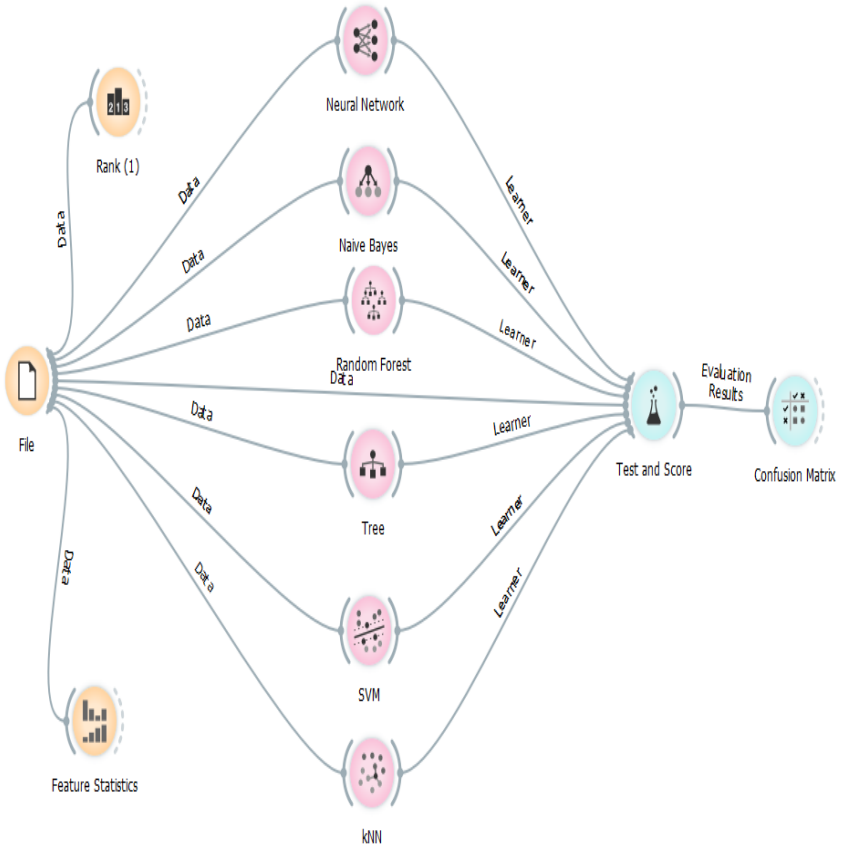

Figure 2: Multi-classifier Model

To train and evaluate the model's accuracy, a 5-fold cross-validation has been used. The dataset is divided into training and testing subsets for each fold where the model is trained and tested using the training and testing sets, respectively.

1.3 Classifying Accuracy Evaluation and Best Classifier Selection.

In this stage, the resulted classifying accuracy of the used classifiers are compared to identify the most accurate classifier to be used for the prediction of section risk of cancelation. The evaluation is performed based on two matrices which are the Classifying Accuracy (CA) (Rakesh Kumar.,et al 2013), which shows the average accuracy for each classifier for all classes, and the confusion matrix (Tharwat,2018), which identifies the classifying accuracy of each classifier for each class.

$$CA = (TP + TN)/ (TP + TN + FP + FN) \qquad \text{Equation1:CA}$$

Where: T: True; F: False; P: Positive; N: Negative

Table (3) shows the accuracy performance of each classifier.

Table 3: Accuracy Performance

MODEL	CA
NAIVE BAYES	0.8555
NEURAL NETWORK	0.8586
TREE	0.8586
RANDOM FOREST	0.8586
SVM	0.3860
KNN	0.4620

The table shows that Neural Networks, Decision Tree, Naïve Bayes, and Random Forest have achieved 85% classifying accuracy which is relatively acceptable having the size of the dataset. However, both SMV and KNN have poor classifying accuracy 38 % and 46%.

For more insight on the accuracy performance of well-performing classifiers, a confusion matrix test has been conducted as shown in the table below:

Table (4) Confusion Matrix Test

Neural Networks

Actual \ Predicted	1	2	3	∑
1	62.2%	9.9 %	27.9 %	1410
2	0.0 %	100.0%	0.0 %	737
3	0.0 %	0.0%	100.0%	1625
∑	877	876	2019	3772

Naïve Bayes

Actual \ Predicted	1	2	3	∑
1	90.1%	9.9 %	0.0 %	1410
2	0.0 %	100.0%	0.0 %	737
3	25.0 %	0.0 %	75.0%	1625
∑	1677	876	1219	3772

Random Forest

Actual \ Predicted	1	2	3	∑
1	62.2%	9.9 %	27.9 %	1410
2	0.0 %	100.0%	0.0 %	737
3	0.0 %	0.0 %	100.0%	1625
∑	877	876	2019	3772

Decision Tree

Actual \ Predicted	1	2	3	∑
1	62.2%	9.9 %	27.9 %	1410
2	0.0 %	100.0%	0.0 %	737
3	0.0 %	0.0 %	100.0%	1625
∑	877	876	2019	3772

The table shows that Neural Networks, Random Forest, and Decision Tree have the same classifying accuracy for all classes (1, 2 and 3) as they achieved 100% classifying accuracy for classes 2 and 3. However, they performed well in classifying class three correctly as they achieved 62.2 % classifying accuracy. On the other side, Naïve Bayes performed well in classifying class 1 (90.1%) correctly, however it was not as accurate as class 3 (75%). In our case, class 1 might be more important than other classes as it represents the courses' sections that have a high probability of cancelation; Therefore, such classes need to be detected in advance to avoid post cancelation disruption. In light of this fact, Naïve Bayes could be considered the most well-performing classifier for our dataset. However, the accuracy performance may vary based on the nature and the size of the data collected in the future.

2- Conclusion

This paper presents an intelligent approach for early-warning mechanisms that could be used by universities to minimize course cancelation cases. The mechanism is intelligent and adaptive such that it utilized the historical timetable and student enrollment data to predict the risk of course section cancelation. It is based on using the machine learning approach using an optimal classifier that is selected among different classifiers. The selection process is achieved through a comparative analysis based on their accuracy performance. In this paper, the data collected has been scaled and reorganized to consists of five main features that have been used in the classification process. These included Student to Student to Cap Rati, Class Timeslot, Lecturer Cancelation Score, Course Cancelation Score, and Course Importance.

In this paper, different classifiers were trained and tested on the collected dataset. The classifiers included Neural Networks, Decision Tree, Naïve Bayes, SMV, Random Forest, and KNN. Neural Networks, Decision Tree, Naïve Bayes, and Random Forest has performed similarly well (85% Classifying Accuracy) and outperformed SMV and KNN which bother had poor classifying accuracy(38 % and 46%). Although Neural Networks, Decision Tree, Naïve Bayes and RandomForest had a similar average classifying accuracy (85%), Naïve Bayes outperformed the Neural Networks, Random Forest, and Decision Tree in classifying class 1 which is the most important class in our case. However, the classifying accuracy is subject to change for all classifiers based on the nature and the size of the collected data. Based on the results, the paper concludes that the proposed approach is promising, and using different classifiers gives the advantage of selecting the most accurate one to use.

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Soft Cloud: A Tool for Visualizing Software Artifacts as Tag Clouds

Ra'Fat Al-Msie'deen*

rafatals3ode@gmail.com

Abstract

Software artifacts visualization helps software developers to manage the size and complexity of the software system. The tag cloud technique visualizes tags within the cloud according to their frequencies in software artifacts. A font size of the tag within the cloud indicates its frequency within a software artifact, while the color of a tag within the cloud uses just for aesthetic purposes. This paper suggests a new approach (SoftCloud) to visualize software artifacts as a tag cloud. The originality of SoftCloud is visualizing all the artifacts available to the software program as a tag cloud. Experiments have conducted on different software artifacts to validate SoftCloud and demonstrate its strengths. The results showed the ability of SoftCloud to correctly retrieve all tags and their frequencies from available software artifacts.

Keywords: Software engineering, software visualization, software artifacts, tag clouds.

* College of Information Technology - Department of Computer Information Systems, Mutah University, Jordan.

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أداة لتصور وثائق البرنامج على شكل سحابة العلامات

رأفت أحمد المسيعدين*

ملخص

يساعد تصور وثائق البرنامج (software artifacts) مطوري البرامج على إدارة حجم وتعقيد البرنامج. تقنيات التصور المستندة إلى سحابة العلامة (tag cloud)، تصور العلامات داخل السحابة وفقا لمعدل تكرارها في وثائق البرنامج. يشير حجم خط العلامة (font size) داخل السحابة إلى تردد العلامة في وثيقة البرنامج. يستخدم لون العلامة (color) داخل السحابة لأغراض جمالية فقط. يقترح هذا البحث نهجًا جديدا (SoftCloud) لتصور وثائق البرنامج على شكل سحابة العلامات. تكمن أصالة SoftCloud في أنها تصور جميع الوثائق المتاحة للبرنامج على شكل سحابة العلامة. للتحقق من صحة SoftCloud، وإثبات نقاط قوتها، أجريت التجارب على وثائق البرنامج المختلفة. أظهرت النتائج قدرة SoftCloud على استرداد جميع العلامات وترددتها بشكل صحيح من وثائق البرنامج المتاحة.

الكلمات الدالة: هندسة البرمجيات، تصور البرمجيات، وثائق البرنامج، سحابة العلامات.

* **كلية تكنولوجيا المعلومات – قسم نظم المعلومات الحاسوبية، جامعة مؤتة، الأردن.**

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1. Introduction

Tag cloud has become a widespread visualization and navigation technique in the software engineering domain (Emerson, 2014; Lohmann et al., 2009). Software artifacts visualization helps software developers to manage the complexity and size of the software system (Al-Msie'deen, 2019c). This study suggests a new approach called SoftCloud to visualize software artifacts as tag clouds. In general, the tag cloud is a visualization technique for the content of a particular document (Al-Msie'deen, 2019a). Tag cloud uses the font size to denote how often a particular tag has been repeated through documents, while the tag color is for decoration purposes only (Al-Msie'deen, 2019b).

Each tag in the cloud usually represents a single word, and tag importance has shown appropriate font color and size (Rinaldi, 2019). Most current studies use the static tag clouds to represent tags of the textual documents and web pages (Hearst and Rosner, 2008; Cui et al., 2010; García-Castro et al., 2009; Greene and Fischer, 2015). Current approaches that build the tag cloud from the software code are either incomplete (i.e., use either classes or methods) or do not perform pre-processing of the tag before adding it to the cloud (such as returning the English word to its root) (Emerson, 2014; Emerson et al., 2013a; Emerson et al., 2013b; Deaker et al., 2011; Cottrell et al., 2009; Anslow et al., 2008; Stocker, 2011; Martinez et al., 2016; Bajracharya et al., 2010). The literature has shown very limited work to mine tag cloud using different software artifacts (cf. Section 2). Figure 1 displays an example of a tag cloud — SoftCloud's representation of the abstract text of this paper.

Figure 1. Tag cloud summarizing the abstract of this paper.

In this work, the software artifacts are any documents related to the software system. This paper considers any document resulting from the

software development process as an artifact. Thus, the following documents are artifacts of the software: source code, commented code (i.e., Javadoc), design documents such as software architecture document (Rational software corp., 2001), and so on. Javadoc is a software artifact developed by software experts to summarize the software code (Kramer, 1999). SoftCloud considers all software identifier names (i.e., package, class, method, and attribute names) inside the code artifact.

In this paper, tag cloud displays the most common tags across software artifacts. In the tag cloud, some tags appear in different font sizes. However, some tags appear important more than other tags. The number of times a tag repeats within a software artifact determines the font size of this tag in the cloud (Yonezawa et al., 2020). However, this allows the software developer to see the most common tags as well as the unique tags in the tag cloud.

SoftCloud accepts any software artifacts as input. However, based on its parser, SoftCloud extracts all software artifact words. After that, it divides words into their constituent words. Then, it obtains the word roots. Then, it determines the weight of each tag based on its frequency across software artifacts. After that, it arranges tags in standard form. Tags are arranged according to their frequency, random or alphabetical. Finally, SoftCloud produces the tag clouds as outputs (cf. Figure 2).

SoftCloud is detailed in the rest of this paper as follows. Section 2 discusses the related work. Section 3 describes the SoftCloud approach step-by-step. Section 4 presents the experiments were conducted to validate SoftCloud's approach. Finally, section 5 concludes and provides future work of SoftCloud.

2. Related Work and Comparison with SoftCloud

This section presents the related work related to SoftCloud contributions. It also gives a concise summary of the diverse approaches and shows the need of suggesting SoftCloud's approach.

In the software engineering field, industrial tools and academic research have not focused on tag clouds as a popular visualization technique. Few studies have proposed the idea of visualizing the software artifacts as a tag cloud (Emerson, 2014; Emerson et al., 2013a; Emerson et al., 2013b; Deaker et al., 2011; Cottrell et al., 2009; Anslow et al., 2008; Stocker, 2011; Martinez et al., 2016; Bajracharya et al., 2010).

This section is limited to providing works very close to the contributions of SoftCloud. In the related work, each approach receives one

type of software artifact as input. There is no generic approach to dealing with different software artifacts. Some existing works deal only with one artifact, such as software code or Javadoc (Al-Msie'deen, 2019b; Al-Msie'deen, 2019c). The approach proposed in this study used different software artifacts as inputs. Besides, SoftCloud listing some user tasks on the tag cloud, such as: finding a particular tag, and finding the most common tags, and so on.

Anslow et al. (Anslow et al., 2008) used a tag cloud to visualize software classes. Cottrell et al. (Cottrell et al., 2009) proposed an approach to visualize software methods as tag clouds. Sourcecloud (Stocker, 2011) created a tag cloud for software classes. Al-Msie'deen (Al-Msie'deen, 2019c) used a tag cloud to visualize software source code, while, Al-Msie'deen (Al-Msie'deen, 2019b) visualized JavaDocs file as a tag cloud. Also, a tag cloud is used in the Sourcerer API Search (Bajracharya et al., 2010) to visualize the code repository. Table 1 presents a comparison between the selected tag cloud studies (i.e., small survey). The author evaluates the studied approaches according to the following criteria: inputs, outputs, cloud layout, and tag order.

Table 1. Selected main studies related to SoftCloud.

ID	**Inputs**							
cf Paper #	Packages	Classes	Attributes	Methods	JavaDocs	Code repositories	Specific text	Code blocks
1	**x**	**x**	**x**	**x**				
2					**x**			
3		**x**						
4		**x**		**x**				
5				**x**				
6		**x**						
7								**x**
8				**x**				
9	**x**	**x**	**x**	**x**				
10						**x**		
11							**x**	
12	**x**	**x**	**x**	**x**	**x**			

ID	Outputs			Layout		Order		
cf Paper #	Tag cloud	Block names	Code labels	Typewriter	Spiral	Alphabetical	Random	Frequency
1	**x**			**x**		**x**		
2	**x**			**x**		**x**		
3	**x**			**x**		**x**		
4	**x**			**x**	**x**	**x**		
5	**x**			**x**		**x**		
6	**x**			**x**		**x**		
7		**x**		**x**		**x**		
8	**x**			**x**	**x**	**x**	**x**	
9			**x**	**x**		**x**		
10	**x**			**x**		**x**		
11	**x**			**x**		**x**		
12	**x**			**x**	**x**	**x**	**x**	**x**

Paper #	Author(s)	Publication type
1	Al-Msie'deen, 2019c	Journal
2	Al-Msie'deen, 2019b	Journal
3	Anslow et al., 2008	Conf
4	Deaker et al., 2011	Technical report
5	Cottrell et al., 2009	Int. workshop
6	Stocker, 2011	Eclipse plug-in
7	Martinez et al., 2016	Conf
8	Emerson, 2014; 2013ab	MSc thesis, Conf
9	Al-Msie'deen, 2018	Journal
10	Bajracharya et al., 2010	Conf
11	Feinberg, 2013	Tool
12	SoftCloud	Journal

The brief overview of the current approaches shows the need to suggest an approach to visualize different software artifacts as a tag cloud. SoftCloud's approach deals with different software artifacts such as source code, design documents, and JavaDocs. On the other hand, SoftCloud's approach performs preprocessing of the tag before adding it to the cloud,

where it separates the words based on the camel-case splitting method, and then returns each word to its origin. Also, SoftCloud introduces some useful filters and user tasks (e.g., search tasks) within the cloud.

3. SoftCloud Step by Step

This section gives an overview of SoftCloud approach and describes the approach step-by-step.

The study presented in this paper exploits the tag cloud visualization technique and applies it to the software engineering domain. The originality of this approach is that it receives as inputs different software artifacts. Then, this approach generates the tag clouds to render the input information. SoftCloud's approach is designed to deal with the software engineering datasets challenges (e.g., scale and complexity of software) using suitable visual mappings existing in tag clouds to render the dataset data.

To visualize a software dataset as a tag cloud, it is important to define visual characteristics that might influence perception within tag cloud such as cloud layout (e.g., typewriter), tag order (e.g., random), tag length (e.g., a variable number of letters or an equal number of letters), tag position, font size (also font family, style, size, and color), and cloud background color. In addition, it is important to choose visual characteristics that are suitable for data mapping, such as font size.

Dataset needs the necessary pre-processing procedure to prepare it. In the approach proposed in this paper, pre-processing is carried out by extracting the words of the available software artifacts. Then, the words have divided into their constituent words, and then each word is returned to its original. In conclusion, word repetition has counted throughout software artifacts, and at last, tags are arranged through the cloud using a specific order. An overview of SoftCloud's approach is shown in Figure 2.

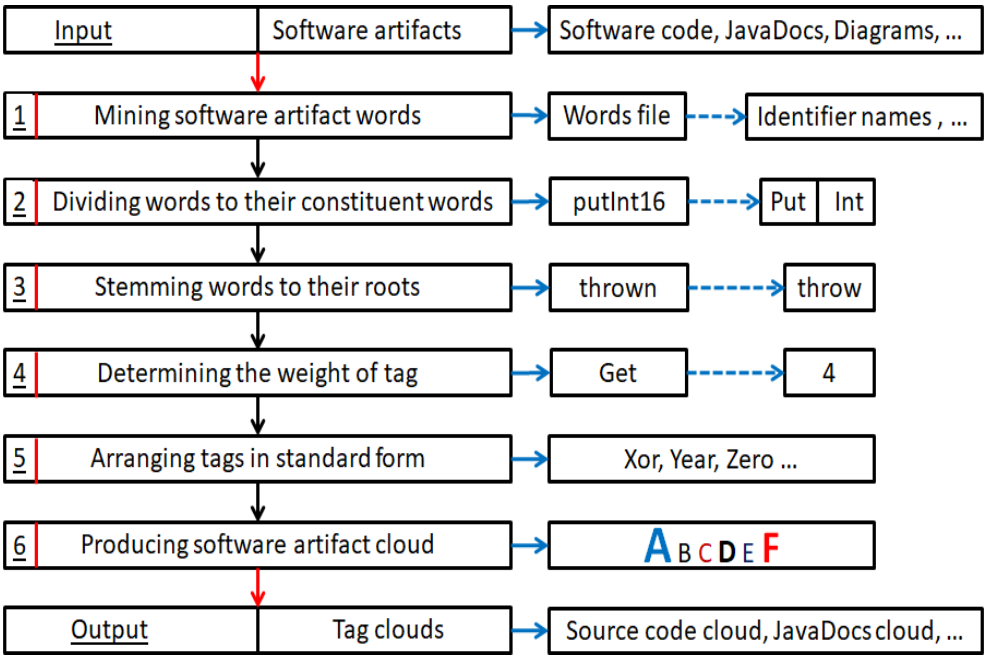

Figure 2. SoftCloud approach overview.

A tag cloud is a type of weighted list to visualize software artifact data (Jin, 2017), which gains growing attention and extra application opportunities in the software engineering field. As a demonstrative example, SoftCloud considers the source code of the Rhino software (Mozilla, 2012) and JavaDoc of NanoXML software (Scheemaecker, 2020). Rhino is an open-source application of JavaScript written completely in Java language. It is embedded in Java implementation to deliver scripting to end-users. J2SE 6 is used Rhino as the default Java scripting engine. NanoXML application is Java software for parsing XML documents. SoftCloud produces the artifact cloud in six phases are detailed below.

3.1. Mining Software Artifact Words

SoftCloud accepts the software artifact as input. Then, SoftCloud generates a words file as output. The words file contains all the words for the software artifact. Table 2 presents samples of words file contents of Rhino and NanoXML artifacts.

Table 2. Samples of words file contents.

Software artifact	
Rhino code	**NanoXML JavaDoc**
org.mozilla.classfile	XMLParseException
itsExceptionTableTop	class
getClassName	summary
addLoadConstant	package
emptySubString	nanoxml

SoftCloud considers the textual datasets (or words file), where the ideal datasets contain textual identifiers such as method names. The kind of dataset that would be ideal to show in a tag cloud is one that contains considerable amounts of textual information. Several datasets have contained this kind of information, in the form of identifiers, words, or labels. Software engineering datasets contain this type of data like package names and JavaDoc words.

3.2. Dividing Words to Their Constituent Words

SoftCloud divides the words extracted from the program's artifact into their constituent words. SoftCloud uses the camel-case splitting method to split artifact's words based on capital letters (e.g., A-Z), special characters (e.g., underscore), and numbers (e.g., 0-9). Each word is divided into words based on the camel-case rules (Al-Msie'deen et al., 2014b).

Table 3. Samples showing examples of dividing words using camel-case.

NanoXML JavaDoc words				
JavaDoc word	**Words**			
	word1	**word2**	**word3**	**word4**
NanoXML	nano	x	m	l
ParseException	parse	exception		
getLocalizedMessage	get	localized	message	
printStackTrace	print	stack	trace	
getLineNr	get	line	nr	
fillInStackTrace	fill	in	stack	trace
Rhino identifier names				
Identifier name	**Words**			

	word1	word2
org.mozilla	org	mozilla
itsFlags	its	flags
addField	add	field
putInt16	put	int
unHex	un	hex
find_split	find	split

The Camel-case method is easy and widely used for dividing words (Al-Msie'deen et al., 2014a). For instance: getMaximumInterpreterStackDepth identifier name has split into get, maximum, interpreter, stack, and depth. Table 3 presents samples of word splitting from Rhino and NanoXML software.

3.3. Stemming Words to Their Roots

Stemming is the text normalization (or called word normalization) technique, in the field of software engineering word normalization is used to prepare words for more processing. Stemming is a way of stripping attaches from words to form the word root (e.g., protected to protect). The word root generated by SoftCloud does not have to be the real word itself. Stemmer is used in SoftCloud to return the word to its word root. In SoftCloud, stemming was performed through WordNet (Fellbaum, 1998). SoftCloud relies on WordNet dictionary to swap English words with their roots or stems (Princeton university, 2010).

Table 4. Examples of returning English words to their roots or origins.

Rhino code words		**NanoXML JavaDoc words**	
Identifier word	**Root or stem**	**JavaDoc word**	**Root or stem**
synchronized	synchronize	indicates	indicate
interfaces	interface	extends	extend
reserved	reserve	thrown	throw
parameters	parameter	parsing	parse
arguments	argument	occurred	occur

In SoftCloud, stemming is a method of changing an artifact word to its root. The word root is the final form of the word that will appear in the cloud as a tag. SoftCloud stemmer accepts as an input English word and generates as output word root (or tag). For instance, the words parsing, parses, and parsed all have the same root/stem which is parse. Sometimes, the WordNet may not be dependable in all cases to return word root. In this

case, SoftCloud returns the word itself as being the root of the word. Table 4 shows examples of the word stems from Rhino and NanoXML software artifacts.

3.4. Determining the Weight of Tag

In SoftCloud, tag weight gives a sign about tag frequency across software artifact words. In this stage, a weight is assigned to each tag based on its occurrences in software artifact words. Table 5 displays examples of tags and their weights from Rhino and NanoXML software artifacts.

Table 5. Examples of tags and their weights from Rhino and NanoXML artifacts.

Rhino code tags		**NanoXML JavaDoc tags**	
Tag	**Weight**	**Tag**	**Weight**
Activation	20	Exception	10
Adapter	24	From	2
Add	134	Get	4
And	35	Java	7
Arg	12	Line	6

In fact, the number of times a tag is repeated is a very important indication of the importance of this tag in the software artifact. For instance, in drawing shapes software (Al-Msie'deen, 2019c), the shape tag arose thirteen times across software source code, so the given weight of this tag is thirteen. The font size for the tag in the mined cloud is the number of times the tag is repeated throughout the software artifact document. Tags that appear with a large font size are more important than others.

3.5. Arranging Tags in Standard Form

SoftCloud uses typewriter-style to arrange tags in the cloud from left to right and from top to bottom. SoftCloud displays tags in the cloud in alphabetical order (i.e., a-z). Software developer looks more able to find tags in alphabetically ordered clouds (Al-Msie'deen, 2019c). Table 6 shows examples of tags in alphabetical order.

Table 6. Examples of tags in alphabetical order.

Rhino code tags		NanoXML JavaDoc tags	
Unordered tags	Tags in alphabetical order	Unordered tags	Tags in alphabetical order
Mozilla	Xmlend	Nano	Or
Classfile	Xop	X	Package
Class	Xor	M	Parse
File	Year	L	Print
Writer	Yield	Class	Public
Acc	Z	Parse	Runtime
Public	Zero	Exception	Stack

On the other hand, SoftCloud allows the developer to arrange the tags according to their frequency. Tags have arranged within the cloud from the highest to lowest frequency. If some tags are equal in frequency, then SoftCloud sorts these tags alphabetically. Figure 3 shows the generated tag cloud after applying the frequency order filter.

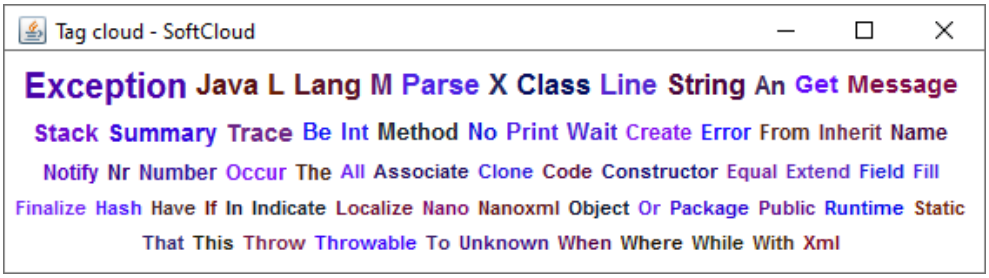

Figure 3. A tag cloud produced from JavaDoc of XMLParseException class of NanoXML.

In this cloud, tags appear according to their importance. The most important tags appear first in the cloud. The tag cloud in Figure 3 shows that the most common tag in the JavaDoc of XMLParseException class is an exception. The most common tags have been displayed in larger fonts.

3.6. Producing Software Artifact Cloud

In SoftCloud, the dataset is extracted first from the software artifact. Then the dataset words are divided into their constituent words. After that, each word is returned to its root. Later, the weights are determined for the tags, and then the software engineer determines the appropriate arrangement of the tags in the cloud. Finally, the cloud has been created. As an example,

SoftCloud uses the JavaDoc for XMLParseException class of NanoXML software. Table 7 shows JavaDoc of XMLParseException class.

Table 7. JavaDoc of XMLParseException class of NanoXML (Scheemaecker, 2020).

Class Summary	
Package nanoxml.XMLParseException	
public class XMLParseException extends java.lang.RuntimeException An XMLParseException is thrown when an error occurs while parsing an Xml string.	
Field Summary	
static int	No_Line, indicates that no line number has been associated with this exception.
Constructor Summary	
XMLParseException(java.lang.String name, int lineNr, java.lang.String message), creates an exception.	
XMLParseException(java.lang.String name, java.lang.String message), creates an exception.	
Method Summary	
int	getLineNr(), Where the error occurred, or No_Line if the line number is unknown.
Methods inherited from class java.lang.Throwable	
fillInStackTrace, getLocalizedMessage, getMessage, printStackTrace, printStackTrace, printStackTrace, toString	
Methods inherited from class java.lang.Object	
clone, equals, finalize, getClass, hashCode, notify, notifyAll, wait, wait, wait	

Figure 4 shows a tag cloud extracted from JavaDoc of XMLParseException class of NanoXML (*cf.* Table 7). This cloud contains all tags of JavaDoc. The number next to each tag is an indication of how often that tag is repeated within the software artifact. The mined tag cloud shows the rarest tags such as when and unknown.

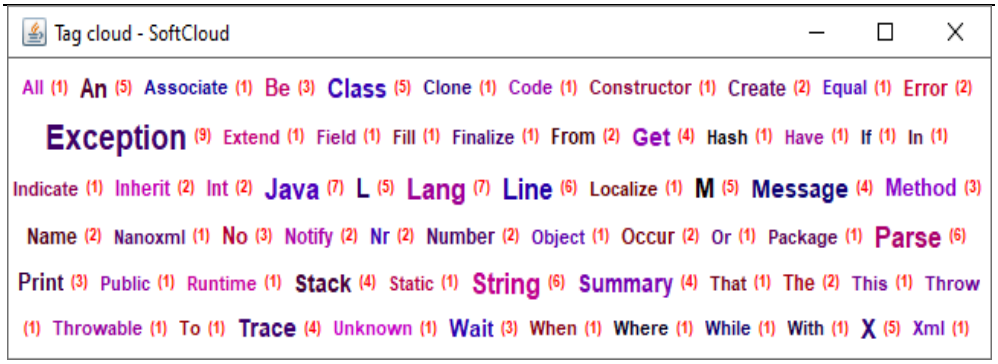

Figure 4. A tag cloud generated from JavaDoc of XMLParseException class.

SoftCloud contains several features to allow data exploration such as filtering data and handling large scale data. These features are the most important to software engineering datasets. SoftCloud prototype is formed to extract tag clouds from different software artifacts. SoftCloud prototype is available at author page (Al-Msie'deen, 2021a).

4. Experimentation

This section presents the experiments conducted in this research to display its soundness and presents different software artifacts. Also, it shows the obtained results for some artifacts and presenting the threats to the validity of SoftCloud. Figure 5 shows mined tag cloud from Rhino software. SoftCloud algorithms need 22697 ms to generate tag cloud from Rhino artifact. The most common tags (*resp.* the rarest tags) across Rhino artifacts are presented in Table 8.

Table 8. Tags mined from Rhino artifact.

The most common tags		**The rarest tags**	
Tag	**Frequency**	**Tag**	**Frequency**
Get	510	Zone	2
Id	444	Collect	1
Set	172	W	4
Name	168	After	3
Class	159	Yield	6
The *number of tags* across Rhino code is equal to *1095*.			
The *execution time* of SoftCloud in *ms* is equal to *22697*.			

The success of a SoftCloud is measured by three metrics: precision, recall, and F-Measure (Al-Msie'deen, 2019b). Precision and recall give a value of one, if the tag and its frequency in the cloud are the same as tag frequency in the software artifact. F-Measure gives a value of one in cases where both precision and recall are one (Al-Msie'deen, 2014). SoftCloud evaluation metrics have values between zero and one.

For a specific tag within the cloud, a precision metric is a percentage of correctly retrieved tag frequencies to the total number of retrieved tag frequencies (cf. equation in Table 9), whereas recall metric is the percentage of correctly retrieved tag frequencies to the total number of relevant tag frequencies. The F-Measure metric combines recall and precision in one value (Al-Msie'deen, 2014). An example of the calculation of these three metrics are presented in Table 9.

Figure 5. A tag cloud generated from Rhino artifact.

An illustrative example is introduced in Table 9 to show: 1) how to calculate these measures for a trace tag from JavaDoc of XMLParseException class (*cf.* Table 7), and 2) the equation of each measure. Moreover, 3) how to compute these measures based on some samples (not related to SoftCloud experimentation).

Table 9. Standard SoftCloud evaluation metrics: precision, recall, and F-Measure.

Tag	relevant tag frequency	correctly retrieved tag frequencies	retrieved tag frequencies
Trace	4	4	4
Metric	**Precision**	**Recall**	**F−Measure**
Value	1	1	1

Precision = |{relevant tag frequencies} ∩ {retrieved tag frequencies}| / |{retrieved tag frequencies}|
Recall = |{relevant tag frequencies} ∩ {retrieved tag frequencies}| / |{relevant tag frequencies }|
F−Measure = 2 × [(Precision × Recall) / (Precision + Recall)]

Tag	relevant tag frequency	correctly retrieved tag frequencies	retrieved tag frequencies
Notify	100	50	150
Metric	**Precision**	**Recall**	**F−Measure**
Value	0.3	0.5	0.4
Tag	relevant tag frequency	correctly retrieved tag frequencies	retrieved tag frequencies
Wait	70	70	100
Metric	**Precision**	**Recall**	**F−Measure**
Value	0.7	1	0.8

Low precision (e.g., precision = 0.1) leads to low trust in the proposed system (i.e., too much noise). On the other hand, low recall (e.g., recall = 0.1) leads to unawareness and inefficiency of the suggested approach (i.e., too many missing frequencies for the tag). Table 10 summarizes the obtained results of some tags from Rhino and NanoXML software artifacts.

Table 10. Tags mined from Rhino and NanoXML software artifacts.

Software	Tag	Tag within the cloud	Tag within the artifact	SoftCloud evaluation metrics		
				Precision	Recall	F-Measure
Rhino	A	37	37	1	1	1
	And	35	35	1	1	1
	Arg	12	12	1	1	1
NanoXML	Get	4	4	1	1	1
	X	7	7	1	1	1
	An	5	5	1	1	1

Results display that precision value is one of all mined tags. Thus, all frequencies of the retrieved tag are relevant. Recall metric value equals one of all mined tags. Hence, all relevant tag frequencies are retrieved. F-Measure value equals one of all mined tags. Consequently, all relevant tag frequencies are recovered, and only the relevant tag frequencies are recovered. The results demonstrate the efficiency and ability of SoftCloud to accurately retrieve the correct frequency of tags from software artifacts. Figure 6 shows the tag cloud generated from the source code summarization of the draw method from drawing shapes software (Al-Msie'deen and Blasi, 2019).

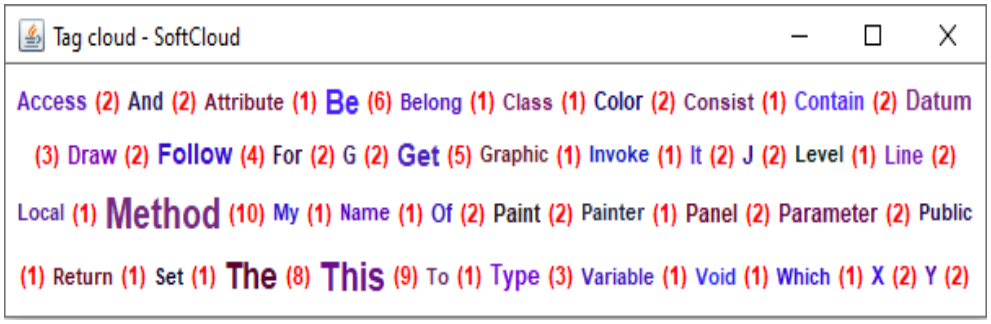

Figure 6. Tag cloud generated from source code summarization.

I have implemented numerous tag cloud layouts. Tags are positioned one at a time within the cloud, with the chosen order (e.g., alphabetical order). SoftCloud layouts are typewriter and spiral layout. In typewriter layout tags are positioned left to right, jumping to a new line once the next tag cannot be positioned on the existing line. While, in a spiral layout the

first tag is positioned in the middle of the cloud, with consecutive tags are being positioned around it in a spiral style. Figure 7 expressions the same data set in Figure 6 with a spiral layout chosen. This layout is less appropriate for some tasks, including discovering a particular tag or emphasizing its absence.

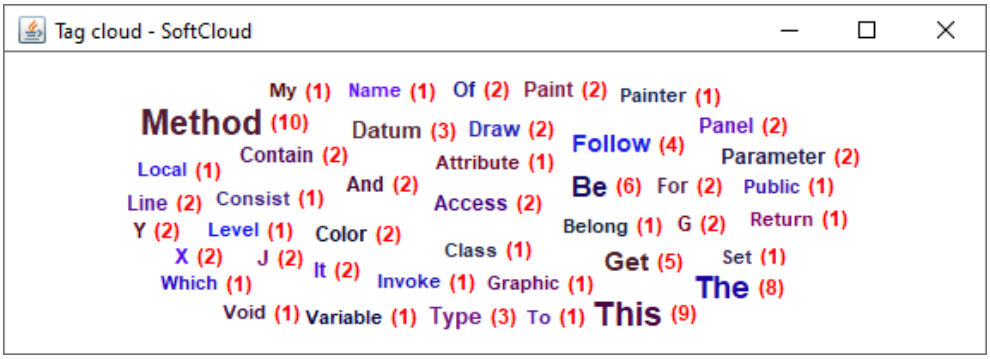

Figure 7. Tag cloud with spiral layout.

Figure 8 shows the tag cloud generated from user and system requirement of registration service. This requirement is included in the requirements document of the interactive multimedia magazine application (Al-Msie'deen, 2021b). A software engineer can extract the tag cloud from several software artifacts such as use-case description (Al-Msie'deen, 2008), use-case diagram (Alfrijat and Al-Msie'deen, 2010), software identifiers map (Al-Msie'deen and Blasi, 2021), and feature descriptions (Salman et al., 2012).

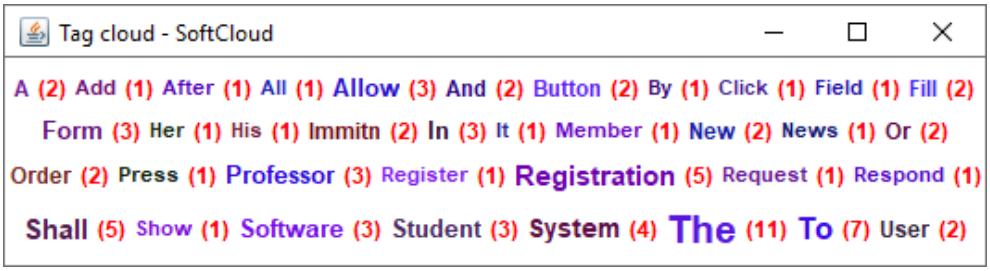

Figure 8. Tag cloud generated from the software requirements specification document.

The software architecture document is one of the software's artifacts. This document is a design document. Figure 9 represents the tag cloud generated from a software architecture document of the collegiate sports paging system (Rational software corp., 2001).

Figure 9. Tag cloud summarizing architecture document of collegiate sports paging system.

The user of SoftCloud has the choice of filtering the tag text to a fixed number of letters (e.g., 10 letters). This filter has two aims (*cf.* Figure 10), to exploit available space in the cloud, and to minimize any side effect a larger number of letters in a tag may have on user awareness (i.e., eye attention).

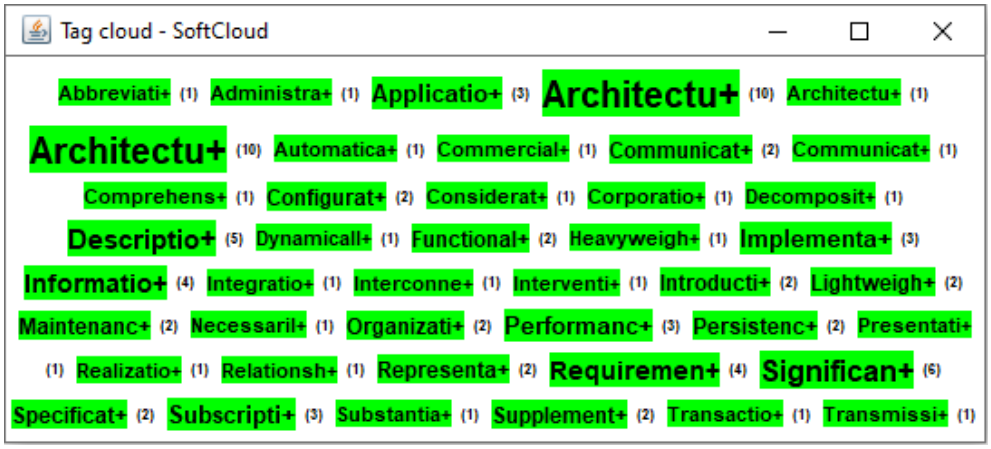

Figure 10. A tag cloud generated by using fixed number filter.

The *threat to the validity* of SoftCloud is that the existing prototype considers only a Java code artifact. Moreover, when a software engineer uses mixture words inside software artifacts (e.g., SeTStandardS) the camel-case splitting method cannot deal with it (or should be enhanced with other methods). The WordNet dictionary may not be dependable in all cases to reveal the word root. Currently, SoftCloud is missing some filters, for instance, it does not filter tag names that are textually similar.

5. Conclusion and Future Directions of SoftCloud

This paper proposed a new approach to visualize software artifacts as a tag cloud. However, SoftCloud has executed on different software artifacts. Such as rhino, nanoXML, drawing shapes, interactive multimedia magazines, and collegiate sports paging software artifacts. The results were showed that all tags and their occurrences are mined correctly from software artifacts. However, the mined tag clouds have shown the most common and rarest tags. Also, tags have been arranged randomly, alphabetically, or according to their frequency. Also, tags within the cloud are filtered based on their frequency or length. Besides, clouds have been organized according to a typewriter or spiral layout. For future work, some user tasks will be added to the cloud and use new cloud layouts. Finally, there is an urgent need for a comprehensive survey providing all studies related to the tag cloud techniques in the software engineering domain.

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رقم الإيداع لدى مديرية المكتبات والوثائق الوطنية
(1986/5/201)

رقم الترخيص لدى دائرة المطبوعات والنشر
(3353/15/6)
تاريخ 2003/10/22

الفهرس:

* ما ورد في هذا العدد يعبر عن آراء الكتاب أنفسهم ولا يعكس بالضرورة آراء هيئة التحرير أو سياسة جامعة مؤتة.

الهيئة الاستشارية الدولية

مؤتة للبحوث والدراسات

سلسلة العلوم الطبيعية والتطبيقية

مجلة علمية محكمة ومفهرسة تصدر عن عمادة البحث العلمي في جامعة مؤتة

كلمة المحرر

تصدر مجلة مؤتة للبحوث والدراسات في سلسلتها **العلوم الطبيعية والتطبيقية** منذ عام 1986، وهي مجلة علمية محكمة ومفهرسة، وتصدر بشكل منتظم وبواقع مجلد واحد في كل عام منذ تأسيسها، يحتوي المجلد على عددين، ويشرف على تحريرها هيئة من الأساتذة المتخصصين والأكاديميين في مختلف التخصصات العلمية والتطبيقية، ورقم تصنيفها الدولي (ISSN 1022-6812). تقوم المجلة بنشر الأبحاث الأصيلة التي تسهم بنشر العلم والمعرفة في كافة تخصصات **العلوم الطبيعية والتطبيقية**. وتخضع الأبحاث المقدمة للنشر إلى معايير دقيقة تشمل التدقيق الفني والتحكيم العلمي من قبل محكمين اثنين للتحقق من صلاحية البحث للنشر.

وقد حظيت المجلة بسمعة رائدة محلياً وإقليمياً على مدار الثلاث عقود الماضية، فأصبحت مجلة معتمدة لغايات النقل والترقية للباحثين في كافة الجامعات الحكومية والخاصة في الأردن، بشكل خاص، والعالم العربي، بشكل عام، وهذا يبرر العدد الكبير والمتزايد من الأبحاث الذي يرد إلى المجلة من جامعات ومؤسسات ومراكز بحثية محلية وإقليمية ودولية، ولضمان جودة الأبحاث المنشورة في المجلة، فإنها تتبع معايير وضوابط وإجراءات تضمن جودة المنتج البحثي وتتضمن:

1. قواعد النشر
2. المواصفات الفنية
3. إجراءات النشر
4. أخلاقيات النشر

عميد البحث العلمي

رئيس التحرير

أ. د عبدالله العدينات

1. قواعد النشر.

انسجاماً مع الخطة الاستراتيجية لجامعة مؤتة ورؤيتها للوصول إلى تحقيق معايير التصنيفات العالمية للجامعات، وانطلاقاً من الخطة الاستراتيجية لعمادة البحث العلمي ورؤيتها التي تنص على: **(نحو عمادة حاضنة لبحث علمي متميز يرتقي بتصنيف الجامعة محلياً وإقليمياً وعالمياً)** ورسالتها التي تتضمن: **(تأمين بيئة قادرة على إنتاج بحوث علمية تسهم في تعزيز دور الجامعة في البحث والابتكار محلياً وإقليمياً وعالمياً)**. فقد ارتأت عمادة البحث العلمي تطوير مجلة مؤتة للبحوث والدراسات للوصول إلى قواعد البيانات العالمية، مثل: SCOPUS, ISI, PubMed والارتقاء بعامل التأثير (Impact Factor) للمجلة، لوصول الانتاج البحثي للمؤلفين إلى العالمية.

وبناء عليه، وعند تقديم أبحاثكم للنشر في المجلة، يراعى الآتي:

1. اعتماد نظام جمعية علماء النفس الأمريكية (APA)، للاطلاع على الدليل المختصر لطريقة التوثيق، ولمزيد من الأمثلة، يرجي زيارة الموقع التالي: http://www.apastyle.org/ وموقع المجلة على الرابط: https://ejournal.mutah.edu.jo
2. تكتب جميع المراجع العربية باللغة الإنجليزية في المتن وفي قائمة المراجع.
3. ترجمة كافة المراجع غير الإنجليزية (بما في ذلك المراجع العربية) إلى اللغة الإنجليزية، مع ضرورة ابقاء القائمة العربية موجودة.
4. اذا كان للمراجع العربية ترجمة إنجليزية معتمدة فيجب اعتماد ذلك، أما المراجع التي ليس لها ترجمة إنجليزية معتمدة (مثل: فقه السنه) فيتم عمل Transliteration أي كتابة المرجع بالأحرف الإنجليزية كتابة حرفية، (Fiqih Alsunah) .
5. إعادة ترتيب كافة المراجع (والتي يفترض أنها قد أصبحت باللغة الإنجليزية) حسب ترتيب الأحرف الإنجليزية (Alphabets) بما يتناسب مع نظام APA.
6. يجب الالتزام بالمواصفات الفنية لتحرير المخطوط المبينة على موقع المجلة، علماً بأن البحث يخضع للتدقيق الفني عند استلامه. وفي حال عدم الالتزام بهذه المواصفات الفنية يُعاد البحث.
7. يتم تسـليم البحث والملفات المطلوبة والنماذج الخاصة بهـا الكترونيـاً على الموقع https://ejournal.mutah.edu.jo/ والمبينة في الجدول التالي.
8. عدم الالتزام بأي من النقاط السابقة يعفي المجلة من السير في إجراءات التحكيم

الرقم	اسم الملف	ملاحظات
1.	رسالة تغطية **Cover Letter**	توجه الى رئيس التحرير
.2	صفحة الغلاف **Title Page**	يكتب التالي باللغتين العربية والإنجليزية في صفحة الغلاف وحسب الترتيب التالي: 1. عنوان البحث 2. اسم الباحث (الباحثين) من ثلاثة مقاطع. 3. العنوان البريدي 4. الرتبة العلمية 5. البريد الإلكتروني 6. رقم الهاتف
.3	ملخص البحث **Abstract**	يكتب الملخص باللغتين العربية والإنجليزية بحيث لا يزيد الملخص عن (150) كلمة والكلمات المفتاحية **(keywords)** عن خمس كلمات.
.4	البحث **Research Document**	يجب أن تلتزم وثيقة البحث بالمتطلبات التالية: 1. عدم وجود اسم الباحث (الباحثين). 2. أن لا يحتوي البحث على أي معلومات تشير إلى الباحث (الباحثين). 3. أن يكون التوثيق للمراجع في المتن **(In-text Citation)** باللغة الإنجليزية. 4. اعتماد نظام جمعية علماء النفس الأمريكية **(APA)**. 5. الالتزام بالمواصفات الفنية لطباعة البحث. 6. تخضع البحوث للتدقيق الفني قبل السير في إجراءات التحكيم.
.5	قائمة المراجع **References**	يجب أن تلتزم قائمة المراجع بالمتطلبات التالية وترسل في نفس الملف: 1. تكتب المراجع (الواردة في البحث باللغة الإنجليزية) في القائمة النهائية مرتبة حسب الحروف الهجائية **(Alphabets)**. 2. إذا كان للمراجع العربية ترجمة إنجليزية معتمدة فيجب اعتماد ذلك، أما المراجع التي ليس لها ترجمة إنجليزية معتمدة (مثل: فقه السنة) فيتم عمل **Transliteration** أي كتابة المرجع بالأحرف الإنجليزية كتابة حرفية **(Fiqih Alsunah)**. 3. إعادة ترتيب كافة المراجع (والتي يفترض أنها قد أصبحت باللغة الإنجليزية) حسب ترتيب الأحرف الإنجليزية **(Alphabets)** بما يتناسب مع نظام **APA**. 4. الإبقاء على قائمة المراجع العربية وإدراجها في نهاية الملف بعد المراجع المترجمة.
.6	التعهد Pledge	يلتزم الباحث بتعبئة التعهد

2. المواصفات الفنية.

يجب الالـــتزام بالمواصفات الفنيـــة لتحريـــر المخطوط والموجـــودة على الرابـــط: https://ejournal.mutah.edu.jo ، حيث يخضع البحث للتدقيق الفني عند استلامه، وفي حال عدم الالتزام بهذه المواصفات الفنية يُعاد البحث.

3. إجراءات النشر.

1. يُقدم البحث للنشر إلى عمادة البحث العلمي في جامعة مؤتة الكترونياً على موقع المجلة https://ejournal.mutah.edu.jo.
2. يوقع الباحث على تعهد النشر وفق نموذج خاص تعتمده المجلة.
3. يعرض البحث على هيئة تحرير المجلة، ويسجل في السجلات المعتمدة.
4. يخضع البحث المرسل إلى المجلة إلى التدقيق الفني والتحكيم الأولي من هيئة التحرير؛ لتقرير أهليته للتحكيم الخارجي، ويحق للهيئة أن تعتذر عن السير في إجراءات التحكيم الخارجي أو عن قبول البحث للنشر في أي مرحلة دون إبداء الأسباب.
5. يرسل البحث إلى محكمين اثنين على أن يقوم كلاً منهما بالرد في مدة أقصاها شهر، وفي حال عدم الرد ضمن الموعد المحدد يتم ارسال البحث إلى محكم آخر، وبناء عليه يكون قرار هيئة التحرير على النحو الآتي:
   أ. يُقبل البحث للنشر في حالة ورود تقارير إيجابية من المحكمين الإثنين، وبعد أن يقوم الباحث بإجراء التعديلات المطلوبة، إن وجدت.
   ب. في حال ورود تقارير سلبية من كلا المحكمين يرفض البحث.
   ج. في حالة ورود رد سلبي من أحد المحكمين ورد إيجابي من المحكم الثاني يرسل البحث إلى محكم ثالث للبت في أمر صلاحيته للنشر.
6. إذا كان الباحث من جامعة ما فلا يجوز أن يُحكَّم البحث من قبل زميل يعمل في الجامعة نفسها.
7. يجب على الباحث بعد إبلاغه بإجراء التعديلات أن يقوم بذلك وفق ملاحظات المحكمين في مدة أقصاها أسبوعين من تاريخه، وفي حال عدم استجابة الباحث ضمن المدة المحددة يتم وقف إجراءات السير في نشر البحث.
8. إذا أفاد المحكم (مراجع التعديلات) أن الباحث لم يقم بالالتزام بإجراء التعديلات المطلوبة، يُعطى الباحث فرصة ثانية وأخيرة مدتها أسبوعين للقيام بالتعديلات المطلوبة، وإلاّ يرفض البحث ولا ينشر في المجلة.
9. تمنح رسالة القبول بعد إجراء التدقيق الفني المترتب على البحث بعد التعديل.
10. ترتب البحوث المقبولة في المجلة وفقا لسياسة المجلة.
11. ما ينشر في المجلة يعبر عن وجهة نظر الباحث ولا يعبر بالضرورة عن وجهة نظر جامعة مؤتة، أو هيئة التحرير، أو القائمين عليها.

4. أخلاقيات النشر.

تلتزم هيئة التحرير والمحكمون والباحثون بأخلاقيات النشر التالية:

أولاً: واجبات هيئة التحرير

1. العدالة والاستقلالية: يقوم المحررون بتقييم المخطوطات المقدمة للنَّشر على أساس الأهمية والأصالة وصحة الدراسة ووضوحها وأهميتها لنطاق المجلة، بغض النظر عن جنس المؤلفين أو جنسيتهم أو معتقدهم الديني بحيث يتمتع رئيس التحرير بسلطة كاملة على كامل المحتوى التحريري للمجلة وتوقيت نشره.
2. السرية: هيئة التحرير وموظفو التحرير مسؤولون عن سرية أية معلومات حول البحث المقدم وعدم إفشاء هذه المعلومات إلى أي شخص آخر غير المؤلف والمحكمين والهيئة الاستشارية كلٌ وفقاً لاختصاصه.
3. الإفصاح وتضارب المصالح: هيئة التحرير مسؤولة عن عدم استخدام معلومات غير منشورة موجودة في البحث المقدم لأغراض النشر دون موافقة خطية صريحة من المؤلفين، ويجب على عضو هيئة التحرير الإفصاح عن وجود أي تضارب في المصالح مع أي من المؤلفين. مثل علاقات تنافسية أو تعاونية أو علاقات أخرى مع أي من المؤلفين؛ بدلاً من ذلك، سوف يطلبون عضو خارجي للتعامل مع المخطوطة.
4. قرارات النشر: تحرص هيئة التحرير على أن تخضع جميع الابحاث المقدمة للتحكيم من قبل اثنين على الأقل من المحكمين الذين هم خبراء في مجال البحث. وتعتبر الهيئة مسؤولة عن تحديد أي من الابحاث المقدمة إلى المجلة التي سيتم نشرها، بعد التحقق من أهميتها للباحثين والقراء.

ثانياً: واجبات المحكمين.

1. المساهمة في صنع قرارات هيئة التحرير.
2. السرعة والدقة في الوقت: أي محكم يشعر بعدم قدرته على مراجعة البحث لأي سبب كان يجب عليه إخطار هيئة التحرير على الفور ورفض الدعوة للتحكيم بحيث يمكن الاتصال بالمحكمين البدلاء.
3. السرية: أي أبحاث وردت للمجلة للتحكيم والنشر هي وثائق سرية؛ لذا يجب ألا تظهر أو تناقش مع الآخرين إلا إذا أذن بها رئيس التحرير وينطبق هذا أيضا على المحكمين المدعوين الذين رفضوا الدعوة للتحكيم.
4. معايير الموضوعية: يجب مراجعة وتحكيم الأبحاث بموضوعية وأن تُصاغ الملاحظات بوضوح مع الحجج الداعمة، بحيث يمكن للمؤلفين استخدامها لتحسين أبحاثهم بعيداً عن النقد الشخصي للمؤلفين.

5. الإفصاح وتضارب المصالح: يجب على أي محكم مدعو للتحكيم أن يُخطِرْ هيئة التحرير على الفور بأن لديه تضارب في المصالح ناجم عن علاقات تنافسية أو تعاونية أو علاقات أخرى مع أي من المؤلفين بحيث يمكن الاتصال بالمحكمين البدلاء.
6. المحافظة على سرية المعلومات أو الأفكار المتميزة غير المنشورة والتي تم الكشف عنها في الأبحاث المقدمة للتحكيم وعدم استخدامها دون موافقة كتابية صريحة من المؤلفين وينطبق هذا أيضاً على المحكمين المدعوين الذين يرفضون دعوة التحكيم.

ثالثا: واجبات المؤلفين.

1. معايير إعداد البحث: يجب على المؤلفين الالتزام بالقواعد والإجراءات والمواصفات الفنية وأخلاقيات النشر الموجودة على موقع المجلة.
2. السرقة الأدبية: لا يجوز بأي حال من الأحوال الاعتداء على حق أي مؤلف آخر بأي صورة من الصور فالقيام بهذا العمل يعتبر سرقة أدبية ويتحمل من قام بهذا العمل كامل المسؤولية القانونية والأدبية عن ذلك.
3. الأصالة: يجب على المؤلفين التأكد من تقديم أعمال أصيلة تماما، وتوثيق أعمال أو كلمات الباحثين الآخرين التي تم الرجوع اليها في بحثهم. وينبغي أيضا الاستشهاد بالمنشورات المؤثرة في مجال البحث المقدم. فأخذ المعلومة دون توثيق المصدر بجميع أشكاله يُشكل سلوكاً غير أخلاقي للنشر ويأخذ أشكالاً عديدة، مثل اعتماد بحث على أنه للمؤلف نفسه، نسخ أو إعادة صياغة أجزاء كبيرة من بحث آخر (دون الإسناد).
4. عدم إرسال البحث إلى مجلات مختلفة وبشكل مُتزامن: يجب على المؤلف عدم إرسال أو نشر نفس البحث في أكثر من مجلة واحدة. وبالتالي، لا ينبغي للمؤلفين أن يُقدِموا مخطوطة سبق نشرها في مجلة أُخرى وذلك لأن تقديم بحث بالتزامُن مع أكثر من مجلة واحدة هو سلوك غير أخلاقي وغير مقبول.
5. تأليف المخطوطة: يجب أن يتم إدراج الأشخاص الذين يستوفون معايير التأليف التالية كمؤلفين في البحث بحيث يكونوا قادرين على تحمل المسؤولية العامة عن المحتوى: (1) تقديم مساهمات كبيرة في تصميم أو تنفيذ أو الحصول على البيانات أو تحليل أو تفسير الدراسة؛ (2) المساهمة في صياغة وكتابة محتوى البحث أو مراجعته. (3) مراجعة النسخة النهائية من البحث والموافقة عليها وعلى تقديمها للنشر. إضافة إلى ذلك هناك أشخاص لا يستوفون معايير التأليف فيجب ألا يُدْرَجوا كمؤلفين، ولكن يجب ذكرهم في قسم "شكر وتقدير" بعد الحصول على إذن كتابي منهم.
6. الإفصاح وتضارب المصالح: يجب على المؤلفين الإبلاغ عن أي تضارُب في المصالح مع جهات لا تعلمها هيئة التحرير يمكن أن يكون له تأثير على البحث. ومن أمثلة التضارب المحتمل في المصالح التي ينبغي الإفصاح عنها مثل العلاقات الشخصية أو المهنية، والانتماءات، والمعرفة في الموضوع أو المواد التي نوقِشَتْ في البحث.
7. المخاطر والمواد البشرية أو الحيوانية: إذا كان العمل ينطوي على استخدام مواد كيميائية أو إجراءات أو معدات لها أي مخاطر غير عادية، فيجب على المؤلفين تحديدها بوضوح في البحث. وكذلك إذا كان العمل ينطوي على استخدام أو إجراء تجارب على البشر أو الحيوانات في بحثهم، فيجب على المؤلفين التأكد من أن جميع الإجراءات تم تنفيذها وفقاً للقوانين والتعليمات ذات الصلة وأن المؤلفين قد حصلوا على موافقة مسبقة بهذا الخصوص. وكذلك ويجب مراعاة حقوق الخصوصية الخاصة بالمشاركين من البشر.
8. التعاون: يجب على المؤلفين التعاون بشكل كامل والاستجابة الفورية لطلبات المُحررين بشأن البيانات الأولية والتوضيحات وإثبات الموافقات الأخلاقية وموافقات المرضى وأذونات حقوق الطبع والنشر. وفي حالة اتخاذ قرار أولي بشأن إجراء التعديلات الضرورية على البحث، يجب على المؤلفين الاستجابة لملاحظات المحكمين بشكل منهجي ويقوموا بإجراء التعديلات المطلوبة وإعادة تقديمها إلى المجلة بحلول الموعد النهائي المحدد.
9. الأخطاء الأساسية في الأعمال المنشورة: عندما يكتشف المؤلفون أخطاء كبيرة أو عدم دقة في أعمالهم المنشورة، فإن عليهم الالتزام بإخطار محرري المجلة أو الناشر فوراً والتعاون معهم إما لتصحيح البحث أو سحبه.

رئيس هيئة تحرير مجلة مؤتة للبحوث والدراسات

الأستاذ الدكتور عبدالله العدينات

عميد البحث العلمي

جامعة مؤتة

الرمز البريدي (61710) مؤتة / الأردن

Tel: +962-3-2372380 Ext (6117)

Fax. +962-3-2370706

Email: darmutah@mutah.edu.jo

مؤتة للبحوث والدراسات

مؤتة للبحوث والدراسات

مجلة علمية محكّمة ومفهرسة تصدر عن

عمادة البحث العلمي

جامعة مؤتة

قسيمة اشتراك

أرجو قبول اشتراكي في مجلة مؤتة للبحوث والدراسات:

☐ سلسلة العلوم الإنسانية والاجتماعية ☐ سلسلة العلوم الطبيعية والتطبيقية

للمجلد رقم ( ) الاسم :..... العنوان : .....

التاريخ : / / 200 التوقيع :..... .....

طريقة الدفع : ☐ شيك ☐ حوّالة بنكية ☐ حوّالة بريدية

أ – داخل الأردن : للأفراد (9) دنانير أردنية.

للمؤسسات (11) ديناراً أردنياً.

ب – خارج الأردن (للأفراد والمؤسسات): (30) دولاراً أمريكياً.

ج– للطلبة: (5) دنانير سنوياً

د – تضاف أجرة البريد لهذه الأسعار.

تُملأ هذه القسيمة، وترسل مع قيمة الاشتراك إلى العنوان التالي:

رئيس هيئة تحرير مجلة مؤتة للبحوث والدراسات

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Tel: +962-3-2372380 Ext (6117)

Fax. +962-3-2370706

Email: darmutah@mutah.edu.jo

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